Plattform für Naturschutz- und Biodiversitätsforschung

JAPAN FOUNDATION

BM.W_F

6. - 8. May 2008

# International Symposium: Preservation of Biocultural Diversity – a Global Issue

University of Natural Resources and Applied Life Sciences, Vienna - Center for Environmental Studies and Nature Conservation

## Proceedings

# Proceedings of the International Symposium: Preservation of Biocultural Diversity – a Global Issue, BOKU University, May 6 – 8, 2008.

**Editor:**
Bernhard E. Splechtna
Centre for Environmental Studies and Nature Conservation, Department of Integrative Biologie and Biodiversity Research, University of Natural Resource Management and Applied Life Sciences, Vienna, Austria
Gregor Mendel Str. 33, A- 1180 Vienna, Austria

Satoyama – BOKU Platform for Nature Conservation- and Biodiversity Research

**ISBN: 978-3-900962-79-1**

**Acknowledgement:** The financial support for the International Symposium by the Austrian Federal Ministry of Science and Research and by the Japan Foundation is gratefully acknowledged.

**Suggested Citation:** Splechtna, B.E. (ed.) 2009. Proceedings of the International Symposium: Preservation of Biocultural Diversity – a Global Issue, BOKU University, Vienna, May 6 – 8, 2008, University of Natural Resource Management and Applied Life Sciences, Vienna, Austria. 169p.

# The right place – An integrated model for the evaluation of suitability and estimation of potential on alpine pastures for sheep and goats

Albin Blaschka, Thomas Guggenberger, Wilhelm Graiss
Agricultural Research and Education Centre Raumberg - Gumpenstein, Austria
e-mail (corresponding author): albin.blaschka@raumberg-gumpenstein.at

## Abstract

In the past, the use of Alpine pastures during summer was an economical resource for farmers, which became neglected due to intensification of agriculture after World War II. Nowadays Alpine pastures are becoming important again, mainly because of new demand for typical, local products, but also because the extensive management on alpine pastures creates landscapes of touristic value and high biodiversity.
However, this requires new solutions for management of mountain pastures, or more generally, the development of innovative land management tools. In this paper a methodology for both a qualitative and quantitative assessment of suitability and potential of grazing areas based on GIS (Geographical Information Systems) are presented. For the application of the quantitative approach a coherent software package named ENEALP was created.

Keywords: Sheep, Goats, Alpine Pastures, Land management, Remote Sensing

## 1 Introduction

The project „Alpine network for sheep and goats promotion for a sustainable territory development" - AlpiNET GHEEP - supported by the European Community Initiative Programme INTERREG IIIB Alpine Space, was developed in order to promote sheep and goat breeding with the development of innovative land management and production tools e.g. wool, meat, milk and dairy products, as well as the connected activities through a permanent network set up among the breeder associations, local administrations and research institutes. In the three years project period (2005 - 2007), the productive sectors of Austria, Germany, Slovenia and North-East Italy, were involved in order to enhance the economical aspects of breeding, to increase their role in the social context of local communities and to emphasize the positive effect on the cultural landscape of the Alps and on sustainable development of the different territories. The high pastures play a central role in the Alpine region; nevertheless they became neglected due to intensification of agriculture after World War II. Nowadays, they are becoming important again, mainly because of new demand for typical, local products, but also because the extensive management on alpine pastures create landscapes of high touristic value and high biodiversity.

Sheep and goats are regaining their importance for at least two reasons: First, because in many areas cattle farming declined, which lead to an upward trend of small ruminant breeding. Second, goats and sheep are particularly suited for low-intensity farming and for multifunctional use of marginal resources. This would suggest that it is reasonable to abandon the usual residual approach in favour of small ruminants, i.e. giving them what is left after cattle needs have been met.

Therefore, the central aim of this part of the AlpiNET GHEEP project presented in this paper, was to develop an assessment of suitability and potential for the development of future grazing strategies, which was realized with two approaches developed through interdisciplinary work: The first one is a qualitative approach ("…evaluation of suitability") and the second one is a quantitative approach based on the ENEALP software ("…estimation of potential"). The software program analyses the energy flow on alpine pastures (ENE = energy, ALP = alpine) and which gives an estimation on the number of animals that can be pastured.

