A multi-disciplinary framework for optimising the intensity of grassland management in mountain regions of Austria

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Summary

This paper introduces the MAB-project "Landscape and Agriculture in Transition: Grassland in the Mountain Areas of Austria", which deals with the optimisation of grassland management in disadvantaged mountain regions. The project is due to continue over a period of four years and attempts to reflect the complexity of the core subject, "Grassland", through a multidisciplinary research approach, which is described in this paper. The construction of a theoretical explanatory model and initial empirical results from the socio-economic component of the research are presented. This particular research component seeks to identify those factors influencing the level of intensity of grassland management, by analysing the effects of selected field-level and enterprise-level socio-economic measures on the use of production factors in grassland management. This study uses information gathered in a survey of farm managers in Central Ennstal, Styria.

The innovative potential of the research approach is seen in the range of ways in which data from the socio-economic research component presented here can be combined with data from botanical and production-orientated project teams. Although the interdisciplinary analysis is still in progress, it is clear that such a complex, multidisciplinary approach carries with it a range of new opportunities and problems. Its success depends on proper organisation and co-ordination of research activities and a willingness on the part of all participants to communicate with each other.

Introduction

Thanks to the alpine nature of the country, a large proportion of Austria's farms are found in disadvantaged mountain regions. Grassland is a key component of the traditional cultural landscape in these areas as it accounts for around a third of all land use (BMLF, 1998). Therefore, changes in the way meadows and pastures are managed have far-reaching effects on the landscape. In this context, we are currently witnessing a trend towards polarisation, where grassland management is becoming more intensive in some areas and less intensive in others. Intensification has negative implications for the environment, while extensification may go as far as converting the land to an alternative land use, such as forestry, or taking it out of production all together. Given that grassland fulfils a variety of agricultural, socio-economic and ecological functions (Wytrzens 1995; Briemle and Elsässer 1997), the consequences of such developments from the point of view of society (e.g. reductions in biodiversity or loss of a recreational resource) can certainly be considered undesirable.

The ongoing project "Landscape and Agriculture in Transition: Grassland in the Mountain Regions of Austria"[1] was set up against this background of changing land-use practices. The research is part of the UNESCO Man and Biosphere Programme and deals with the core issue of optimal management intensities for grassland in Austria's mountains.

This paper first outlines the multidisciplinary approach taken in the project and then describes the socio-economic research component and its place in such a pluralistic research design. We then introduce an explanatory model which seeks to describe the relationships between socio-economic and environmental factors and management intensity. A one-year pilot study has already been carried out in Central Ennstal (Styria) and the initial empirical results from the socio-economic component are also presented. Finally, we discuss the practical experiences obtained to date and report on some of the opportunities and problems associated with co-operation across research disciplines.

The multi-disciplinary research approach

Given that both socio-economic and ecological principles play a role in grassland management, research on the subject has to follow a multi-disciplinary approach. Experience has shown that such approaches work best when all research participants work towards a clearly defined set of common goals (Isermeyer, 1996). All members of the research team involved in the work presented here have committed themselves to the following objectives:

1. the development and specification of an environmental/ economic model representing the complex interactions between socio-economics and ecology (man and biosphere), and
2. the establishment of a body of knowledge which can help us manage grassland in a way that is resource-efficient, socially acceptable and ecologically sustainable, and which also accounts for the multi-functionality of meadows and pastureland and the desire to preserve the cultural landscape as much as possible.

As mentioned earlier in the Introduction, a detailed case study was carried out as a pilot project in Central Ennstal (Styria). The intention was to provide some initial insights into the

[1] Financial support for this project was kindly provided through UNESCO's MAB Programme (co-ordinated through the Austrian Academy of Sciences).

factors underlying differences in the intensity of grassland management. This pilot analysis addressed the complex of interactions involving social factors, economic rationale, process-based decisions, production potential and ecological components. The disciplines involved in both the pilot and main projects, together with the key research topics tackled within each discipline, are given in Figure 1.

Initial work concentrated on finding interdependencies between the socio-economic conditions, vegetation composition on grassland units subject to different levels of management intensity and the importance of this vegetation for the agricultural enterprise in terms of farm production.
The aim was to find these interdependencies from the perspective of as many different specialisms as possible and for each type of grassland management. In order to help guarantee a truly multi-disciplinary approach, a common framework of test parcels was used, i.e. all project scientists had to focus on the same research units, irrespective of research discipline. These individually delineated units provided therefore a central interface where data from different strands of the research could be integrated.

Since the results from the different research components are still being drawn together, the remainder of this paper restricts itself to the socio-economic research component and the empirical results obtained to date.

