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Establishing ecological networks in the Central Alps - ECONNECT's pilot region Inn - Etsch

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Abstract

ECONNECT is a three-year project (2008-2011) within the Alpine Space Programme of the EU. Sixteen partners from six Alpine countries jointly promote new approaches for the conservation of the natural heritage in the Alps by establishing ecological networks. The general aims are a) to identify corridors and barriers for ecological connectivity in the Alpine space and b) to implement concrete measures improving spatial links for species between protected areas in seven pilot regions. The Swiss National Park is the leader of one of these pilot regions. Together with a group of regional stakeholders the aims of ECONNECT should be realised in the area between the Inn river in the North and the Lake Garda in the South, including two national parks and several regional natural parks in Austria, Italy and Switzerland.

Keywords

connectivity, biodiversity, protected areas

Introduction

In the Alps currently more than 350 areas larger than 100 ha are legally defined as protected areas. This is some 23-25% of the whole Alpine bow (ALPARC 2007, JUNGMEIER et al. 2006). Protected areas in the Alps constitute major properties for the protection of species, biodiversity, the protection of natural, humanly unaffected territories and are – as in the Swiss National Park important research areas. But many of these protected areas are in high altitudes where the conservation is guaranteed anyway because of limited land use intensity (KOHLER 2009). Regarding this we have to ask, whether protected areas are sufficient for the preservation and advancement of the natural diversity of species and the safeguarding of an adequate exchange of genetic materials.

The ecological trouble spots are located in the valleys, are used intensively by humans and underlie neither protection nor affirmative action for improvement of the ecological situation. Some of the researchers are analyzing today genetic diversity to find out how strong ecological connections are needed (FRANKHAM 2006). Other studies are analysing if the large protected areas are linked sufficiently and try to propose precise measures for improving the linkage (JUNGMEIER et al. 2006). To implement such connectivity measures between neighbouring countries or between agriculture and forestry, coordination and communication is essential, but often still missing.

Aims and approach of the ECONNECT project

The project, named 'ECONNECT- restoring the web of life' aims to advance the ecological connectivity in the Alpine countries, as specified in Article 12 of the Nature Conservation Protocol of the Alpine Convention. The project works on two levels. First, it is foreseen to provide an Alpine-wide overview where corridors are necessary, where the preconditions are adequate and where barriers exist. This will be exemplary implemented on the basis of single species like the otter, black grouse, bullhead, red deer and the group of the large predators.

Second, concrete measures should be planned and realized in the 7 alpine pilot regions. The Swiss National Park (SNP) coordinates the work in one of these pilot regions named 'Inn-Etsch'.

Area of Study

The pilot region ranges from the river Inn in the North to the Lake Garda in the South, including the Etsch valley in the South Tyrol and the Trento area in Italy (fig. 1). Two geographical regions of the area are of particular interest for the project: In the main valleys with higher population density and intensive agriculture, ecological connectivity may already be reduced. This includes the Etsch valley from the Reschenpass until the river enters the Po-area in the South as well as the other main river system in the North, the Inn valley in the Grison (CH) and the Tyrol (A).
The second important area is located between the existing protected areas: the Swiss National Park and the National Park Stilfserjoch, the Biosphere Val Müstair, the Natural Parks Kaunergrat and Adamello /Adamello Brenta as well as parts of the South Tyrolean Natural Parks.

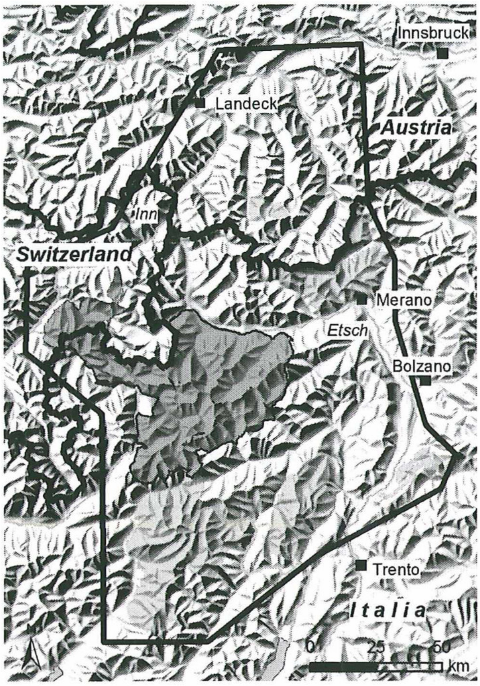

Figure 1: Pilot region Inn – Etsch

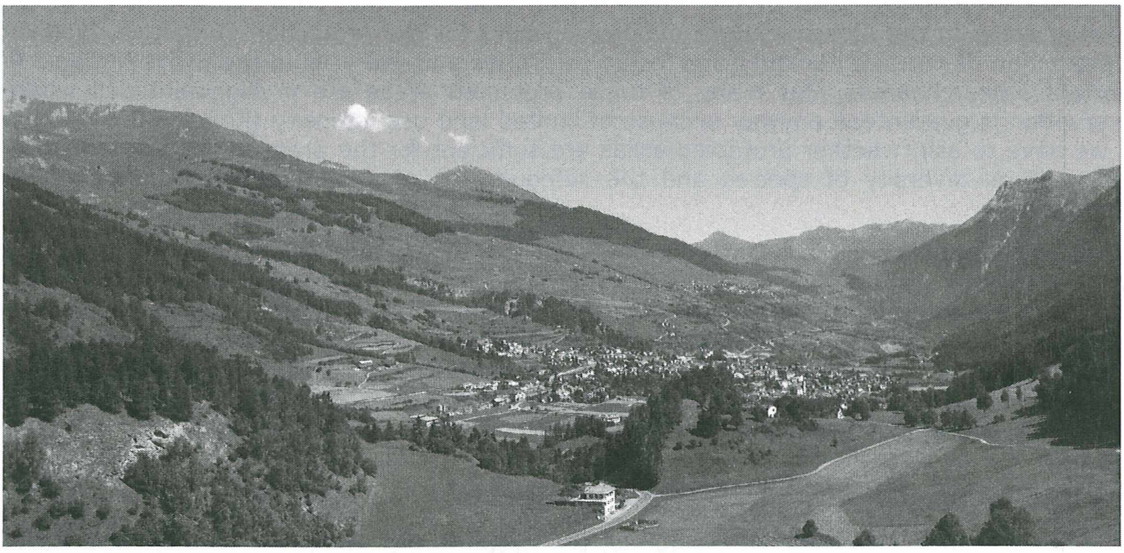

Figure 2: The Lower Engadine valley constitutes an important corridor between the Eastern and Western Alps or rather between the Swiss National Park and the large protected areas in Tyrol.

Expected results

At the end of the project, an overview on existing ecological network element, spatial and legal barriers and possible solutions for identified problems and the implementation of measures will be established. The outcome will be a map with a classified potential for areas for the successful realisation of ecological corridors. A main purpose will be improved connections between the large protected areas in the pilot region.

In addition existing measures in the pilot region are collected, georeferenced and assessed following their profit for the ecological connectivity. The pilot region has planned to submit or even to realize one new spatial connection and three (contractual) measures. A capacious goal, as the project is not fully supported by governmental funding like the other pilot regions.