The results of this study stem from a joint effort of four ALPINET GHEEP project partners: The Agricultural Research and Education Centre Raumberg - Gumpenstein (Austria), the Research Centre of the Agricultural Institute of San Michele all'Adige (Trento, Italy), the Breeders´ Provincial Association of Belluno (Italy) and the Regional Agency for Rural Development Friuli Venezia Giulia (Italy).

For a complete description with all implementation details for the two models, including the ENEALP Software, please see Guggenberger et al. (2007).

## 2 Methodology

To reach the goal and to be able to cover all requirements - both the estimation of suitability and potential - two different, but complementing approaches were chosen: A more field oriented, qualitative one and a strictly quantitative model-oriented one. The field-oriented approach can only characterize the qualitative suitability of specific alpine pastures for selected species of animals. The model-oriented approach is applicable on a wider, more general spatial scale and additionally enables a quantitative estimation of the energy content and forage potential thus making an estimation of how many animals can be sustained by a certain area.

### 2.1 Basic Data

For both approaches, the first step is to acquire basic ecological data on the area, specially land cover, vegetation and climate. Only good knowledge of the available vegetation enables further conclusions concerning the yield capacity and forage quality of a pasture. Therefore, the area studied must be mapped completely and classified.

In the present study vegetation was classified by all partners according to categories (called structural types) defined in the „Pasture Evaluation Model“ (PEM) model set up at the Research and Education Centre Raumberg - Gumpenstein, the Austrian partner in the project (Egger et al. 2004). This model laid also one foundation for the quantitative approach described later in this paper.

The mapping of land cover is possible through field work or with the aid of remote sensing methods. Using remote sensing techniques, as a first step, the locally available vegetation has to be studied and classified. The assessments of vegetation in the study area were made following the methodology of Braun-Blanquet (1928). The releve`s were, following a detailed multivariate analysis, aggregated to biotope types. These biotope types served for the validation of the classification of land cover by means of aerial- and satellite imagery evaluation. The result of field mapping and remote-sensing classification is a comprehensive map of land cover. Those biotope type found in the field are both in the qualitative and quantitative approach later assigned to so-called structural types (see the following chapters and table 2).

To evaluate the suitability of the different vegetation types for sheep and goats grazing both bibliographic sources and the knowledge of experts was used. Since most of the studies published on grazing on open land of small ruminants, particularly goats, refer to Mediterranean environments, the experts' know how was very important specially to calibrate the qualitative model. Especially for the qualitative model productivity, water availability, slope, structural fragmentation and accessibility of the specific study area was assessed, either by GIS or field study. In general, the model is designed so that additional parameters can easily be incorporated.

For the quantitative approach, the environmental factors determining the potential of a pasture have to be converted into various formulas and functions. One example is the duration of vegetation period or the average energy content of a specific forage type. The basic groundwork for this part was done in two studies, described in detail in chapter 2.3. Additionally, data is gained via remote sensing by means of satellite imagery, within the study presented here, with SPOT 5 (SIRIUS) data. For the calculation of annual precipitation and precipitation during the vegetation period, data for the whole Alpine region is available from the ALP-IMP project (see http://www.zamg.ac.at/ALP-IMP, last visit Sept. 24$^{th}$, 2008). Cadastral data for core pastures, land-register borders and regional borders are obtained from the local agricultural administration.

### 2.2 Qualitative Approach

The qualitative approach assesses individual spatial entities under different aspects, which have to be determined in the field. The factors reflect the needs of the animals and have an alternating effect. Overall, high points guarantee best conditions; poor conditions correspond to lower scores. The assessment can be done in parallel for different species, according to their demands: Cattle, especially dairy cows have high demands, in contrary to sheep and goats, which have lower. Wild animals can even get along in areas with the lowest scores. The following usage classes were set:

- **High**: cattle, including diary cows, above 4.25 points
- **Medium**: sheep and goats, between 3.25 and 4.25 points

- **Low**: wild animals, below 3.25 points

The obligatory criteria to calculate the suitability score of a certain pasture are:

- Vegetation type
- Water availability
- Slope

Additionally, depending on data availability, the following criteria bring valuable information into the assessment:

- Productivity analysis
- Structural fragmentation of pastures
- Accessibility
- Sheep stocking rate estimation

For each class a score is assigned, mainly based on expert's knowledge and experience of farmers. The scores are modelled after the "Land Suitability Classes" of the FAO (Food and Agriculture Organisation 1976, see table 1). For the detailed scores for vegetation type, water availability and slope as examples, see tables 2 to 4. The values calculated can be used to produce different thematic maps, or all together as mean make up the overall suitability score which then is used to produce a "suitability map" (see chapter 3.1) for the pasture studied. An overview of the work flow is given in figure 1.

