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Land Use Potential Analysis Achenkirch

By

A. OTTITSCH[1)]

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Summary

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The project "Land Use Potential Analysis Achenkirch" was aimed at the development of solutions regarding conflicts between various forms of land use in an alpine region of Austria.

The spatial information system which was developed for this project is based on three modules. These are data, methods and GIS-technology. GIS technology is seen as a tool rather than a method. The modular approach was chosen in order to stress the difference between the development of new approaches in land use analysis and land use planning, which are of course inspired by new technological possibilities, and the functionalities are provided by an individual software vendor.

Integrated data were used to perform assessments on the relative potentials for timber production, hunting, grazing, nature conservation and recreation in the project area. Potential conflict areas were identified by locating areas where high land use potentials for conflicting forms of land use existed. The comparison with actual land use conflicts in the area provided information on the competing of the land use intensities in the area. A combination of small to medium-scale prioritary land use allocations and large-scale intensity-adaption was chosen as the guideline in the proposed new land use concept.

Introduction

For centuries the Alps have been subjected to various types of land use, which have shaped the present appearance of this landscape. In addition to agriculture, forestry or hunting, which have served as economic basis for centuries, new forms of use have gained importance since the middle of the twentieth century. Nowadays tourism is the most important source of income in many regions of the Alps; the importance of nature conservation is increasing, both, because an intact

[1)] Institute of Forest Economics and Forest Policy, University of Agriculture, Forestry and Natural Resources, Gregor-Mendelstr. 93c, A - 1180 Vienna, Austria.

landscape is the most important asset of tourism and because the role of the Alps as an area where human influence, compared to the highly industrialised and densely populated areas in the lower located regions of Europe, is still at a rather low level.

Land use in the Alps has reached the limit of the carrying capacity of this sensitive landscape and in some regions this edge has already been transgressed. Any further use of its potentials therefore requires diligent planning under consideration of all possible factors (BÄTZING 1991).

Environmental studies in various disciplines have been performed in an area of about 7000 ha near Achenkirch, funded by the FUST-Tirol (Förderungsfonds für Umweltstudien, the "Fund for Environmental Studies"); An organisation established and sponsored by Mr. Emil and Mrs. Christiane UNDERBERG. Because of this long term activity a vast amount of existing environmental data could be used as the main source of input for the project "Landuse Potential Analysis Achenkirch". The goal of this project was the design of an integrated land use concept for that area. Nature conservation, agriculture, the protection against disasters (torrents and avalanches), tourism, forestry, and hunting were the landuse forms considered in this project. The area is displayed in Fig. 1.

Methods

For this project a spatial information system based on land use potential and conflict analysis was developed the results of which were then used to develop the land use concept.

The spatial information system approach

The use of a spatial information system (SIS) allowed the integrated planning and evaluation of all landuses and their effects on the alpine environment.

The SIS consists of three modules. These are data, methods and geographic information technology. The aim of this modular conception is to ensure a maximum portability of all the project's results. The data stored may be used for further scientific research in the project area, whereas the methods developed may be applied to other regions to solve similar problems.

Data represent formalized spatial information, methods are stored as methodic knowledge, which has been formalized to specific algorithms. Quantitative and qualitative queries can be entered into the system resulting in outputs that can be issued in the form of maps, statistics or reports. These outputs then result in altered and, hopefully, increased spatial and methodic information, which may influence new queries to the system.

Land use potential analysis

The potential offered by a given landscape element, to perform a certain type of land use may be calculated using the following formula (EASTMAN & al. 1993):

$$P = \sum \cdot W_i \cdot X_i$$

P = land use potential value
X = indicator value for a factor relevant to land use
W = weight assigned to each land use factor

The values for X_n in this formula represent objective field measurements (e.g. slope, elevation, soil fertility), whereas W_n represent user specific subjective assessments of each factor's relevance for the land use, for which a potential is to be calculated. The other subjective element is the choice which factors are to be used for the calculation.