The socio-economics of different grassland management intensities

The socio-economic research approach

In order to ensure its compatibility with the broader research agenda, the socio-economic research sought to identify and test a model which would explain the emergence of different levels of grassland management intensity. After all, the identification of those factors responsible for the appearance of different management intensities (or which at least impose some form of pressure on alpine grassland management) must precede any realistic attempt to optimise these management intensities.

The model concepts presented treat grassland management as the net outcome of a range of multilayered and interconnected social and economic forces and ecological influences.

Before constructing any form of model it was of course necessary to define both ”management intensity” and the means by which it could be quantified[2]. Enterprise-level management intensity is the sum total of capital and labour invested in grassland management across the whole agricultural enterprise divided by the grassland area. This definition is best suited to comparisons between enterprises. Unit or field-level management intensity is the labour and capital used on a single parcel of land divided by the size of the grassland unit and recognises that management intensity can vary within a single enterprise

The model illustrated in Figure 2 refers primarily to the second definition of management intensity. This model is based on the idea that socio-economic and ecological factors (and the complex interactions between the two) are responsible for the differences in grassland management intensities (Mayer & Wytrzens, 1998; Pistrich, 1998).

Ecological factors can only be partly influenced by human intervention and include both abiotic site conditions (climate, topography, soil) and the biotic elements of the grassland ecosystem (Klapp 1971; Opitz von Boberfeld 1994). Socio-economic factors can be split into two groups. One group contains those factors that remain constant across an enterprise or a group of enterprises, for example family size or the proportion of land taken up by forestry. The factors in the second group are those that can vary between different parcels of land and which determine the production potential of individual grassland units. The research identified thirty potential factors of relevance to management intensity, whereby the presence or absence of these factors and their importance varies on a case-to-case basis. Taking these factors into account, the model gives the following broad explanation for the existence of a particular grassland management intensity: The farmer or farming family has special intentions and objectives regarding the use and management of the grassland on their enterprise. The decisions made in this regard are dependent on the broader conditions in which the farm operates and on enterprise-specific characteristics. These overlying objectives, together with the local socio-economic conditions prevailing on each grassland unit, then determine the intended uses and management objectives for each individual unit of land. Their actual implementation is however constrained by the degree to which each of these land units is suited to agricultural production. This suitability is itself expressed though the unit’s yield capacity and its potential level of mechanisation; these are themselves determined by ecological factors (see also Scheurer-Lietz (1989)).

Methodology behind the empirical socio-economic analysis

The proposed model was tested empirically using the results of an Autumn 1997 survey of 125 farmers. This survey gathered detailed information on the current management of 377 pasture and meadow units, social and enterprise characteristics, and aspects of production technology.

A precise quantification of the labour and capital input on individual units of land turned out to be impossible. Therefore, the following ”intensity parameters” were used to represent the level of management intensity on any one unit of land[3]:

1) cutting and grazing frequency, calculated according to the following formula:
   n = number of cuts + number of grazings * 0.67 + follow-up grazing * 0.3354,
2) amount of nitrogen applied each year (d),
3) number of mechanical treatments (p),
4) pesticide use (l),
5) oversowing (yes/no) (u), and
6) grassland improvement (yes/no) (g).

In a first step, each intensity parameter was tested independently for any correlation with field-level or enterprise-level

[2] The clarification of these terms provided a useful theoretical reference point for all the participating researchers, whose initial understanding of the concept was not uniform.

[3] Bockholt, Fuhrmann & Briemle (1996) also give some guidelines for estimating different levels of grassland management intensity.

socio-economic characteristics, i.e. the hypotheses regarding the importance of selected economic and social factors were tested using ANOVA and the t-test. Net management intensity was evaluated through a "field-level management intensity factor" (bi):

$$bi = 2 * \nu + 2 * \delta + 2*\pi + \lambda + \upsilon + \gamma$$

This intensity factor is the sum of the standardised numeric expressions (hence the Greek letters) of each of the intensity parameters listed above. "Cutting and grazing frequency" and "amount of nitrogen applied each year" were weighted with a factor of 2 because they are particularly important in determining the quality and quantity of the yield. The "number of mechanical treatments" was given a similar weighting. This is because this variable covers a wide range of potential treatments (rolling, mechanical weed control etc.); the weighting compensates for the fact that pesticide use, oversowing and grassland improvement are treated separately and are, by implication, given a higher weighting than any of the other individual mechanical treatments covered under parameter p.

If the mean level of management intensity across the whole enterprise is known, then this allows comparisons between different enterprises. The parameters used in calculating this "enterprise-level management intensity factor" (BI) are the proportion of total farm grassland categorised as labour- and capital-intensive (i.e. meadows subject to repeated mowing and improved pastures) (a) and input use (on grassland) (b), where:

0 = no artificial fertilisers or pesticides[5] used anywhere on the enterprise [as part of the Austrian Agriculture and Environment Programme (includes organic farms)],

0.5 = no artificial fertilisers or pesticides[5] used on some parts of the grassland area [as part of the Austrian Agriculture and Environment Programme], and

1 = no reduction in use of artificial fertilisers or pesticides on any part of the enterprise [as part of the Austrian Agriculture and Environment Programme]

BI is the sum of these two parameters:

$$BI = a + b$$

There was no need to standardise these two variables since they can both only take values between 0 and 1.