In the last few months, 3 project outlines have been worked out, which are important for the pilot region Inn - Etsch and could have pilot character for measures in these sectors.

The first project should assure the spatial link (for example fish migration) between the recently restored Rom stream in the Mustair Valley (CH) and the planned restoration of the Etsch river realized within the framework of the River Space Programme in Glurns - Prad in South Tyrol (I).

The second project is located in the upper Vinschgau (I). The apple cultivation has a fragmentation effect on the dry meadow belt. A further development of fruit cultivation is aspired with promotion by the government. The spatial expansion will lead to gaps within the dry meadow beit. The project planned would like to reduce these effects and increase the awareness for the importance of ecological connectivity along valleys.

The third project is working on a habitat network along the Inn valley in the Engadine and the Tyrol, where dry meadows and dry pastures are common. However, they are suppressed by the intensive land use. In a project initialized in the Kauner Valley and in regional networking projects in the Engadine and the Val Mustair, missing linkage structures will be established or regenerated, for example through the conservation and maintenance of dry grassland and dry pasturage.

Discussion

The project ECONNECT is not the only dealing with connectivity issues. Everywhere and especially outside of protected areas, remarkable efforts have been made until today in order to conserve and advance the ecological diversity. One of these initiatives is the foundation Pro Terra Engiadina and the project INSCUNTER in the Lower Engadine. The project *INSCUNTER – tourism, forestry and agriculture, nature and landscape protection on a collective way* will enhance coordinated teamwork of the different policy sectors. In the foundation Pro Terra Engiadina, whose creation was a goal of INSCUNTER, the teamwork in the Lower Engadine continues. Econnect would like to pick up this exemplary course of action for other territories in the Alps. This shows exemplary, that ECONNECT's project team is searching for the collaboration with other regional initiatives and indicates the characteristics of the ecological connectivity. Moreover, Econnect tries to communicate good project approaches from one region in the Alps to another.

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The "Untere Lobau" Biosphere Reserve – The management challenge between urban recreation demands and nature conservation

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Summary

Peri-urban protected areas are confronted with high use pressures often exceeding their ecological and social carrying capacities. The goal of this project was to improve the management of the heavily used peri-urban Untere Lobau biosphere reserve in Vienna through the integration of social and ecological carrying capacities. The objectives were (1) To assess the impacts of high-use levels and visitor behaviour on visitors' outdoor recreation experience and analyse compensatory strategies of visitors' and local residents' use due to overcrowding perceptions using interviews and route analysis, and (2) Assess impacts of different human use levels on wildlife (red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), European beaver (*Castor fiber*)), using monitoring methods in parallel over a period of two years. Results indicated that, due to exceeded social carrying capacities, impacts on wildlife are increased.

Keywords

Social carrying capacities, Place attachment, Ecological carrying capacities, Protected Area, Visitor monitoring, Wildlife monitoring

Study aims

Urban protected areas are important components of cities, providing many benefits to society. They are places for outdoor recreation activities, refuges from hectic city life and valuable habitats for wildlife. At the same time, these areas are confronted with high-use levels that often exceed their ecological and social carrying capacities. There is a need for monitoring carrying capacities; however, knowledge about this topic is often rather limited. As social carrying capacities and ecological carrying capacities are closely related, a complex monitoring scheme, using several social and wildlife science methods in a comparative manner over an extended period, is needed. The heavily used "Untere Lobau" biosphere reserve in Vienna has been chosen as a test area to analyse several indicators of carrying capacities by:

Assessing the impacts of high-use levels and visitor behaviour on local residents' and visitors' outdoor recreation experience, and analysing the compensatory strategies (coping behaviour) of respondents due to overcrowding (Arnberger & Brandenburg, 2007),

Assessing impacts of recreation use on wildlife - red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), beaver (*Castor fiber*),

Understanding the attachments that local residents and visitors form with the protected area to enhance land managers' ability to address a deeper understanding of the landscape and place-specific symbolic values in natural resource management (Williams & Vaske, 2003).

Duration of the Project

The project, called "Ecological and Social Carrying Capacities as Management Challenges for Peri-Urban Biosphere Reserves – The Upper Lobau" started in spring 2005 and lasted three and a half years. The project was co-financed by the Austrian Man and Biosphere Programme of the Austrian Academy of Sciences.

Area of study

The "Untere Lobau" biosphere reserve of 1100 hectares in size lies within the municipal boundaries of the City of Vienna. The area was declared a biosphere reserve in 1977 and is part of the Donau-Auen National Park. Suburbs of Vienna, rural communities, areas of intensive agriculture, the "Obere Lobau" national park area and the Danube River border the area. About 150,000 people live within a few kilometres of its borders, and about 2.5 million live in the region. The Viennese part of the national park is a traditional, intensively used, recreation area as documented by at least 600,000 visits during the year (ARNBERGER, 2006). The "Untere Lobau" receives fewer visits compared to the "Obere Lobau", which is closer to the urban settlements.

Methods

Social and wildlife monitoring methods were applied in parallel during the period of two years (Table 1). A postal survey, using a modified Dillman approach (1978), was carried out among local residents in 2006. More than 600 residents answered the questionnaire. On-site interviews with about 600 visitors, including a route questionnaire about the trails which visitors had used during their visit of that day, were carried out in 2006. Long-term visitor counting was done using counting devices.

Temporal-spatial behaviour patterns of red deer and roe deer were analysed by using GPS- and VHF-telemetry. Beaver monitoring was conducted by mapping activity signs as well as spatial distribution on selected sample plots.

Table 1: Principal methods applied for the study

Method		Period
Mail survey (N = 602; response rate 53%)	Local population (22nd district of Vienna; community Groß-Enzersdorf)	Late winter to early spring 2006
On-site interviews (N = 605)	Visitors to the Untere & Obere Lobau; at main access points	Spring to autumn 2006; 8 days
Visitor counting by pressure pads, infra-red sensors and image-based observation systems	Several trails in the Untere Lobau	Continuously from late winter 2006 to summer 2008
In-depth interviews	Interviews with experts in urban planning, tourism, agriculture, nature conservation, etc.	During 2005
GPS- and VHF-Telemetry of wildlife	Roe deer and red deer (a total of 5 individuals)	Spring 2006 to autumn 2008
Beaver monitoring	Direct field observations of behaviour Mapping of activity signs	Late spring to December 2006 Winters of 2005/06, 2006/07 and 2007/08.

Results

Local residents, as well as people coming from further away, are very frequent visitors to the Lobau. The Lobau accounts for about 70% of all recreational visits to green spaces in and around Vienna made by local visitors. Respondents assigned very high place attachment and satisfaction scores to the protected area. About half of them indicated overcrowding perceptions on Sundays, and applied coping behaviour because of the overall crowded situation. The strategy most often used was intra-area use displacement, such as off-trail use or a shift of use to less frequented areas. Temporal use displacement was characterised by a shift from weekend to workday use or a shift from afternoon to evening use. A route analysis confirmed the existence of intra-area use displacement due to overcrowding, affecting the Untere Lobau, which harbours very valuable areas for nature conservation.

An analysis of wildlife behaviour patterns indicated that red deer remain in dense vegetation during the day, and went out to open areas (meadows) only during the night. Roe and red deer avoided areas with heavily used trails. Changes in the behaviour patterns of beavers due to variations in recreation use intensities were not observed their main activity periods hardly overlapped with human recreational activities.