A land use potential is calculated for each individual landscape element. A landscape element may be defined as a point, line or polygon, if a vector-based GIS is used for data processing, or also as one or more raster cells, if a raster-based system is applied.

Land use conflict potential analysis

The land use conflict potential analysis is based on the input/output concept of landscape potential. The landscape potential of a given landcape is determined by ecological factors (climate and terrain), which are limited for any spatial entity within a specific period of time. On the other side of this concept there is a demand by the socio-economic system for various forms of output. This demand is determined by landuse interests of different groups and individuals. If the accumulation of these different landuse interests becomes larger than the limited landscape potential, land use conflicts result.

High interests in the use of a specific landscape element are assumed, if there are high potentials for different landuse forms with similar demands regarding to land use specific factors. Conflict potential analysis is therefore performed by an overlay of the results of different land use potential analyses.

Whether these conflict potentials result in actual land use conflicts depends on the intensity of land use demanded by different groups and individuals.

Land use concepts

There are two basic strategies for the solution of land use conflicts: Segregation and adaptation.

In the segregation approach conflicting forms of land use are either assigned to different land use elements or scheduled for different periods of time. The adaptation approach tries to allow for the simultanous performance of different forms of land use by adapting the intensity of conflicting land uses to a compatible level.

The decision for one of these two strategies will depend on the individual conflict situation, which may also require a combination of strategies. Such approach may result in land use priorities, to which non-prioritary forms of land use have to adapt.

Participative approaches

If land use planning is intended to aid in preventing or regulating land use conflicts, the people, whose different interests are the primary cause of conflicts, have to be integrated into the planning process. While it is possible to perform a technical optimization of land use under a given set of directives, theses directives themselves cannot be derived by means of optimization techniques, since they reflect people's interests and values. The definition of land use goals is therefore a social problem, which has to be solved using social sciences. Modern land use planning requires the participation of all groups and individuals that may be affected by the planning results so that conflicts can be detected before they become manifest. In Switzerland, for example, the use of participative land use management approaches is already officially encouraged (LINDER & al. 1994).

The use of spatial information technology in participatory land use planning processes allows for the integration of various information relevant to land use, the simulation of land use management techniques and the visualization of alternative solution strategies (BUCHANAN 1993).

Results and Discussion

Land use information

Apart from the actual land use concept, the established land information database is one result of the project which is of value also to other scientific work in the area.

Organised in three levels Table 1 gives an account of this information.

The primary information level (level 1) contains information, which has been gathered by field actual observations or measurements, including remotely sensed data (e.g. soil type, elevation, vegetation, game observations). The secondary level (level 2) contains information, that has been produced by processing or combining level 1 information (e.g. slope, soil productivity, habitat diversity). The third level (level 3) contains information, that is the result of evaluation and interpretation of level 1 and/or level 2 information (e.g. landuse potential evaluations). While level 1 and level 2 contain only objective data, subjective elements are introduced at level 3. Nevertheless the selection of any information to be integrated into the system is already a subjective decision, thus there is some subjectivity also at levels 1 and 2.

An analysis of conventional forest regional planning in Austria

The forest development plan (AMT DER TIROLER LANDESREGIERUNG 1989), is an evaluation of protective, welfare, recreation, and productive functions of the Austrian forests. The highest priority in most of the project area is assigned to the protective function of the forest, which is typical for most mountain regions in Austria. The plan is shown in Fig. 2. Since this is a tourism area there are also areas where the highest priority is assigned to recreation. It is interesting to notice that the boundaries of these recreation-priority areas coincide with the boundaries of the alpine skiing area "Christlum". This can be seen as an example for the philosophy of the forest development plan, which is influenced by descriptive elements rather than by actual planning (KROTT 1987). It is also worthwile to note that the skiing slopes, which are the argument for assigning the highest priority to the recreation function of the forests, require the removal of forest and are, by legal definition no forest areas. The conflict between these two landuse forms is not treated in the forest development plan; in fact it is rather ignored by it.