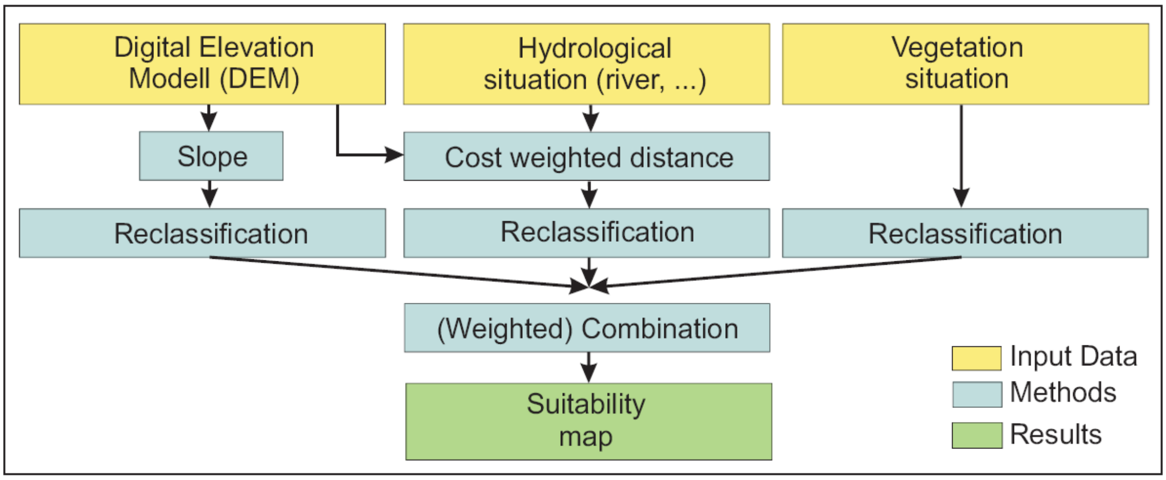



Figure 1: The basic work flow and used procedures for the qualitative approach

## 2.3 Quantitative approach, the software ENEALP

The starting point for the development of the model to estimate quantitatively pastures of mountainous regions with the software ENEALP are two current studies (see references for details):

- The GIS-supported Pasture-evaluation Model (PEM): Egger et al., 2003
- „Höhenprofil Johnsbach": Gruber et al., 1998

Table 1: Suitability scores assigned to the indicators (FAO 1976, modified)

| Land suitability class | Suitability score | Description |
|---|---|---|
| S1: Highly suitable | 5 | Land without significant limitations. Include the best 20% - 30% of suitable land as S1. It is not perfect, but the best which can be found |
| S2: Moderately suitable | 4 | Land that is clearly suitable, but has limitations that either reduce productivity or increase inputs needed to sustain productivity, compared to S1 land |
| S3: Marginally suitable | 3 | Land with significant limitations in regard to productivity/production costs |
| N1: Currently not suitable | 2 | Land with limitations to a sustainable use that can not be overcome at a currently reasonable cost |
| N2: Permanently not suitable | 1 | Land with limitations that can not be overcome |
| Not grazed | 0 | |

Table 2: The structural types as defined in the "Pasture Evaluation Model" and used for classification of vegetation in both approaches. Also shown are the suitability scores used in the qualitative approach

| Structural type | | |
|---|---|---|
| | Sheep | Goat |
| Rich pasture | 5 | 5 |
| Rough pasture | 4 | 4 |
| Tree pasture | 3 | 3 |
| Tall herbs | 2 | 3 |
| Shrub formations | 2 | 3 |
| Bush formations | 2 | 3 |
| *Alnus* sp. formations | 2 | 4 |
| Tall conifer shrubs | 1 | 1 |
| Wood | 1 | 1 |
| Unproductive | 0 | 0 |