Discussion

This urban protected area is confronted with high-use levels, which diminish the visitors' recreation quality. In conditions of overcrowding, visitors activated coping behaviour. Because of high place-attachment values and the lack of attractive recreational areas in the vicinity of the Lobau, intra-area and temporal displacement are the most frequent forms of coping behaviour. However, use displacement increases the problems for the environmental management. Greater dispersal of unpredictable visitor use in time and space increasingly fragments the already heavily used area thereby limiting further undisturbed zones for wildlife. Thus exceeded social carrying capacities seem to increase the use pressure on park wildlife. Strategies for reducing use pressure should address unwanted visitor behaviour (off-leash dog walking, off-trail use) and the establishment of an attractive buffer zone around the area for absorbing visitors.

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A Research Programme for the Hohe Tauern National Park

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Summary

Research has a long tradition in the Hohe Tauern area. The spectacular high-mountain landscape of rock, ice, white water, alpine pastures and near-natural high forest has always fascinated visitors and inspired scientific investigations in those with a natural history bend. In the early days, systematic exploration centred on capturing and identifying flora and fauna in the area. Ever since the establishment of the Hohe Tauern National Park, research on anthropogenic influences and on management issues has gained importance.

Today the Hohe Tauern area is an internationally recognized large protected area, the oldest national park in Austria and the largest national park, both in Austria and within the entire alpine arc (http://www.hohetauern.at). Science & research, managing natural space and education & visitor information make up the three core task blocks of a national park. Research activities here are based on the 2020 Research Programme (www.hohetauern.at/de/forschung.html), which was passed by the national park council in 2007 and covers all three federal state sections in Salzburg, Carinthia and Tyrol.

Keywords

Research, management, (research) programme

Objectives

The Hohe Tauern National Park provides excellent conditions for research. It has a total size of 1,836 km², with a high diversity of natural spaces, long-term protection, natural zones devoid of any utilization, large near-natural areas, a high potential for natural dynamics and a solid research record.

From its inception, many research institutions with numerous research projects have been active in the national park. In 1997, for the first time, a common research programme was developed for all three sections of the Hohe Tauern National Park. It was evaluated in 2006 and replaced in 2007 by a new research programme, redesigned from scratch. Its main objective was for research to take into account current requirements of the national park management and to integrate topical research themes like climate change or biodiversity into the programme.

In developing the programme we looked at four areas:

- objectives and tasks ("why" research)
- substantive foci ("what" research)
- the technical and organizational framework ("how to" research)
- the weight of research within the protected area ("how much" research)

Methods

Three main groups of actors worked on the project: Hohe Tauern National Park, an external consultant and (inter)national experts. It was directed and coordinated by the external consultant, in cooperation with a member of the Working Group Research (Arbeitsgemeinschaft Forschung AGF) of the Hohe Tauern National Park, which works across federal state boundaries. The external experts in alpine and protected area research – without any direct links with Hohe Tauern National Park – came in via structured telephone interviews. In addition, we talked to individual scientists doing research in the national park area. The research programme received its final adaptations after debates with the national park administration.

Three workshops plus an internet platform, equally accessible from all three federal states involved, served as communication channels. The internet platform allowed collecting and debating all necessary research questions and framework conditions via a searchable database.

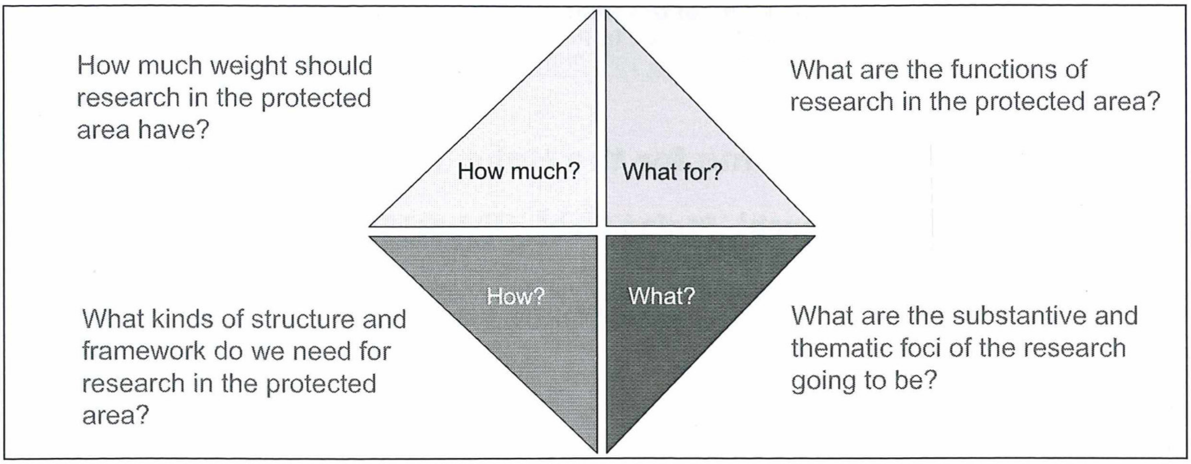

Figure 1: the four areas for developing the Research Programme Hohe Tauern National Park 2020 (Source: E.C.O.).

Starting point

The evaluation had shown that research commissioned and funded by the Hohe Tauern National Park was focussing on management issues. Research which aimed mainly for a general increase in knowledge or basic research was clearly subordinate (see Fig. 2). Natural science research dominated (see Fig. 3).

The new research programme, which – including evaluation – is due to run until 2020, confirms these priorities again for the next decade.

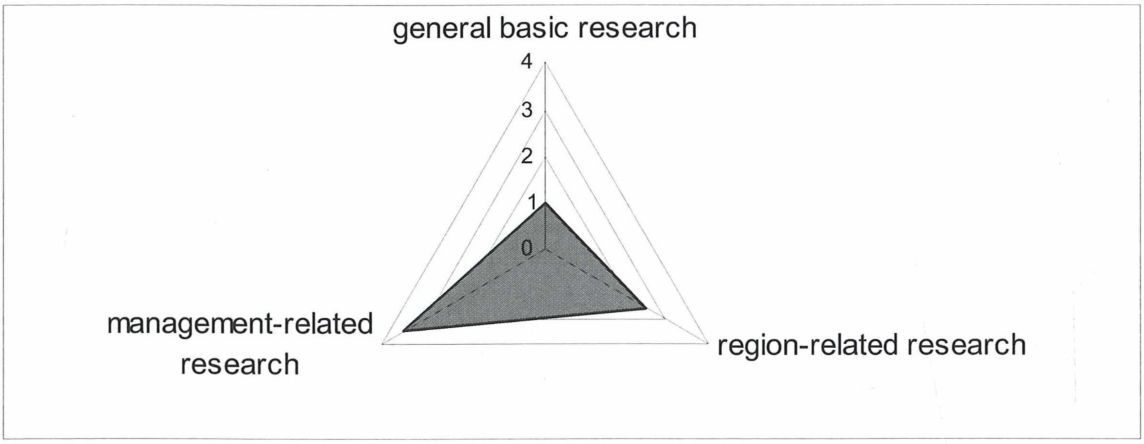

Figure 2: Research in Hohe Tauern National Park (Source: E.C.O.).