It is now possible to describe the relationships between the two intensity factors and the various field-level and enterprise-level socio-economic factors.

Main socio-economic results

With respect to the field-level socio-economic factors, significant relationships were found between BI and grassland unit size, accessibility and environmental protection requirements. Relatively small (< 1 ha) or inaccessible management units, for example, tend to be managed less intensively. The input of labour and capital to grassland units subject to some form of environmental protection is also well below average. In contrast, ownership and whether the land is in a declared water protection area or not seem to have no significant impact on management intensity.

Significant relationships between the two intensity factors and enterprise-level socio-economic factors are given in Figure 3. In general the relationships with the whole-enterprise management intensity factor are stronger. This is because there is usually a wide variation in the use of production factors within a single enterprise, dependent on the particular conditions prevailing on each pasture or meadow unit. Nevertheless, the effects of a whole range of enterprise factors on individual grassland units can still be observed, albeit to a lesser extent.

There is a comparatively strong relationship between the two management intensity factors and mountain farming zone. The intensity factors on grassland units from farms in zones 3 and 4 are well below average. Since zone classification is partly based on abiotic site factors, such as slope and elevation, this result would seem to suggest that such factors are likely to be of considerable importance. The accessibility of the enterprise, which is also used in zone classification, was analysed separately in this research; there was also a strong significant relationship between this factor and the levels of management intensity, as there was for farming methods (organic/conventional) and forest area[6].

The education of the farmer also proved to be a key determinant behind the level of management inputs applied to a grassland unit. On average, enterprises run by farmers with no agricultural training have the lowest intensity factors.

There appears to be a two-way relationship between management intensity and milk quota, stall capacity, silage storage capacity and inside mechanisation. While higher values for these factors do encourage more intensive land management, the factors themselves are also likely to be dependent on the intensity with which the grassland is used. The same applies to livestock density, which is also significantly correlated with both management intensity factors.

The age of the farmer / manager is significantly correlated with the whole enterprise management intensity factor and also seems to influence the readiness to participate in various extensification schemes proposed under ÖPUL, the Austrian Agriculture and Environment programme. The willingness to give up the use of yield-boosting inputs, such as pesticides, or to convert to organic agriculture, falls with increasing age.

A large number of enterprise-level socio-economic factors, including farm employment status, proportion of total income accounted for by agriculture and amount of agricultural land, showed no correlation with either of the two management

[4] a correction factor for grazing is needed because it can be undertaken more often than mowing in any one vegetation period. (Reisch and Zeddies, 1983). The grazing factor is calculated here by comparing two grassland units which were located very close to each other in the surveyed area; one gave three cuts and a follow-up grazing (Nachweide), the other was a grazing ley giving two cuts and two grazings. The equation is therefore: 3 cuts + 1 follow-up grazing = 2 grazings + 2 cuts. Assuming that a follow-up grazing is equivalent to half a normal grazing, then the correction factors become: 1 grazing = 0.67 cuts; 1 follow-up grazing = 0.335 cuts.

[5] exclusively by directed plant protection.

[6] It is important to note that there are, of course, numerous correlations between the indicidual socio-economic factors. Both organic agriculture and the proportion of the farm occupied by forestry are positively correlated with mountain farming zone.