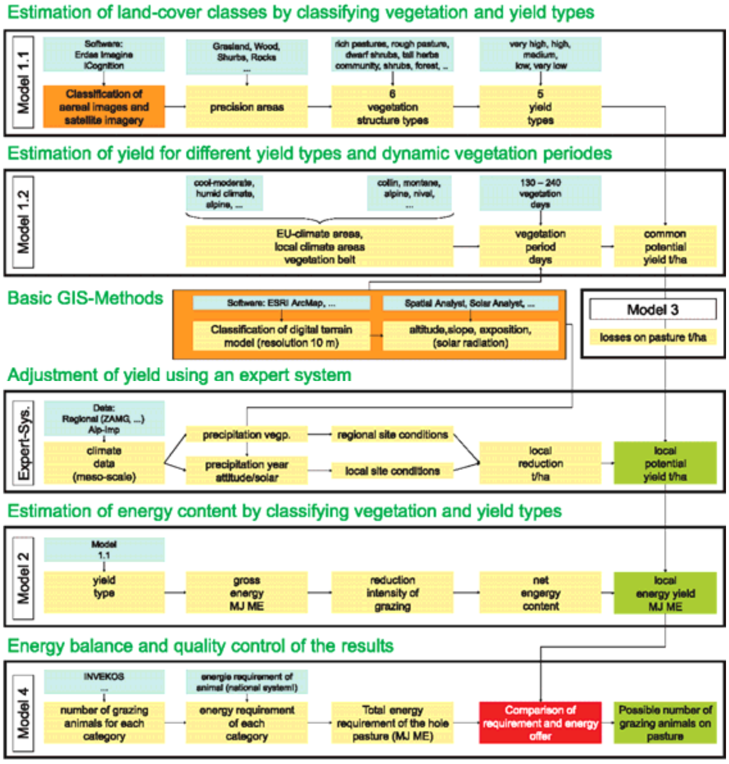
Table 3: Suitability scores for water availability

| Distance from water [km] | Suitability score |
|---|---|
| 0.0 – 0.5 | 5 |
| 0.5 – 1.0 | 3 |
| 1.0 – 1.5 | 1 |
| > 1.5 | 0 |

Table 4: Suitability scores for slope

| Slope [°] | | Suitability score | |
|---|---|---|---|
| Sheep | Goat | Sheep | Goat |
| 0 – 20 | 0 - 20 | 5 | 4 |
| 21 – 45 | 21 – 40 | 3 | 5 |
| > 45 | 41 – 50 | 1 | 3 |
| | 50 – 60 | | 2 |
| | > 60 | | 1 |

Figure 2: Basic workflow and procedures for the pasture evaluation model (PEM)




The basis of the quantitative model is the abstract design of the Pasture Evaluation Model (PEM). It can be applied worldwide to every alpine-pasture-like area. Adaptation to local biotope types and yield functions, however, is an absolute necessity for a specific, local use. Following a purely model-oriented approach, the quantitative model of the ground-cover information is taken from the evaluation of a SPOT 5 satellite image (SIRIUS). In the case of the Raumberg - Gumpenstein project partner, the "Höhenprofil Johnsbach" is used for the local definition of yield functions. The following results are calculated

- Optimum forage- and energy yield (maximum theoretical volume)
- Local forage- and energy yield (realistic volume)
- Potential (balance from local need and yield)

At the trial sites of the "Höhenprofil Johnsbach", alpine forage was manually harvested on site and conserved into hay without loss of residue at the Research and Education Centre. This was fed to male sheep in a digestion trial to define the exact usable energy content (in vitro digestibility) (GFE 1991, GFE 1998). The trial was repeated between 1994 and 1997.

The PEM is a multivariate data-model to estimate the quality and quantity of an alpine pasture. The model is based on the combination of GIS-Methods and expert knowledge of plant production. The original model was set up by Egger, Angermann, Aigner and Buchgraber in 2003. For the AlpiNET GHEEP Project it was adapted (Blaschka, Guggenberger, Graiss 2007). Overall, the estimation of the potential in an area goes in five steps (see figure 2). This workflow is translated in the software ENEALP.