Results

Research includes all activities designed to answer substantive questions, the results of which represent an information gain for scientists and practitioners. It is essential that ways be found to ensure ready access to data and results and their long-term availability.

In general, research in Hohe Tauern National Park should aim for inter- and transdisciplinarity, long-term prospects and a regional focus within an international context.

"Why" research

Purposes of research in Hohe Tauern National Park:

- to provide basic information for effective conservation and sustainable development of the national park and its region (basis for management)
- to monitor, interpret and assess as well as to document the status of the area and its natural developments (general epistemological gain, interpretation of the region)
- to explore the role and responsibility of the national park within the region and within society (socio-political responsibility)

In its effects, the research should strongly relate to practice.

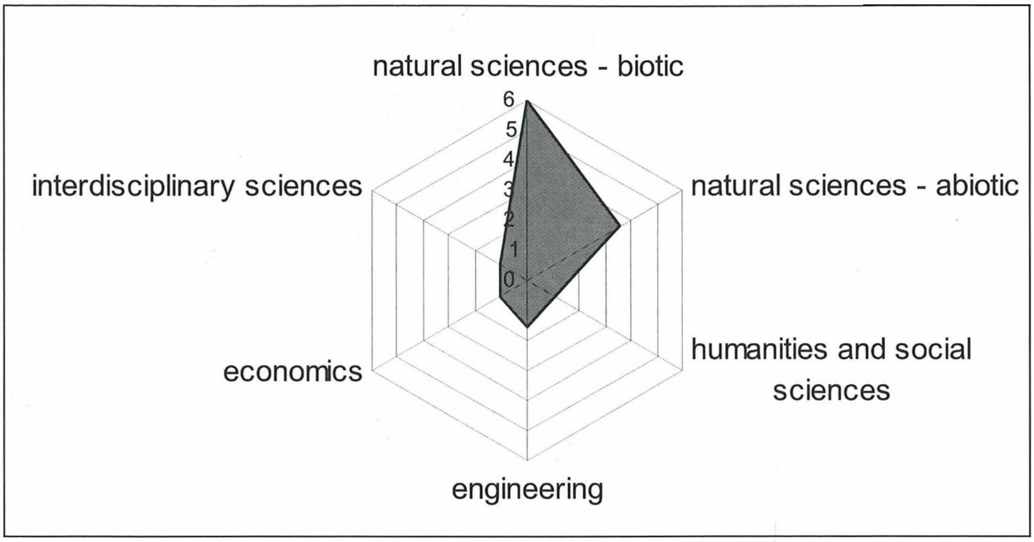

Figure 3: Research themes in Hohe Tauern National Park (Source: E.C.O.).

"What" research

The 2020 Research Programme identifies six thematic foci:

- systematic research into ecosystem processes and longitudinal studies
- capture and assessment of biodiversity within the protected area
- accompanying research into national park management
- development of technologies and processes tailored to the protected area
- socio-economic and cultural-educational national park research
- capture and assessment of the abiotic situation in the protected area

As regards general epistemological gain, the Hohe Tauern National Park aims not only to create an inventory of its relevant protected resources (species, processes) but also to explore systemic links (e.g. comparative studies along conservation and utilization gradients) and effects (anthropogenic influences, conservation status).

Numerous projects on capturing biodiversity have already been implemented (e.g. butterflies, grasshoppers, birds, bats, lichen), also projects on the natural resources at the levels of habitat and landscape (e.g. aerial image interpretation in the HABITALP project; mapping of moors, alluvial lands, biotopes and utilization of alpine pastures). Systemic links, processes and interdependencies are currently being researched in relation to specific causes (e.g. the influence of human land use on the habitat requirements of the red-spotted bluethroat, modelling the extent of present and future permafrost).

A related aim is the establishment of an intricate system of long-term measuring networks and monitoring programmes to facilitate the recognition, interpretation and forecast of changes and their effects on a secure data basis.

Monitoring programmes have already been implemented in species protection, e.g. for bearded vulture, golden eagle and capra and in habitat changes after the end of utilization, e.g. in the special protected area Piffkar.

In terms of management research, the Hohe Tauern National Park aims to develop practice-oriented action knowledge, based on scientific methods and insights. The focus is on measures for monitoring success and efficiency with a view to long-term quality assurance.

Projects already implemented include attendant game-biological research in the leased hunting grounds of the national park and the attendant research on the reintroduction of the indigenous brook trout.

"How to" and "how much" research

One of the greatest challenges in implementing the research programme is the large size of the national park. A suitable framework is needed to ensure feasible and affordable research management, which should also be easy to coordinate between the three federal state national park administrations, if needed.

There are four basic categories of research in Hohe Tauern National Park:

- free research covers research activities within the protected area which are neither commissioned nor supported by the national park. The Hohe Tauern National Park endeavours to have knowledge of any resulting publications.
- funded research covers research activities (co)funded by the national park on submission of a research proposal.
- contract research covers research activities commissioned and (co)financed by the national park.
- internal research covers research activities of national park staff.

The four categories are situated along a gradient of accountability towards the national park. Contract research has priority.

The national park administrations coordinate research, act as interface for any publishing activity and are responsible for the internal technical infrastructure. They are supported in their task by targeted research cooperation with selected public institutions. An example is the Haus der Natur in the city of Salzburg which cooperates on maintaining the biodiversity database.

As regards documenting research results and making them available, the Hohe Tauern National Park aims to establish continuously updated catalogues in the short term and make them available online.

An online media database (11,400 media) and an online map service have already been established. Currently work is under way to create an online project database, an online bibliography (12,931 references from the natural sciences) and an online version of the biodiversity database (191,119 collection, monitoring and literature data of 8,270 species).

In addition, every four years the Hohe Tauern National Park is organizing an international symposium on research in protected areas. The first one was held in 1996. These meetings not only serve to make participants aware of who is currently researching on which topics and where, they also promote debate on methods and results, provide an opportunity to intensify contacts and partnerships and inspire new research questions.

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(www.hohetauern.at/de/forschung.html)

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The Role of Regional Identity in Protected Areas: the Biosphere Reserve Rhön (Germany) as Benchmark

Tobias Behnen

Summary

The historical landscape of the sparsely wooded central German upland Rhön has been protected as biosphere reserve since 1991. It has induced a positive change by adapted landscape protection and support of endogenous economic processes. The region has various functions like as a rural habitat with a high number of outgoing commuters, as an area for transit traffic and as a mountainous tourism destination which induce many difficulties and conflicts. Interviews with residents were carried out to find out about the identification with the region which is important for further regional development and about the relationship of the inhabitants to the landscape. One important result is that the regional identity is partially split up caused by the boundaries of the federal states. The influence of the biosphere reserve on the sense of togetherness was seen as mainly positive as well as for the process of cultural landscape change.

Keywords

Regional Identity, Central German Upland, Biosphere Reserve Rhön

The central German upland Rhön (up to 950 m a.s.l.) is situated in the middle of Germany. The federal states Bavaria, Hesse and Thuringia have a share of this manifold volcanic landscape and the same-named biosphere reserve. The Rhön is a typical historic cultural landscape (Fig. 1). Therefore it includes several anthropogenous biotopes like mountainous grazing grounds (esp. *Nardetum strictae*), hedges or meadow orchards. After several changes during the last centuries today the Rhön contains approximately 40% forests, 30% grassland, 20% arable farm land and 5% settlements. Only within the core zone of the biosphere reserve (2%) no use takes place. Many rounded summits are not tree-covered and allow enormous ranges of vision, but most of the slopes or plateaus are wooded with beeches (*Fagus sylvatica*) as potential natural vegetation or with common spruces *(Picea abies)* as atypical monoculture.