The Austrian Forest Development Plan, is however of great value as a source of information about the conditions in Austrian forests, especially since it is available over all Austria. Using this and other information sources as valuable inputs, methods have to be developed, which allow for the separation of descriptive and planning information so as to strengthen the methodic basis of regional forest planning. The work described is meant as one step towards this goal.

Table 1. The Landuse Information System Achenkirch.

	Primary Level
Topography	Digital Elevation Model (Austrian Federal Office of Survey)
Vegetation	Potential natural vegetation (site mapping)
	Actual vegetation
Site information	Site mapping (soil and vegetation type)
	Site descriptions (Austrian Federal Forests)
Hydrology	Stream network
Fauna	Observation data for ungulates
Infrastructure:	
General Infrastructure	Road network
Hunting Infrastructure	Hunting lodges, raised hides, feedings
Agricultural Infrastructure	Agricultural buildings and roads
Forestry Infrastructure	Forest roads
Tourism Infrastructure	Lodges, restaurants, marked paths
Legal information	Ownership structure, Landuse rights, protected areas
Landuse information:	
Timber production	Austrian Federal Forests management information
	Management information from biotope descriptions
Agriculture	Information about the use of grazing rights
	Assessment of grazing intensity by local informants
Tourism	Assessment of tourism activities by local informants
Hunting	Information about game kills
Conservation	Distribution of disturbing sources
Disaster control	Distribution of forest cover, protection installations
Landuse interactions:	Damage to forest vegetation by game and cattle
	Secondary Level
Timber production	Structure and texture
	Assessment of forest access
Agriculture	Suitability of land for grazing
Tourism	Assessment of access
Hunting	Habitat assessment
	Time series analyses of observations and kills
	Influence of disturbances
Conservation	Biotope quality assessments (e.g. diversity)
Disaster control	Avalanche and land slide risk assessments
	Third Level
Landuse:	
Timber production	Landuse potential evaluation
Agriculture	Landuse potential evaluation
Tourism	Landuse potential evaluation
Hunting	Landuse potential evaluation
Conservation	Landuse potential evaluation
Disaster protection	Landuse potential evaluation

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Landuse conflicts:	Conflict potentials from overlays of Landuse potential evaluations
Landuse concept:	Concept regarding the solution of present time landuse conflicts

Examples of landuse potential evaluations and conflict resolution

The examples described here are taken from OTTITSCH 1995. Due to lack of space only general descriptions can be given here. The following examples were chosen because they are of relevance to stress factors.

Disaster control

The protection against natural disasters is one of the most important services provided by the forests in Austria's mountain regions. To evaluate the potential of a site to perform this service does, however, not seem to be the correct approach, as this potential will be highest on flat, low located sites whithout edaphic extremes, where there is not so much demand for this service. This demand is highest on steep slopes, at high elevations, with additional risk factors, such as avalanches or landslides. The term "demand" here includes only site-specific factors, which determine the erosion risk, it does not include the demand for the protection of human infrastructure. The latter was not evaluated in the project, although it would be possible to do so with the existing database.

The indicator for the protection necessity was calculated using slope, aspect and elevation as input values to determine the erosion risk. An additional factor was added for avalanches using critical slope zones as the determining factor. Fig. 3 shows the result of this evaluation, which were normalized to a range of 1 to 16, like all other indicator values in the project. High values for this indicator also show increasing difficulties for reafforestation.

Recreation

The potential for recreation is determined by landscape factors as well as by infrastructure elements. The natural beauty of the Alps, especially in comparison to densely populated industrial regions, is the main reason why people from all over Europe and the world choose to spend their holidays there. But it is the quantity and quality of infrastructure, which determine the regional and local distribution of touristic activities. For the recreation potential evaluation in this project only the infrastructure-determined recreation potential was evaluated. This indicator also gives an impression of potential stress by tourist activities.