**Step 1: Estimation of land-cover classes by classifying vegetation and yield types**:

A conceptual model in the PEM for the estimation of energy quantum based on several Alpine pastures as examples was developed. Based on its realisation, the expert differentiation of various classes of ground cover has been given. This differentiation is roughly planned and summarises its members in the following biotope types: alpine pastures, dwarf-shrub heath land, bushes, pastures with trees, forests, infrastructure, vegetation-free areas, and water. Above all, the alpine pasture class is of great significance because it is a nutrition-rich sector. The alpine pastures are differentiated according to their vegetation types as rich pastures and rough pastures. Nine differing classes form the basis on which a near-natural or cultural landscape of the Alps can be characterized (see also table 2). For large areas, this work is done most efficiently with remote sensing in combination with a supervised classification (Schowengerdt 1997).

**Step 2: Estimation of yield for different yield types and dynamic vegetation periods**

The nine biotope types are separated in the second stage from their described character and given as a quantity regression. This is strongly coupled with the usability as animal forage and is thus known as a forage type. Biotope types show forage types of differing levels of quality, from very low growth (1,400 kg DM/ha, DM = Dry Matter) to very strong growth (3,800 kg DM/ha). This allocation is dynamically connected to the vegetation period within the most important classes and describes, for example, the alpine pasture structural type with the forage type as medium to very low growth in a second- degree polynomial ($y = (2.407 – 0.0814\ x + 0.0011\ x^2) * 100$, x = vegetation period). The vegetation period is derived from the altitude in differing climatic areas (Harflinger and Knees 1999). A similar model for the assessment of the energy content of the forage is used.

**Step 3: Basic GIS-Methods, Adjustment of yield using an expert system**

The first assessment of dry matter yield and energy concentration leads to an „optimum energy yield". This is a gross estimation that has to be adapted in a further step to local conditions. This adaptation requires an expert system, which comprises a series of local parameters and can calculate the volumes of concentration reductions (Harflinger and Knees, 1999). The local parameters comprise the annual precipitation during the vegetation period, altitude, slope inclination and exposition of each site, as well as the intensity of grazing (stock density). The expert system reduces the „optimum energy yield" to a realistic „local energy yield".

**Step 4: Estimation of energy content by classifying vegetation and yield types**

The PEM offers its users an ordered procedural structure and series of formulas and key features for calculating the local energy yield. To support the expert basis connected with rich and rough pastures, it is complemented by a systematic trial undertaken over several years. Based these trials the energy content of a given vegetation type can by estimated, and is embodied in easily understandable and high-quality formulas.

**Step 5: Energy balance and quality control of the results using real animal grazing**

A mass balance can be carried out if these parameters are put in relation to the requirements of energy and forage for the grazing animals. This data (and of the previous step) is the basis for the production of maps of pasture potential (see chapter 3.2 for an example)

The software ENEALP offers a user friendly input mask for the necessary parameters, and stores all results in a geodatabase, which means, all data has a spatial reference. The individual pixels are given in a relational tupple with clear X/Y coordinates and linked with all necessary information, above all with the identification given to each alpine-meadow. The result is a relational database that permits all calculations of animal feeding (e.g., energy requirements of the animals per pasture). For an efficient use of the available resources with different species (for example cattle and sheep), the pixels representing the best energy yield, which are located at the lowest parts and are easyly accessible are allocated to cattle, as this species is the most demanding (cf. Chapter 2.2). The middle range can only be used efficiently (without over-utilisation) with sheep. The parts with the lowest energy yield remain for wild animals. This distribution of resources is again transferred into a geodataset. Thus, a modern pasture management for a sustainable use of available pastures can be achieved.

## 3 Results

Both approaches were tested in the frame of the AlpiNet GHEEP project. The study areas are situated in Italy, in the region of Friuli Venezia Giulia, in the Province of Trento and in the Province of Belluno. In Austria the study area is located in the Niederen Tauern, Styria. As the scope of this paper focuses on the methodology, only one representative example for each approach is given.

### 3.1 Qualitative Approach

For the qualitative approach, the results from the malga (Italian term for alpine pasture or "Alm" in german) are presented. The pasture stretches over an area of 350 ha, completely within the Stelvio National Park (province of Trento). During 2006, when the botanical relevees were made, 266 goats (partly in lactation) and 225 sheep were kept on the pasture. Two shepherds took care of the cattle, but controlled grazing is practiced only for the dairy goats. The total area is 350 ha, the altitude is between 1520-2560 m a.s.l. The map resulting from the qualitative assessment can be seen in figure 3.