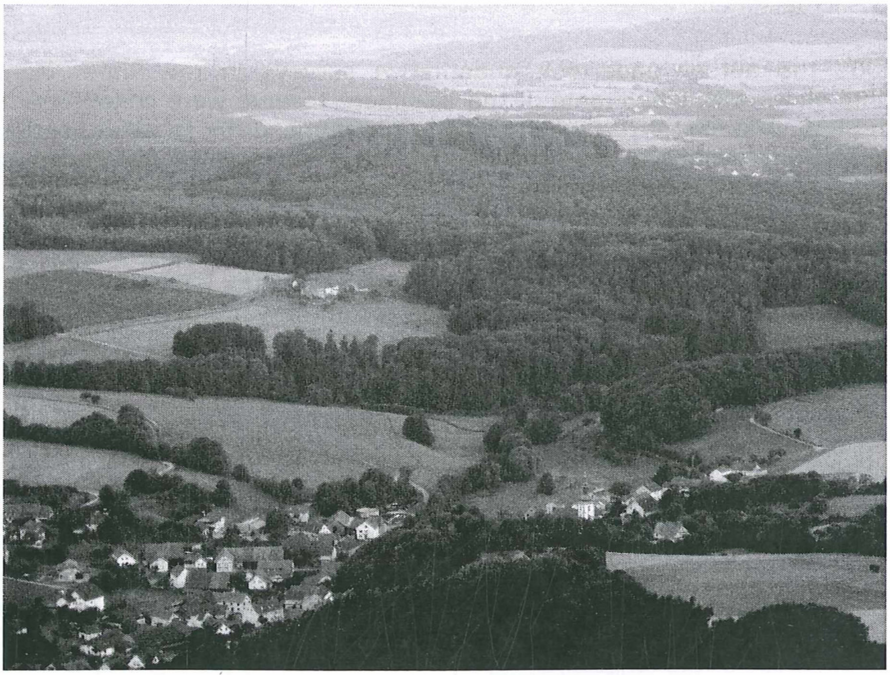

Figure 1: Typical part of the Rhön (Photo: T. Behnen)

Today the inhabitants and tourists perceive the Rhön positively as an original European agricultural landscape a "dreamscape". But it should not be forgotten that in the past the region was characterised by poverty, famine, immobility and social inequity (DIX 2003, 13). However, the Rhön has currently shown a significant intraregional socio-economic heterogeneity and attributes of rural deprivation. Since 1991 large parts of the Rhön have been protected by the biosphere reserve (Fig. 2). It contains 185.000 ha and has 122.000 residents (65 per km²).

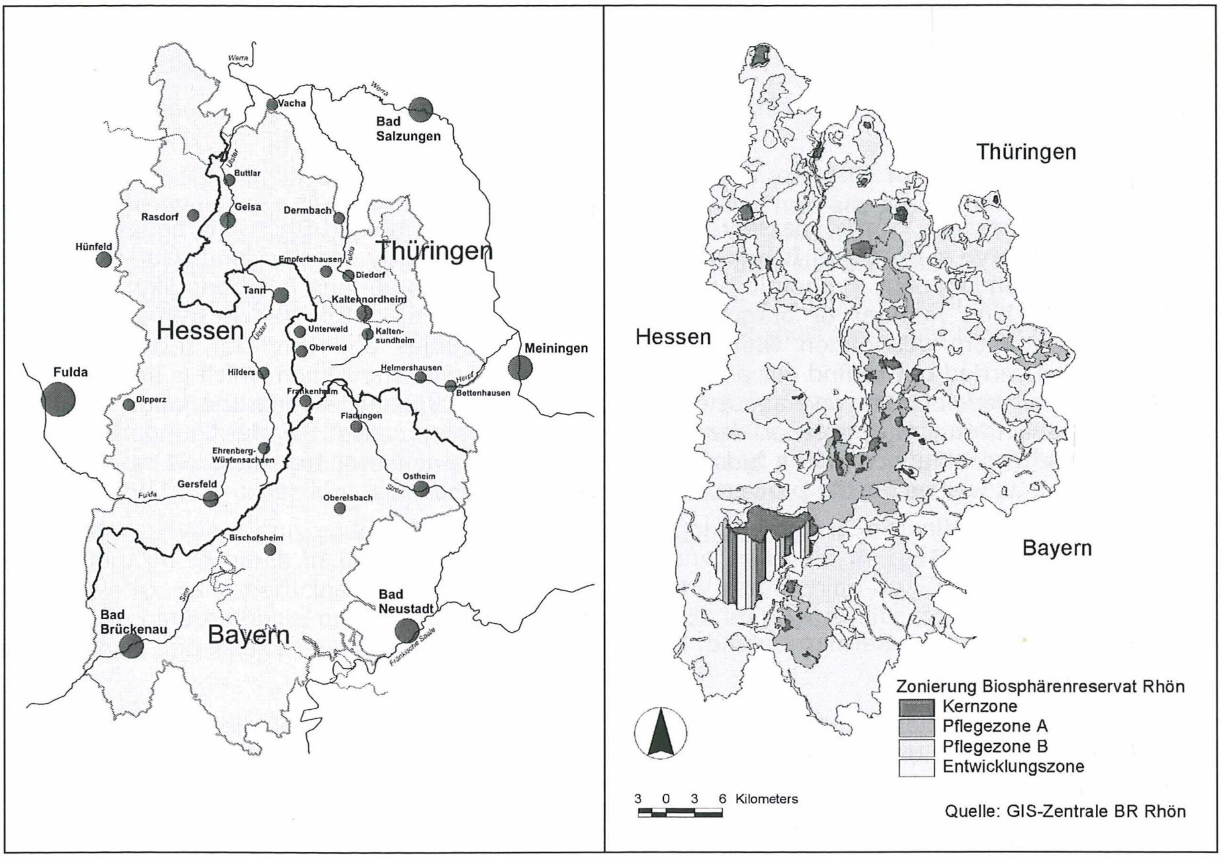

Figure 2: Biosphere Reserve Rhön (Source: BR Rhön)

Livestock plays an important role concerning preservation of the countryside in the biosphere reserve. Meanwhile the regional sheep breed *Rhönschaf* has been re-established as the multifunctional grazer. It supplies wool and meat but also preserves the cultural landscape by reducing scrub encroachment.

From 2005-2008 the author undertook quantitative surveys in the Rhön. More than 2.000 standardised interviews with inhabitants of the biosphere reserve were conducted. The data were evaluated with SPSS. The aim of the project was to comprehend the (positive) reciprocal influence of regional identity, environmental behaviour, social integration and the perception and acceptance of protected areas against the background of an accelerated cultural landscape change.