Tourism-related infrastructure, such as hiking trails or restaurants, as well as infrastructure for other landuse forms (agriculture and forestry) were used for the evaluation. The influence of agriculture and forestry infrastructure on the recreation potential is an indicator of positive external effects of these activities on recreation. The distribution of this indicator value is depicted in Fig. 4.

Records on acute conflicts

Damage caused by game and cattle are one of the most important threats to the regeneration of forests in mountain forest areas. The settlement of these conflicts is therefore of utmost importance.

Fig. 5 shows the distribution of damage caused by browsing and peeling of wild ungulates in the project area. The information has been gathered from the protection forest improvement concept (AMT DER TIROLER LANDESREGIERUNG 1991) and from records taken by local forest and hunting staff. Damage due to game browsing was observed on a total of 1050 ha within the project area, 750 ha of which are within areas, where the forest development plan and the protection forest improvement concept state high priority for the protective function of the forest.

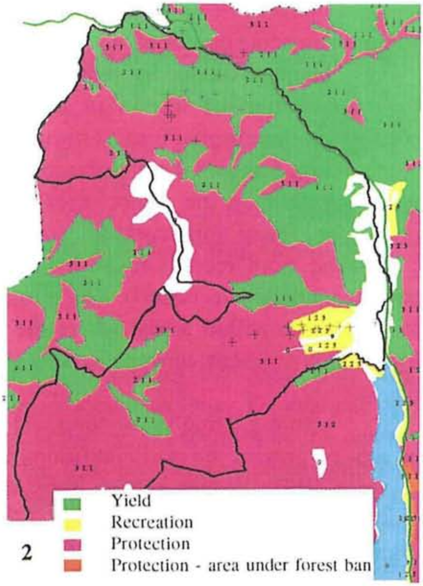
Cattle grazing is the foremost agricultural activity in the project area. The effects of grazing on soil conditions in parts of the project area were studied by ZAUPER 1991. Higher surface flow rates and erosion tendencies are one of the consequences especially in areas with high grazing intensity. In areas where grazing rights exist within the forest regeneration is only possible inside fenced lots. Fig. 6 shows the distribution of cattle grazing in the area both inside and outside of forests as well as damage due to cattle grazing. The latter are recorded in (AMT DER TIROLER LANDESREGIERUNG 1991). The information on the distribution of grazing was derived from records of the Austrian Federal Forests and from local forest and hunting personnel for private lands. Grazing rights exist on 4200 ha, and of these 3000 ha within forests. Grazing damage in areas with high protective function occurs on 1100 ha. In recent years, a separation of grazing and forests was performed on 200 ha.

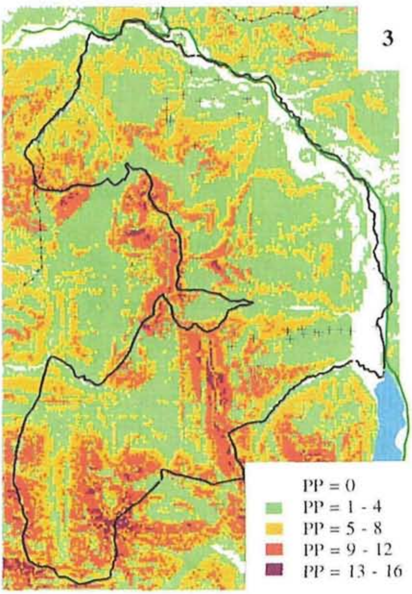
Assessment of actual present conflicts

The comparison of conflict potentials with the present conflict situation helped to identify compatible intensities of potentially conflicting land uses. For the solution of the remaining land use conflicts a land use concept was developed which combines the two basic strategies of adaptation and segregation.

Segregation is suggested for activities where only very low levels of intensity are compatible with one or more of the other land use forms. Adaptation, on the other hand, is suggested for land use forms where compatibility problems occur only at high levels of land use intensity.