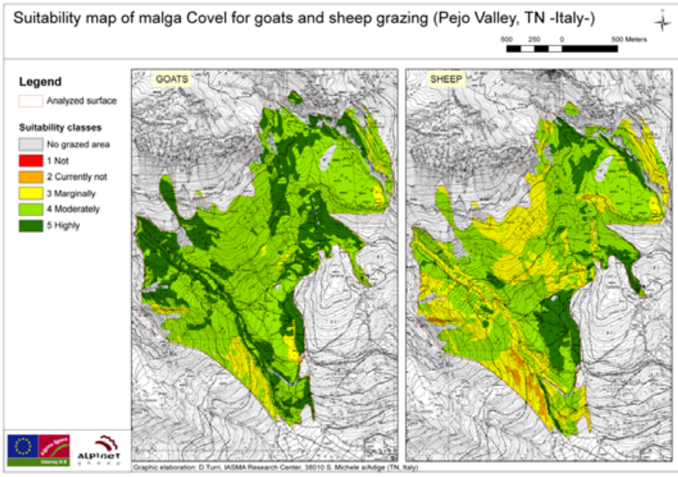



Figure 3: The suitability map of the malga Covel in the province of Trento, Italy

### 3.2 Quantitative Approach

The Austrian study area is situated in the Southwestern part of the district of Liezen in the Schladminger Tauern (Province of Styria, Geocentre: 13° 53‘ E, 47° 22‘ N), South of the river Enns between the towns Schladming and Irdning. The Southern border is formed by the crest of the Niederen Tauern, which are further subdivided in Wölzer (Eastern part of the study area) and the Schladminger Tauern (Western part). In this area (from East to West) the Sölk valley, the Untertal, the Obertal and the Preunegg Valley are found. For the area of the Kleinsölk Valley, a planning process has been started: For manually selected pasture zones the potential, the possible number of sheep has been calculated: The region requires 2,300 sheep for grazing annually. But in a rotation process over several years, a herd of 700-800 animals can suffice to meet the need. The results are depicted in figure 4.

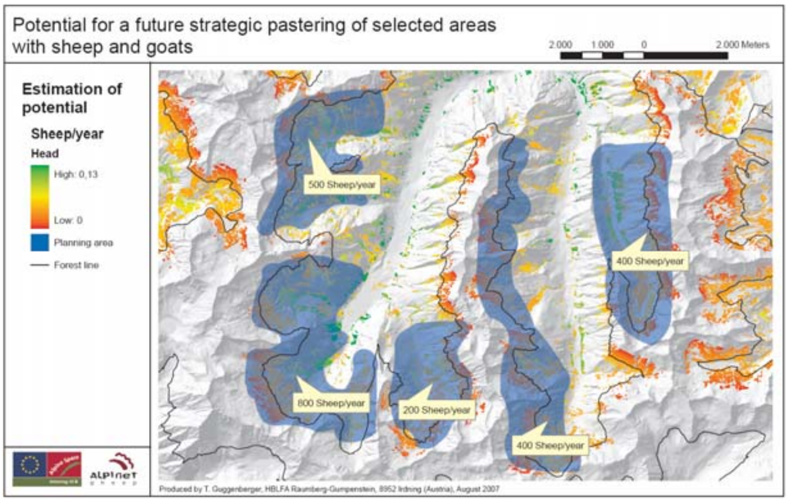



Figure 4: A planning case for the estimation of potential of sheep pasturing in the Niederen Tauern, Austria

## 4 Discussion

This work is based on the application of information technologies, both in the field of Geographical Information Systems (GIS) and remote sensing, which allow studying a territory in a global way. The availability and the development of these technologies, which occurred in the last decade, allow integrating the experimental data based on field assessments, the management experience of experts and instrumental data obtained from cartography and satellite images.
Further need of research was found in the classification of vegetation based on satellite images, which the Research and Education Centre started to meet in the meantime. A need for improvement is the integration of both approaches: The qualitative approach can only characterize

the suitability of specific alpine pastures for selected species of animals; the quantitative approach is applicable on a general spatial scale and enables an estimation of energy content and forage potential. So both approaches complement each other, both on data and spatial scale.