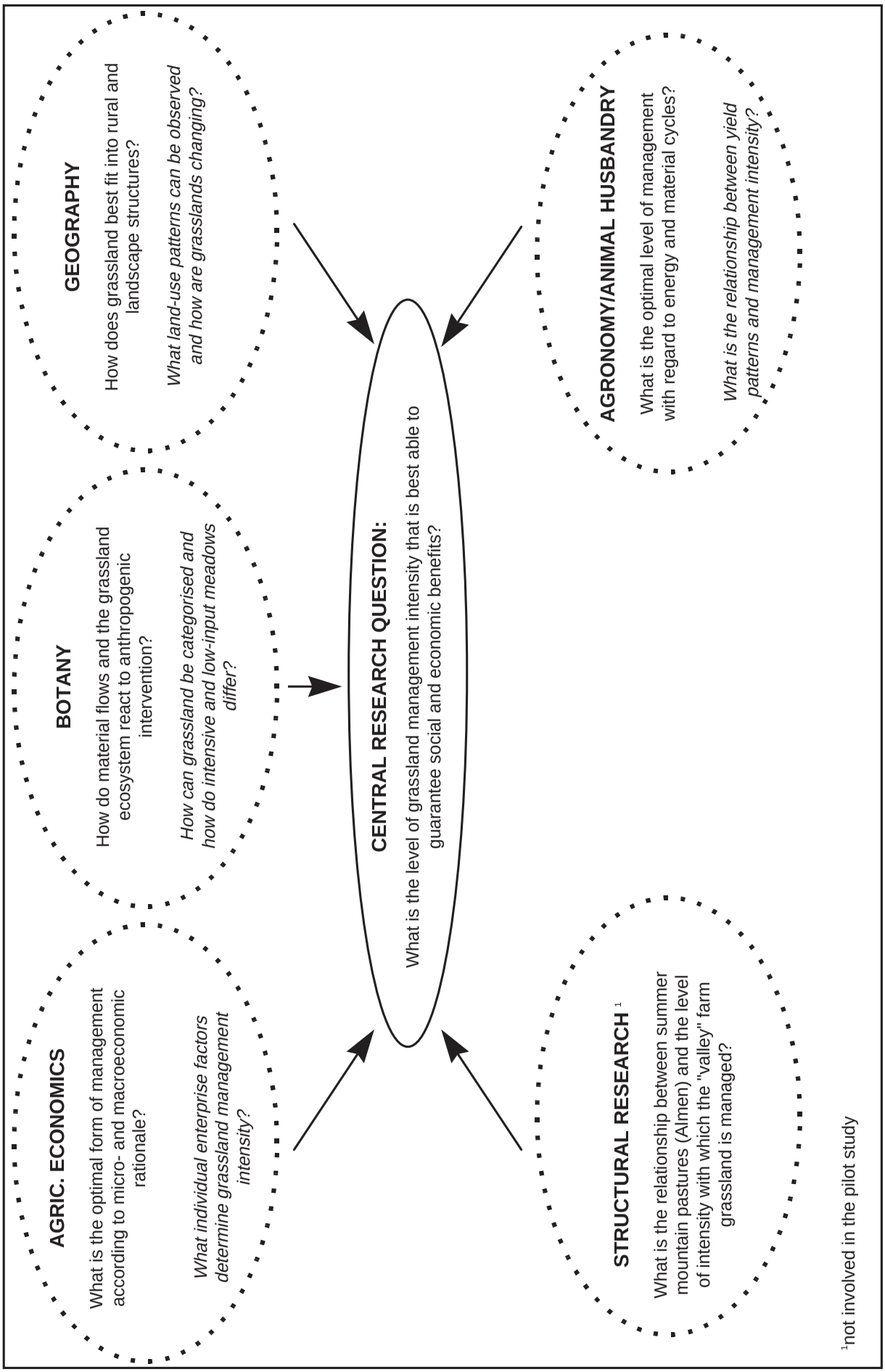


Figure 1. A multidisciplinary research approach for optimising the intensity of grassland management in mountain regions of Austria.