Interviews with representatives of all landuse forms treated in the project, plus official records, led to the following assessment of the situation of landuse conflicts and possible conflict management strategies in the project area, which is described in Table 2. The whole landuse planning process was performed in cooperation with the "FUST-Committee", an advisory board to the "Funds for Environmental Studies - Achenkirch". The members of this board represent the different landuse forms.





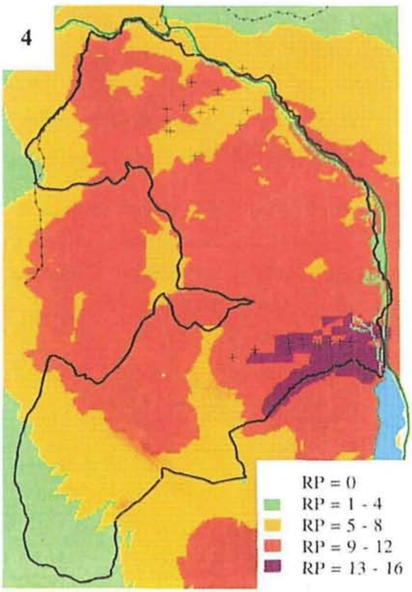
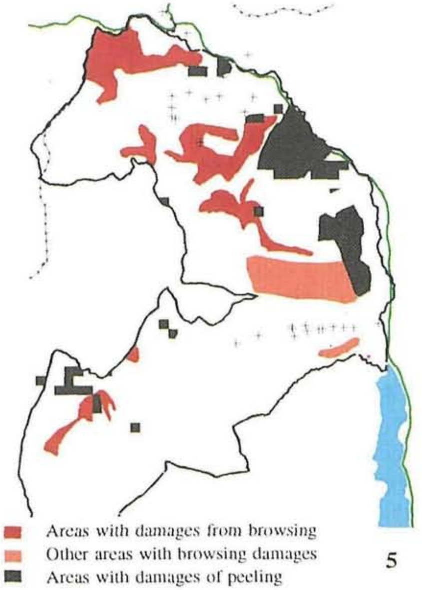


Fig. 1. Map of the investigation area.
Fig. 2. Detail of the map according to the forest development plan (district of Schwaz).
Fig. 3. Critical slope zones regarding the protection necessity.
Fig. 4. Infrastructure-related recreation potential.



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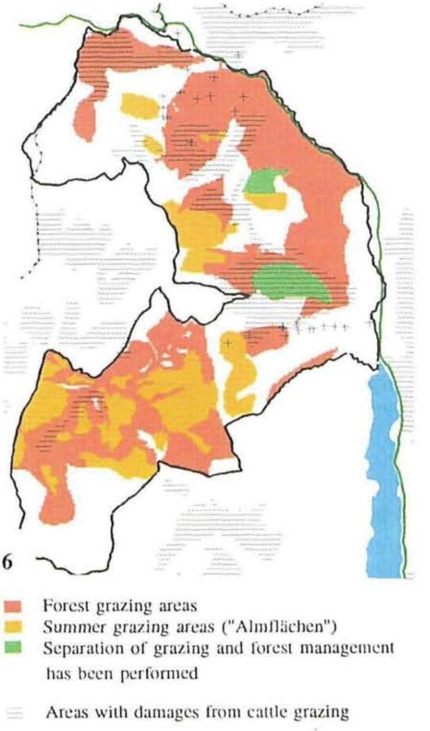