The analysis of the interviews showed that the acceptance for the biosphere reserve is high. About 75% of the people thought that it achieves the goal to protect the landscape as well as to enable human use. The other main question was "In which region do you live?". 40% of the sample said "Rhön", but the percentage of people which answered "Bavarian, Hessian or Thuringian Rhön" was nearly equal in size. The bare majority believed that the biosphere reserve strengthens the sense of togetherness in the Rhön. Especially in Thuringia which was situated behind the Iron Curtain until 1989 the people agreed with this statement. This also applied to the farmers which on the one hand have to follow the rules within the biosphere reserve but on the other hand could profit by filling orders for measures to preserve the anthropogenous landscape. The vast majority of the interviewees (89%) gave their consent to these payments. The results to an open question showed that it is not only the whole aesthetic landscape which supports the regional identity but especially unique mountains (Wasserkuppe or Kreuzberg), plants (Rhön thistle/*Carlina acaulis*) or animals (*Rhönschaf*). 93% of the interviewees said that the landscape is important or very important for their quality of life. The basis of this close relation of many Rhön residents to the landscape is their frequent recreational use of the landscape (94%). The dominating activity was hiking (83%), which is not only environmentally-friendly but also pushes the ecological awareness of the person in general (BRÄMER 1998, 53). However, the survey could not confirm a direct influence of the biosphere reserve on the environmental behaviour (19%). Nevertheless the preference of regional food (69%) which is promoted by the biosphere reserve could be an indirect consequence.

The Rhön is a positive example for protecting and developing historic cultural landscapes. The results show the correlation between the landscape, the residents and their acceptance of the protection goals. Due to the responsibility of there federal states the biosphere reserve is divided into three parts. This is not only an administrative problem, but for the majority of the population the biosphere reserve is furthering the regional identity within the whole region. In summary it could also be said that the management of the protected area achieves public acclaim. For these reasons the Rhön could be a benchmark for developing protected areas.

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A multi-year survey of the Black Grouse *Tetrao tetrix* in the Mont Avic Natural Park (Aosta Valley, Italy)

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Abstract

Censuses of males of the Black Grouse *Tetrao tetrix* on spring display were regularly carried out in a study area of about 20 km^2 within the Mount Avic Natural Park (north-western Italian Alps) from 1986 to 2008. Every year, all the sites where at least one bird had been detected (seen or heard) were monitored at dawn from 25 April to 20 May to geo-reference displaying males. This method is the most precise and accurate possible because both multiple cocks at the arena and soloists are actually detected. Hence, underestimates that are typically associated with censuses focused on lekking sites may be avoided, and this is particularly relevant in the Alps, where densities of solitary displaying cocks are usually high.

The analysis of the entire data set provided information on local spatial ecology (distribution of males in the different sectors of the area) and population dynamics (numerical fluctuations, changes in the proportions of soloists and in the dimension of lekking groups).

To assess the reliability of censuses based on less extensive sampling efforts, results obtained using the entire data sets were compared with those obtained using data from single, sample areas (300 ha) and from the largest local arena.

Keywords

Black Grouse, census methods, soloist, lekking group

Aims

Black Grouse monitoring started in Chalamy Valley in 1986 (Western Italian Alps) within the researches to institute Mont Avic Natural Park. The Natural Park continued the monitoring of displaying Black Grouse males each year on the entire area used by this Tetraonid.

One of the main objectives for the management of a protected area is to obtain reliable data sets, compatibly with the available number of observers involved into censuses.

Censuses concentrated in leks could underestimate the real population size and dynamics, not considering the number of soloist cocks and ignoring disturbances and modifications on a portion of the species habitat.

In this paper we compare the entire data set with data obtained by randomly selecting a portion of the suitable territory and by selecting the greater lek known in the area respectively.

Furthermore we discuss the spatial distribution of displaying males on the entire study area.

Study Area

The study area has an extension of 2000 ha, including forests dominated by mountain pine *Pinus montana*, some subalpine pastures, peat-bogs, small lakes and scree slopes. Larch *Larix decidua* and Scots pine *Pinus sylvestris* are also present. Ericaceae (mostly *Rhododendron ferrugineum, Vaccinium myrtillus, V. vitis-idaea, V. gaultherioides*), junipers and scattered grassy spots constitute the main bushes and grass cover. The study area includes all suitable Black Grouse habitats in the Chalamy stream basin (1400-2250 m a.s.l.).

Methods

Every year all the sites where at least one bird had been detected (seen or heard throughout the year) were monitored at dawn from 25 April to 20 May from fixed observation points.

This method is the most precise and accurate possible because both multiple cocks at the arena and soloists are actually detected. Hence, underestimates that are typically associated with censuses focused on lekking sites could be avoided, and this is particularly relevant in the Alps, where percentages of solitary displaying cocks are usually high.

Every male detected has been geo-referenced and a half km grid has been drawn with ARCGIS 9.1; every group consisting of 2 or more displaying cocks (< 100 m far off) was processed as a lek.

We considered a subset from 1996 to 2008 to analyze population dynamics and the ratio between grouped and soloists males comparing the performance of three different sampling methods, i.e. considering: 1. the entire dataset, 2. a portion of 300 ha mainly utilized by soloists and 3. the main lek in the study area.

We also analyzed the spatial fluctuation of areas occupied by displaying males.

Results

Overall we censused 1025 displaying males ranging from a minimum of 62 (1996) to a maximum of 92 cocks (2007) (mean = 78.85 ± 9.90). The number of soloists was 407 varying from a minimum of 33 (2001) to a maximum of 60 (2005) (mean = 47.54 ± 8.46) while the number of grouped males was 814 varying from 23 to 37 (mean = 31.31 ± 5.39). The number of leks varied from 8 to 13 (mean = 10.38 ± 1.85) in which displayed from 2 to 11 individuals (mean = 3.01 ± 1.92).

The results of pairwise correlation between yearly fluctuation in total number of individuals in the study area, in the 300 ha sample area and in the main lek we found that the only significant correlation was between the numbers of individuals in the full study area and in the 300 ha sample area ($r = 0.734$, $P = 0.04$).

The pairwise correlation between the total number of displaying males, the number of soloists in the full study area and those displaying in leks showed a significant correlation between the number of soloists and the total number of individuals ($r = 0.78$, $P = 0.001$), between the number of individuals in leks and the total number of individuals ($r = 0.61$, $P = 0.028$), while no correlation was found between the number of soloists and the number of individuals displaying in leks. Futhermore, the number of leks found in the area did not varied significantly with the total number of individuals ($r = 0.44$, $p = 0.13$).

The total number of 25 ha cells in which was found at least one displaying male in 13 years was 78, which varied yearly from a minimum of 27 (2001) to a maximum of 36 (2008). The number of cells occupied by at least one displaying male showed a significant correlation with the total number of individuals ($r = 0.56$, $p = 0.04$).

In our study area the cells occupied by leks varied from a minimum of 10 (1997) to a maximum of 21 (2006) and only one cell hosted leks occupied every year.

Discussion

The results obtained in Mont Avic Natural Park point out the presence of a high percentage of soloists (higher than 50 % of the displaying males), although annual density exceeds 4 males in 100 ha. In the study area annual fluctuations of the entire population are not correlated with the number of cocks in the main lek. For management purposes, when limitations of resources could not allow to study the entire area, an appropriate alternative could be to monitor a sample area of at least 300-400 ha of suitable habitat, instead of monitoring only one lek.