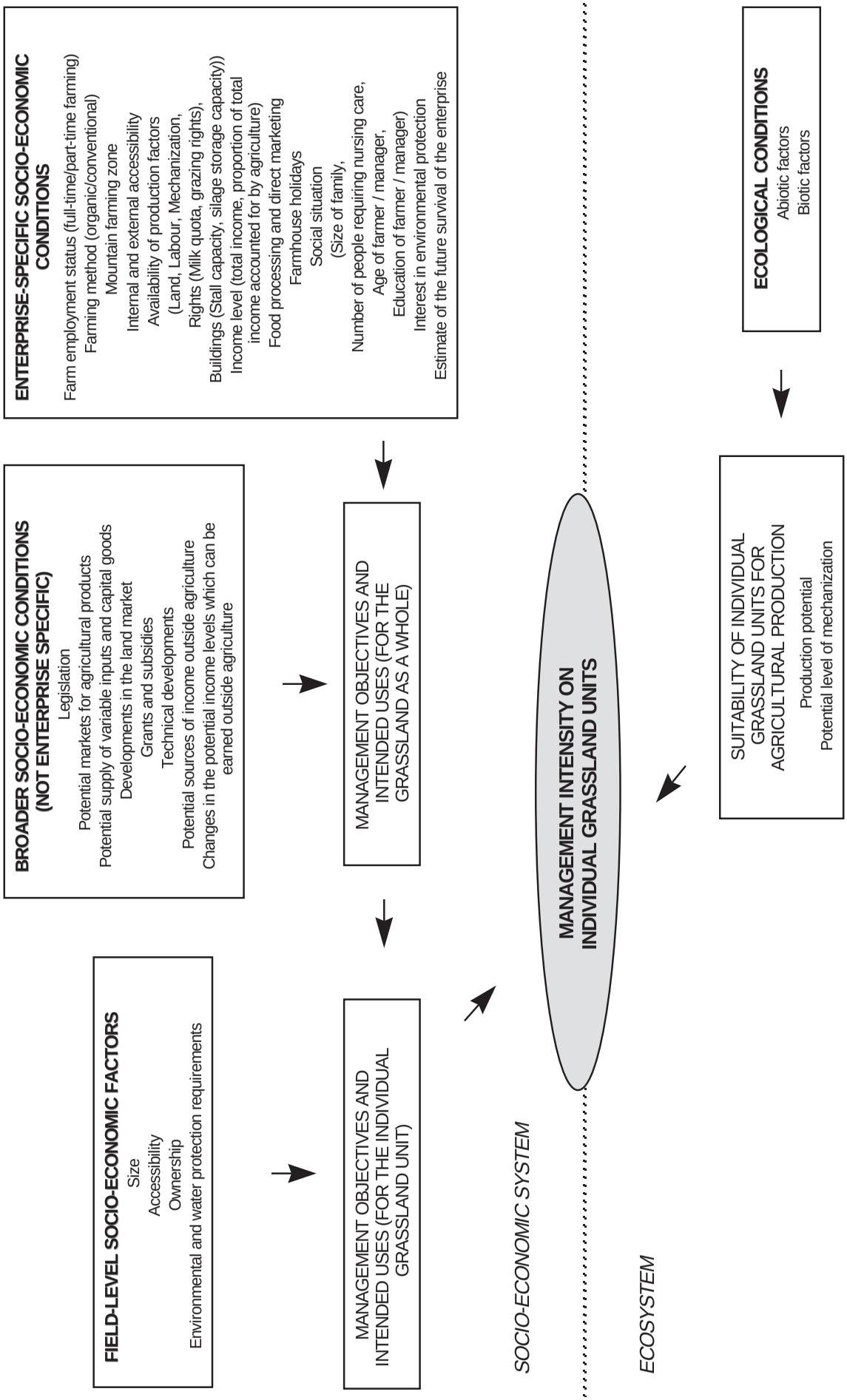


Figure 2. Model describing how differences in grassland management intensity arise.

intensity factors. The presence or absence of particular business activities such as food processing and direct marketing or farmhouse holidays also has no significant influence on management intensities. This may be due to the traditional allocation of responsibilities in the farming household; women tend to do most of the work associated with renting out accommodation (Claupein 1991), for example, while men are generally responsible for managing the grassland. There was also no correlation between management intensities and particular social factors (family size, number of people requiring nursing care, line of succession) or with the estimate of the future survival of the enterprise.

A few factors, such as ownership, are significantly correlated with individual intensity parameters, but not with the net intensity factors. There is no significant relationship between the whole enterprise management intensity factor and the farmer's interest in environmental protection. Nevertheless, those farmers who did express a strong interest in environmental protection are significantly more likely to use no artificial inputs such as fertilisers and pesticides on their enterprises (whether as part of ÖPUL or following conversion to organic agriculture). Other farmers with less of an interest in environmental protection tend to apply such restrictions only to selected parts of their enterprises.

The Austrian agri-environmental programme "ÖPUL" has been a key determinant of grassland management intensity in recent years, since it includes a range of measures which restrict the use of artificial fertilisers and pesticides or which lower livestock numbers. ÖPUL was widely accepted by the farmers in the survey; only two enterprises do not participate in the programme. The most common programme elements found on the farms are the basic subsidy scheme (121 enterprises), mowing in steep and mountainous areas (78 enterprises), and an agreement not to use artificial fertilisers or pesticides on a special percentage of their grassland (53 enterprises). Twenty-five enterprises have given up the use of artificial fertilisers and pesticides completely, and a further 34 farms are run organically; these enterprises tend to be found in the more disadvantaged mountain regions. In 25 cases, farmers cited ÖPUL as the main reason behind a general reduction in fertiliser use on their enterprises, which shows that ÖPUL really is helping to encourage environmentally-sensitive forms of agriculture. In addition to ÖPUL, farmers also gave the following reasons for changes in grassland management intensity (in terms of fertiliser treatment, frequency of cutting and grazing, and general maintenance measures). These were attempts to improve yields - generally through an increase in livestock numbers, conversion to organic agriculture (in one case conversion back to conventional agriculture), increased weed control, expensive artificial fertilisers or bad experiences with artificial fertiliser, and transfer of ownership to the next generation.

It was not possible to test the influence on management intensities of those socio-economic factors which are related to the broader environment in which grassland enterprises operate. The pilot project was focused on a relatively small geographical area, so the variation in these factors was insufficient to allow any form of correlation analysis.