## 5 Conclusions

Yet the computing approach, although pragmatic, is incomplete if the knowledge and the local culture of the breeders are not considered. The sharing of information among breeders, administrators and technicians operating in the alpine space regions is a prerequisite for model qualifying and implementation. Furthermore, the model cannot substitute the training of breeders and the extension services proposed to the pasture management and its importance on cultural, naturalistic and socio-economical points of view.

Finally, this study represents a first step that could become a useful tool for territorial evaluations. The application of the model suggests future improvements, depending on the development of more accurate computing instruments and software, as well as enhancing the collection of experimental data about the vegetation and feeding behaviour of sheep and goats on alpine pastures.

Sheep and goats have been an integrated part of the Alpine cultural landscape. Changes in agriculture and society made them almost irrelevant. Together with sheep and goats the connected knowledge and the traditions are at stake. The tools presented here may help to revive the culture of sheep and goat grazing on Alpine pastures.

## 6 References


Blaschka, A., Guggenberger, T., Graiss, W., 2007: Model for the evaluation of pasture suitability for sheep and goats: Quantitative approach based on the ENEALP software. Presentation at the ALPINET GHEEP Final Conference “Alpine network for sheep and goats promotion for a sustainable territory development”, 6th – 7th November 2007, Udine, Italy

Braun-Blanquet, J., 1928: Pflanzensoziologie. Grundzüge der Vegetationskunde. In: Schönichen, W. (Hrsg.): Biologische Studienbücher 7, Springer, Berlin, 330 pp.

Egger, G., Angermann, K., Aigner, S., Buchgraber, K., 2004: GIS-gestützte Ertragsmodellierung zur Optimierung des Weidemanagements auf Almweiden. Gumpenstein Veröffentlichungen der BAL (Bundesanstalt für alpenländische Landwirtschaft) Heft 40.

FAO - Food and Agriculture Organization of the United Nations, 1976: A framework for land evaluation. FAO Soils Bullettin 32. Rome. http://www.fao.org/docrep/X5310E/X5310E00.htm, last visit Sept. 10th, 2008

GFE (Gesellschaft für Ernährungsphysiologie) – Ausschuss für Bedarfsnormen, 1991: Leitlinien zur Bestimmung der Verdaulichkeit von Rohnährstoffen an Wiederkäuern. J. Anim. Physiol. A. Anim. Nutr. 65, 229-234.

GFE (Gesellschaft für Ernährungsphysiologie) – Ausschuss für Bedarfsnormen, 1998: Formeln zur Schätzung des Gehaltes an umsetzbarer Energie in Futtermitteln aus Aufwüchsen des Dauergrünlandes und Mais-Ganzpflanzen. Proc. Soc. Nutr. Physiol., 7, 141-150.

Gruber, L., Guggenberger, T., Steinwidder, A., Schauer, A., Häusler, J., Steinwender, R., Sobotik, M., 1998: Ertrag und Futterqualität von Almfutter des Höhenprofils Johnsbach in Abhängigkeit von den Standortfaktoren. Alpenländisches Expertenforum „Zeitgemäße Almbewirtschaftung sowie Bewertung von Almflächen und Waldweiden“, BAL Gumpenstein, 24.-25.3.1998, 63-93.

Guggenberger, T., De Ros, G., Venerus, S., 2007 (Eds.): The right place – An integrated model for the evaluation of suitability and estimation of potential on alpine pastures for sheep and goats. Publication No. 47, HBLFA Raumberg-Gumpenstein. Irdning, Austria. 186pp.

Harflinger, O., Knees, G., 1999: Klimahandbuch der österreichischen Bodenschätzung. Klimatographie. 1. Universitätsverlag Wagner - Innsbruck. Wien, 15ff.

Schowengerd, R.A., 1997: Remote Sensing, Academic Press, 2nd Edition.


## 7 Acknowledgements


Development and work was carried out with major financial support from the Community Initiative Programme INTERREG IIIB Alpine Space. Dipl. Ing. Sophie Kickinger made invaluable contributions with her field work. Mag. Roland Kaiser, Department for Organismic Biology helped with statistical analyses with the programme R. Mag. Manuela Hirschmugl and Dipl. Ing. Heinz Gallaun, Institute of Digital Image Processing, Joanneum Research GmbH helped a lot with the interpretation of satellite data