The correlation between density and the number of grid cells occupied by displaying males is probably due to the inconstant use of sites that are not optimal for the species, while there is no evidence of an higher aggregation of males with the increasing of males density.

Acknowledgements

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Biodiversity on avalanche tracks, a case study in the national park "Gesäuse" (Styria, Austria)

Andreas Bohner, Heinz Habeler, Franz Starlinger, Michael Suanjak

Summary

Because there is a conflict between protection of natural processes on the one hand and protection against natural hazards on the other hand, the nature-conservation value of active avalanche tracks was assessed. For this purpose 16 plant stands on three different avalanche tracks in the national park "Gesäuse" (Styria, Austria) were examined.

On the investigated avalanche tracks the soils are very shallow, stony, nutrient-poor, base-rich rendzinas that developed over limestone debris. The sites are steep and mainly east-facing slopes located in the montane belt. Under these conditions, the plant stands are characterized by a high species density. The average number of vascular plant species within a plot size of 20 m² is 71, and the number of bryophyte species is 5. The species-rich plant stands, colourful when in bloom, are dominated by herbs, resulting in a high aesthetic value and an increased diversity of butterflies. The avalanche tracks investigated have a high nature-conservation value because natural ecological processes still happens, leading to near-natural, species-rich ecosystems.

Keywords

species richness, natural disturbance, butterflies, nature-conservation value

Introduction

The protection of natural ecological processes is the basis for a long-term conservation of natural and near-natural ecosystems. In a national park highest priority for nature conservation is therefore protection of natural processes (SCHERZINGER 1990).

Avalanches are not only a natural process and a natural factor of disturbance, but they can also endanger people and cause heavy damage to buildings and infrastructure. From an anthropocentric point of view, protective measures in the form of avalanche barriers are necessary. Avalanche barriers are able to prevent avalanches, leading also to a permanent suppression of the natural dynamics. Hence, there is a conflict between nature conservation on the one hand and protection against natural hazards on the other hand.

For the management in a national park the nature-conservation value of active avalanche tracks has to be assessed. Consequently, the aims of this study were:

recording, documentation, analysis and evaluation of the species composition and species richness of plant stands on active avalanche tracks and

analysis of the importance of natural disturbances by avalanches for biodiversity.

The national park "Gesäuse" is an appropriate study area because of numerous avalanche tracks and frequent avalanche events due to suitable topographical and climatic conditions. Parts of the results, presented in this conference volume, have been developed in the frame of the INTERREG III B project MONITOR.

Methods

Two avalanche tracks on the SE side of the mountain Tamischbachturm near Hieflau (Northern Limestone Alps, Styria, Austria) were investigated. These tracks were selected as study sites because they are two of the largest and most remarkable avalanche tracks in the national park "Gesäuse". In total, 15 permanent plots were established along two altitudinal gradients ranging from 523 to 960 m a.s.l. The tracks are surrounded by mixed spruce-fir-beech forests. An additional permanent plot on a third avalanche track, located on the SE side of the mountain Zinödl, was installed at an altitude of 1451 m a.s.l. The avalanche tracks investigated are devoid of large trees and tall shrubs. There are no avalanche barriers and there is no agricultural land use such as mowing or grazing. All permanent plots have the same plot size of 20 m². At each plot relevès have been done according to the method of Braun-Blanquet. The installation of the plots took place immediately after snow-melting, therefore species richness has not influenced the selection. At the two avalanche tracks on the SE side of the mountain Tamischbachturm also butterfly species and numbers were recorded. Frequency and magnitude of avalanche events are unknown.

Results and Discussion

On the investigated avalanche tracks the soils are very shallow, stony, nutrient-poor, base-rich rendzinas that developed over limestone debris. Soil pH (in a $CaCl_2$-solution) is ranging from 6.2 to 7.3. The sites are steep and mainly east-facing slopes located in the montane belt (523 to 1451 m a.s.l.). Soil water regime is periodically dry (Bohner et al., 2009).

The plant stands investigated belong mainly to *Origano-Calamagrostietum variae*; one stand is classified as *Seslerio-Caricetum sempervirentis*. Both phytocenosis represent near-natural disclimax communities. Range of vegetation cover is between 40 and 90 %.

On the investigated avalanche tracks the plant stands are dominated by CSR strategists, stress-tolerant competitors and competitors; all other life strategy types are insignificant. Moderate stress due to periodically dry, nutrient-poor soils with an excess of Calcium and low intensity of disturbance by avalanches determine species composition. Because of their appearance outside the vegetation period, avalanches damage mainly large trees and tall shrubs. Thus, light-demanding species will benefit from the improved light conditions. The vegetation is characterized by a high species density and evenness value (figure 1 and 2). The average number of vascular plant species within a plot size of 20 m² is 71 (minimum: 58, maximum: 77), and the number of bryophyte species is 5. The plant stands investigated harbour species from different vegetation types and elevation zones, leading to the observed high species richness. In Europe, following Hobohm (2005), plant communities can be viewed as very species-rich, if more than 50 different species of vascular plants, bryophyte species and lichens within an area of 100 m² can be recorded. The plant stands investigated have, on average, a similar species density to semi-natural grasslands dominated by *Narcissus radiiflorus* or *Bromus erectus* in Upper Styria (70 respectively 68 vascular plant species within a plot size of 50 m²). Only plant stands from extensively managed alpine pastures can achieve even higher species densities. On the other hand, in deciduous and coniferous forests plant species density is comparatively lower (figure 1). The species-rich plant stands, colourful when in bloom, are dominated by herbs, resulting in a high aesthetic value and an increased diversity of butterflies. Diversity and abundance of butterflies are much higher than in the surrounding forests. Since 2005, on the two avalanche tracks studied, 501 butterfly species have been recorded. During one night a maximum value of 228 different species was observed.

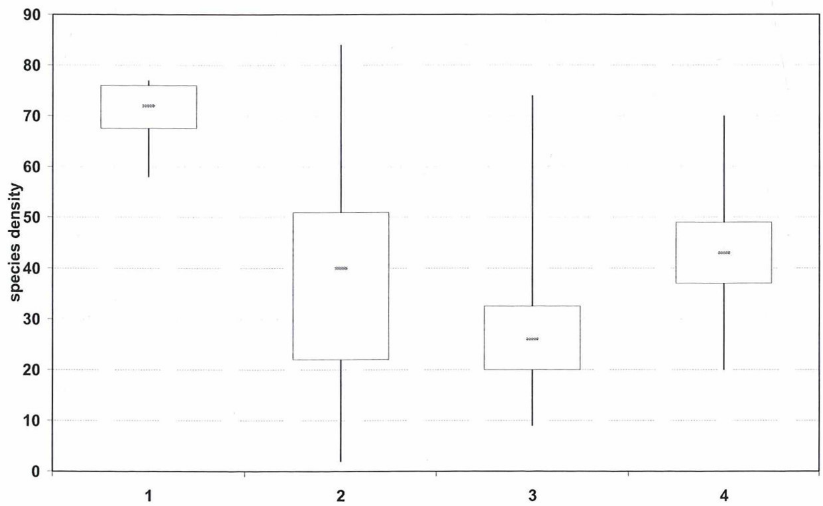

Figure 1: Plant species density (minimum, maximum, median, upper and lower quartile)

1 = plant species density on avalanche tracks (total number of vascular plant species within a plot size of 20 m², 16 relevés); 2 = non-forest areas in the Gesäuse National Park (plot size of 20 m², 145 relevés); 3 = deciduous and coniferous forests adjacent to the Gesäuse National Park (plot size of 300 to 500 m², 123 relevés); 4 = selected grassland communities (extensively and intensively managed grasslands) in Upper Styria, Austria (plot size: 5-100 m², 14 plant communities). See Bohner et al. (2009) for further details.