The socio-economic results and conclusions

The results of this pilot study need to be treated with caution since the survey was not statistically representative[7]. Nevertheless, the results do appear to identify some basic trends, for example, the major role played by parcel size and field accessibility in determining management intensity.

Furthermore in the pilot study we managed to get a reasonable measurement of management intensity at the level of individual grassland units. The whole enterprise management intensity factors obtained can, however, only be considered very rough estimates, and the precision and accuracy of this particular measure needs to be improved in subsequent work.

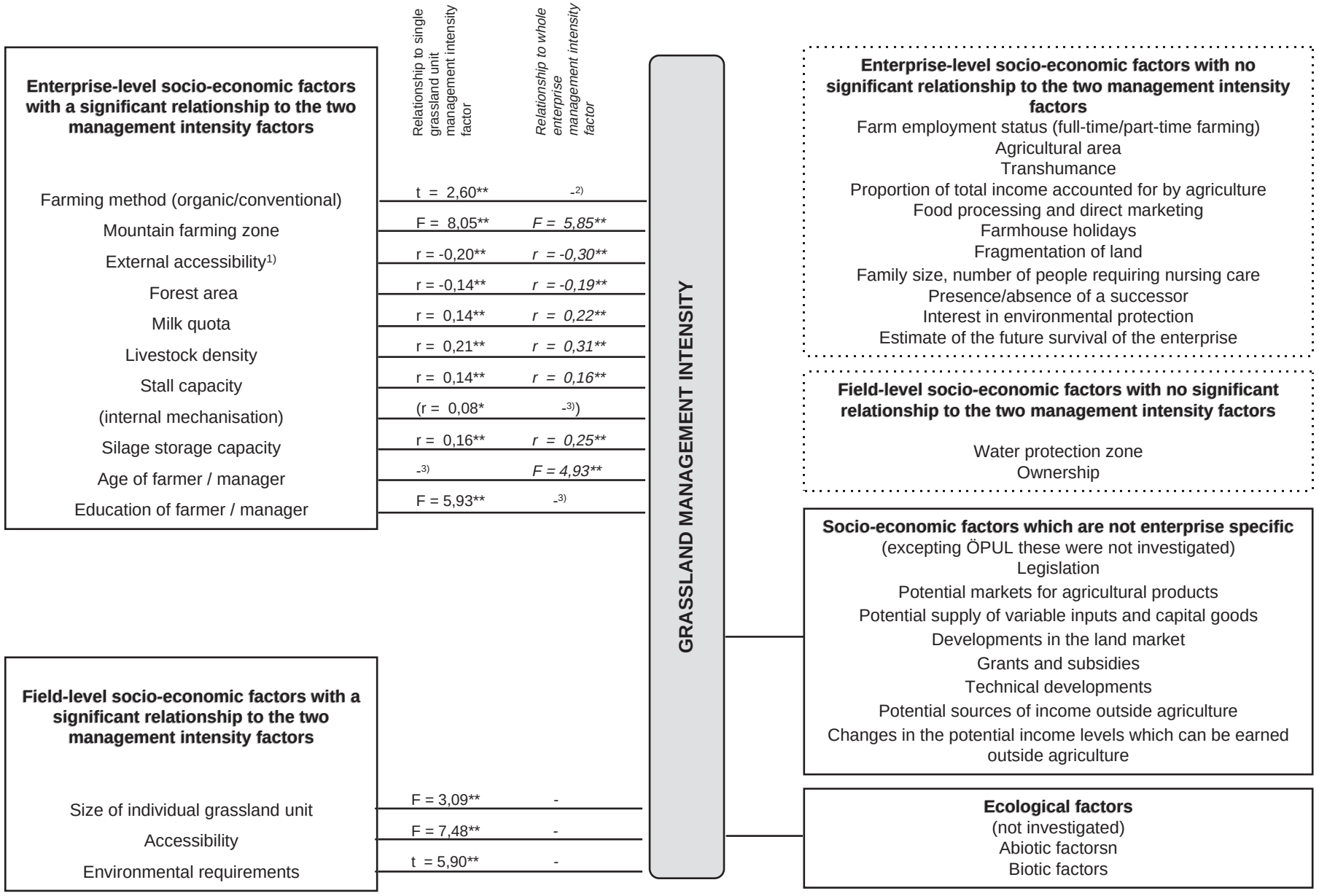
Although the value and relevance of the results obtained should not be overestimated, they do allow us to draw some conclusions with regard to political policy measures.

The results confirm that grassland in favoured agricultural areas tends to be managed more intensively than grassland in more disadvantaged areas. Very few of the enterprises surveyed had actually afforested or abandoned their more marginal grassland units within the last five years. Nevertheless, these kinds of undesirable land-use changes might well become more common if there are further reductions in agricultural prices. Together with the broader transformation of agricultural structures currently taking place, this could lead to the long-term loss of agricultural land and may even make it impossible to maintain the traditional "all-encompassing" nature of agricultural management in alpine areas. This threat, provided it is actually perceived as such by the population at large, could be counterbalanced through measures aimed at increasing the mobility of land ownership. This might provide sufficient incentive to keep those grassland areas which are threatened by abandonment under active management.