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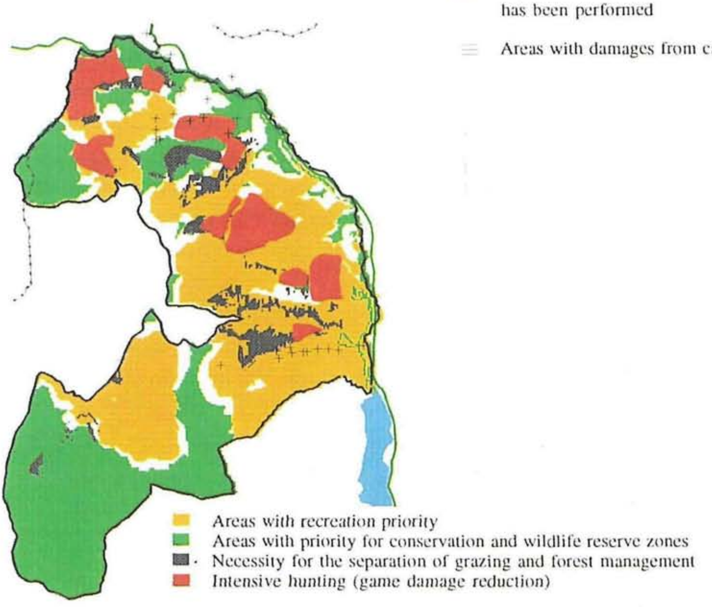

Fig. 5. Distribution of damage by game.
Fig. 6. Distribution of cattle grazing and damage by cattle grazing .
Fig. 7. Area planning map.

Table 2. Landuse conflicts and conflict management strategies.

List of abbreviations:

+	At present no conflict within the project area
C	Conflict
I	Conflict management by intensity adaptation
P	Conflict management by priority assignments
I-P	Conflict management by priority assignments to small areas and intensity adaptation over wide areas

	Hunting	Timber-production	Conservation	Recreation	Disaster control	Grazing
Hunting		C/I	+	C/P	C/I-P	C/I
Timber production	C/I		C/I-P	+	+	C/P
Conservation	+	C/I-P		C/I-P	+	C/I
Recreation	C/P	+	+		+	C/P
Disaster control	C/I-P	+	+	+		C/P
Grazing	+	C/P	C/I	+	C/P	

As to the non-conflicting landuse forms of the project area, it may be assumed that they are performed at compatible intensity levels.

Conflict management strategy to reduce stress due to damage caused by deer, cattle grazing and recreation activities

A hunting management concept was established by REIMOSER 1993. Part of this concept are intensive hunting areas, where damages due to deer grazing and/or browsing have been observed. The idea is to locally reduce deer stands and to lower the attractivity of the relevant areas for wild ungulates.

In order to regulate actual and potential stress from recreation activities, the establishment of priority zones for recreation is suggested. These are areas where the indicator value of the recreation potential which depends on the infrastructure is higher than the conservation potential indicator (which is not discussed in this article). This zonation is the result of weighting recreation and conservation in the ratio of 1:1. New recreation infrastructure is to be established only in areas which are already easily accessible, whereas remoter areas are held to be suitable for conservation and game reserve purposes. In addition to this weighted distribution choice a buffer value was introduced, so that a certain distance between the two conflicting landuse priorities is guaranteed.

Although a separation of cattle grazing and forestry is considered desirable for all the projects area, the rather large area, with existing grazing rights shows, that this goal will not be easy to achieve. Therefore priorities for this separation have to be decided. The potential, or rather the demand for the disaster protection was chosen as the most relevant factor for this decision. Areas, where the indicator value for disaster protection is higher than 12 will not be assigned as potential grazing land, since there the forest cover is considered an indispensable factor to prevent risks from erosion and avalanches.

Fig. 7 shows the spatial distribution of the proposed landuse stragegies.

Conclusions from the project

The land use concept developed in this project is now about to be implemented. This implementation will not, however, consist in a complete rezoning of the area, but the concept is rather to be seen as an informational tool. If new projects are planned, such as new trails or skiing facilities, their feasibility may be evaluated by assessing their compatibility with the concept.

An evalutation of the concept's implementation in a few years will show the strengths as well as the weaknesses of this concept.

Sustainability planning cannot be seen as a one time strike event, after which all the problems will be solved, but rather as the a cyclic process, which one initiated will continue to render graduate results.

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