Infrastructural and land improvement projects could help prevent grassland from being converted to alternative land uses or taken out of production in the first place. Should such measures not achieve the desired results and the farmers show no interest in continuing to farm particularly uneconomical and unproductive parcels of land, then efficient incentives for carrying out some kind of minimal grassland management need to be created (assuming of course that society sees the preservation of grassland as an issue of importance).

The results do confirm that the Austrian Agriculture and Environment Programme (ÖPUL) plays a key role in encouraging and preserving environmentally sensitive grassland management in mountain areas. The future survival of those pastures and meadows that are managed on a less intensive basis (i.e. the kind of land use which environmentalists value so highly) looks certain to depend on the continuing supply of government funds and, in the long term, appropriate support from society. It would seem sensible to try and make the general population more aware of the various socio-economic and environmental roles played by grassland. This would have the positive side-effect of allowing those agricultural support payments which arise through the Agriculture and Environment Programme to be presented as compensation for ecological services rather than as simple subsidies. However, if the internalisation of the positive

[7] The purpose of the case study in Central Ennstal was to gain some initial impressions of, and experience with, the socio-economics of different grassland management intensities rather then to complete a scientifically representative survey.



** Significance <= 0,01 * 0,01 < Significance <= 0,05 1) Distance to communal storage facility
2) included in the calculation of the whole-enterprise management intensity factor 3) no significant relationship found for this particular intensity factor

Figure3. Results.

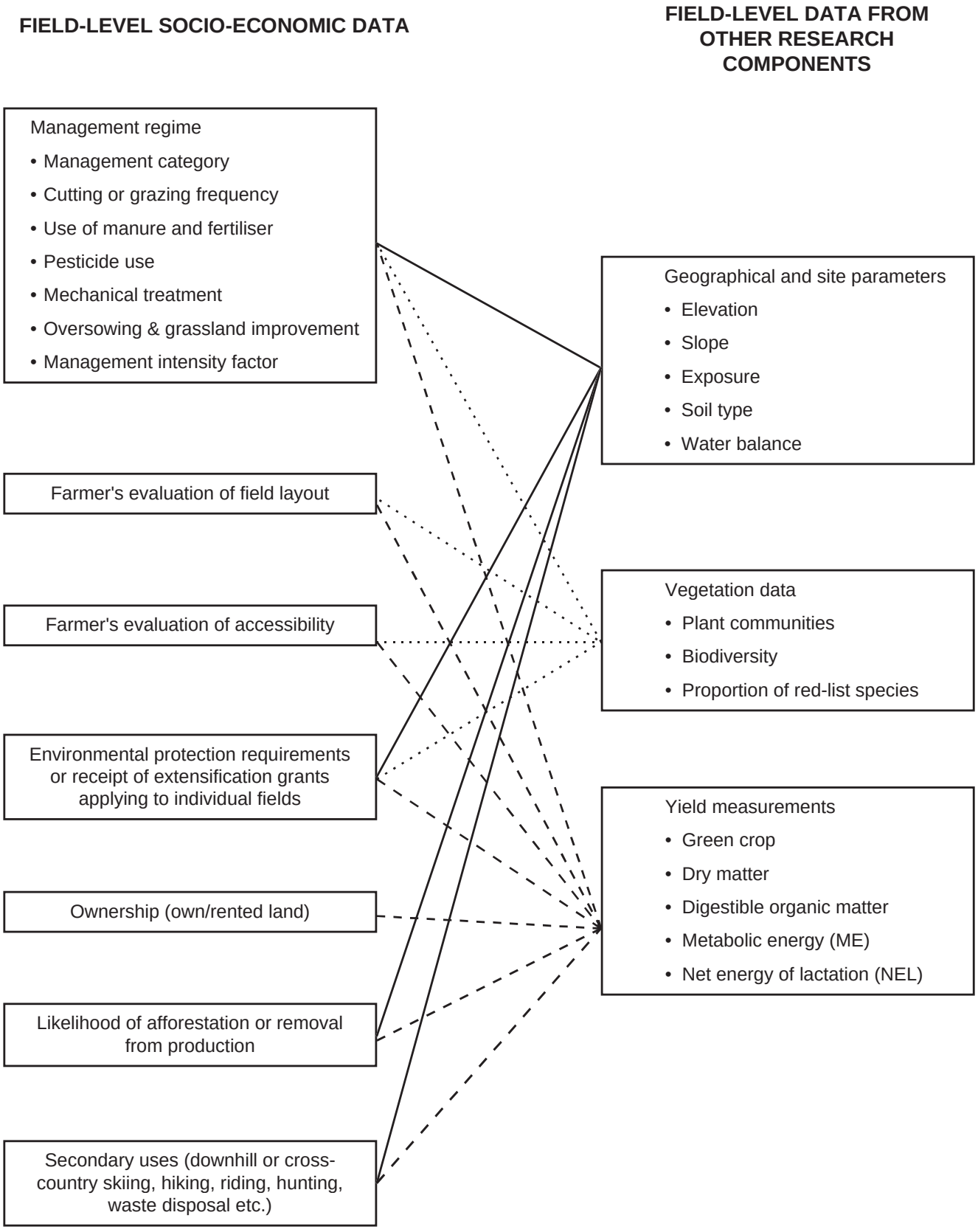


Figure 4. Potential interdisciplinary relationships between socio-economic data obtained for individual grassland units and data obtained from other components on the research.

external effects of grassland management through performance-based payments is to develop further, then scientists and politicians need to be able to define these ecological and socio-economic services more closely. They also need to find methods for adequately measuring the extent to which these services are carried out by farmers.

Integration of the socio-economic approach in the main project

The new challenges faced by researchers and politicians can only be mastered through multi-disciplinary approaches. Existing knowledge and data need to be brought together within a network that recognises no disciplinary boundaries.

Even in its first pilot year, the current project allowed for integration of economic, technological, yield and plant ecological data (with, as mentioned earlier in the paper, the single grassland plot acting as a common reference point). The socio-economic research component has contributed data covering the enterprise as a whole (e.g. animal numbers, degree of participation in agricultural support programmes, mountain zone etc.) as well as information concerning management regimes on, or non-agricultural uses of, selected grassland units. The ways in which socio-economic data relating to individual grassland units might be linked to data arising from research undertaken in the natural and technical sciences are illustrated in Figure 4. This figure reflects the framework of hypotheses constructed specifically for the multi-disciplinary analysis. Although attempts to link all the available data have begun, the final results are not yet available. Preliminary results have, however, made it clear that too many variables were surveyed in the pilot phase. Given the time and effort required for data collection in the pilot project, it would be impractical to scale the project up in terms of geography and content, as originally planned. The set of variables covered in the research must first be trimmed to include just those which are key determinants and relatively easy to survey.

In addition to pruning the set of variables under analysis down to a manageable level, the socio-economic component of the project is currently tackling, or will be tackling, the following tasks in order to be able to make further contributions to the ultimate goal of the project - the optimisation of grassland management intensities. These are:

a) analysis of political objectives and establishment of a function profile for grassland in mountain areas[8],
b) analysis of the impacts of broader socio-economic conditions and agricultural policy interventions on the intensity of grassland management in mountain areas in Austria, and
c) evaluation of the grassland situation at enterprise and macroeconomic levels using a modelling approach.

The aim is to capture the complex social, political and economic relationships involved in the optimisation of grassland management within a model in such a way that they can easily be combined with other ecological, technical and rural planning model elements. The result should be a single model capable of delivering sound ecological, technical and socio-economic information on which to base decisions concerning sustainable grassland management.

Conclusions

Although the planned exchange and integration of data from different components of the pilot project has yet to be completed, some clear conclusions regarding the opportunities and problems associated with a multidisciplinary research approach can still be made. This kind of complex research project, involving an array of scientific disciplines, is relatively innovative and has, therefore, the potential to bring forth new insights and knowledge. The one-year pilot study alone has produced a relatively large amount of data concerning soils, yields and vegetation ecology on individual plots, management regimes, and information on the associated agricultural enterprises. There is much potential for cross-referencing and integrating this data. This kind of multidisciplinary research approach gives individual scientists the opportunity to broaden their horizons and look beyond the confines of their own discipline. Confrontation with alternative approaches and perspectives can have positive repercussions for their own work. As in all multidisciplinary ventures, there is always the danger that the participating researchers begin to develop their own research preferences and priorities. Time and energy has to be invested in co-ordination activities and participants must regularly reaffirm their commitment to follow a common objective. Some problems arose as a result of the different demands of each discipline regarding the best grassland "unit" to choose as a common basis for the research - this unit being the main connection point between the various disciplines. The choice can affect the representativeness of some of the research components; the choice of grassland units, for example, implicitly defines which enterprises are to be included in the socio-economic research and may cause this overlying farm sample to be biased.

In summary, there is considerable potential for conflict in the kind of multidisciplinary project represented by the "Landscape and Agriculture in Transition: Grassland in the Austrian Alps" project. Its success depends on proper organisation and co-ordination of research activities, theoretical and methodological innovation and a willingness on the part of all participants to communicate with each other.

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