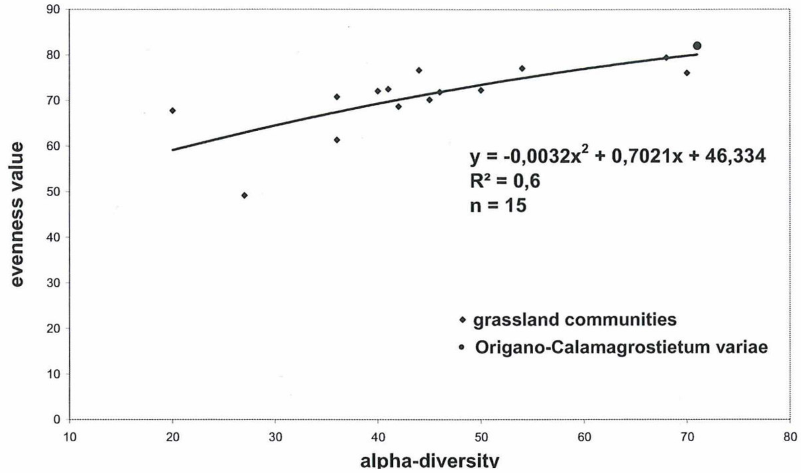

Figure 2: Relationships between alpha-diversity and evenness values of selected grassland communities (extensively and intensively managed grasslands) in Upper Styria plus *Origano-Calamagrostietum variae* (plant stands on avalanche tracks)

Conclusions

Avalanches can be assessed both positive and negative. Seen from a bio-centric point of view, avalanches keep habitates open and species rich in the montane and subalpine belt. The avalanche tracks investigated are most valuable ecosystems from a nature conservation point of view. Disturbances by periodic or occasional avalanche events are the precondition for the existence of these near-natural ecosystems. Hence, the establishment of buildings and infrastructure below these avalanche tracks should be prevented in order to avoid a need for protective measures in the form of avalanche barriers. In the case of permanent suppression of avalanches, natural succession would result in reforestation of the sites, leading to a decrease in biodiversity. Avalanche galleries could be an alternative, because they ensure a protection against avalanches without suppressing natural ecological processes.

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Biosphere Reserves as stimuli for participatory local governance? Conceptual frame and initial results of a research project

Falk F. Borsdorf

Abstract

It's widely agreed that UNESCO Biosphere Reserves aim to provide contexts in which local citizens may participate in decision-making processes. This focus not only forms a central piece of the sustainability concept, but also constitutes a core element of Biosphere Reserve governance according to UNESCO's Seville Strategy of 1995. The MAB-funded research project BIOS PARTIZIP looks at the ways in which local citizens get involved in regional processes and shape local decision-making. The governance arrangement through which locals usually get involved in these processes is "networks". Which networks interact under the umbrella of Biosphere Reserves? Are there any local citizens who try to influence local decision-making processes through regional discourse? How central is their network capital to these processes? These questions pinpoint the project's central assumption: deliberative good local governance practices that meet Seville Strategy requirements need a certain degree of network capital and civic commitment on the part of local citizens. How present and how strong is such behaviour in Biosphere Reserve communities? What are the actions local citizens take when it comes to influencing both regional development processes and patterns of discursive local politics in Biosphere Reserves?

Keywords

regional & local governance in Biosphere Reserves, sustainability, networks, participation, qualitative network analysis

Aims and duration of the project

The central focus of the research project is on governance processes in the Wienerwald (Vienna Woods) Biosphere Reserve, Austria. Like some other Biosphere Reserves, Vienna Woods was established in close inter-communal cooperation between local communities, non-governmental organisations and civil society. This process was participative to the extent that it brought together landowners and communities to get their consent (see Lange 2005). Hence stakeholders from local communities and local associations interacted in such a way as to ensure that a Biosphere Reserve could take hold in the Vienna Woods region (see Lackner & Loiskandl 2007). According to Seville Strategy criteria, this new regional context is supposed to provide locals with an opportunity of participating in regional and local decision-making processes to further the goal of regional sustainability throughout the entire Biosphere Reserve (see Lange 2005; Coy & Weixlbaumer 2007; Köck & Lange 2007; Stoll-Kleemann & Welp 2008). Can we identify patterns of civic engagement and networking with a regional context with the aim of influencing local decision-making processes on the part of local citizens in Biosphere Wienerwald? And if yes: How does this process function? What are the basic components that keep it alive?

Allowing more participation in decision-making processes was one of the central ideas of the 1992 Rio-Conference of UNCED (see Grunwald & Kopfmüller 2006; Baranek & Walk 2005; Brand & Fürst 2002). Future-oriented processes and decisions need the participation of those concerned: the local citizens. To this end, however, Local Agenda 21 initiatives have already and evidently proven successful (see Dangschat 2004). This broader understanding of the sustainability concept was also implemented by UNESCO's *Man and Biosphere Programme.* According to the Seville Strategy, new Biosphere Reserves have to embark upon participative planning, management and decision-making in both the planning and the management aspects of their daily operation (see Stoll-Kleemann & Welp 2008; Coy & Weixlbaumer 2007). Instead of measuring collective involvement in locally institutionalised decision-making processes, the project puts a strong emphasis on voluntary forms of participation: a civic engagement that pinpoints actively involved persons within local communities (see Zimmer 2007). Thus it is assumed that participatory processes in Biosphere Reserves heavily depend upon voluntary support in the frameworks of their constantly changing networks.

The project itself started in November 2008 and receives funding from the Austrian Man and Biosphere Programme for a time-period of two years. It intends to trace central difficulties that Biosphere Reserves as regional settings have to face in the realm of participation requirements. The research project is based on FOUCAULT's (2000) assumption that power is "in the process" and will provide Biosphere Reserve managers, local decision-makers and citizens with pieces of process-oriented advice on how network power and influence on political discourse can be exercised to ensure positive impacts on sustainable development. Furthermore, it cooperates with the large research project "Participation Processes in Biosphere Reserves" to obtain a number of crucial benefits in areas where research focuses overlap. Contributing to scientific discourse, an initial publication and a final report seek to draw together and interpret new pieces knowledge on the topic.

Methods

As far as methods are concerned, the project embarks upon an inductive approach that measures participative and discursive network practices of local citizens - understood as "experts" (see FISCHER 2003) with an entirely participative research design. A first workshop with locals from Tullnerbach focused on perception and role definition within the context of a Biosphere Reserve. What do the participants of this workshop know about this regional context? Have they got into contact with the Biosphere Reserve? How do they perceive their role within this new context? And how does this role fit with the roles they take on in their daily routines? A short research questionnaire completed this first round of the survey. Building on the knowledge gathered in this first round, the second workshop will try to steer and measure the networking of the locals involved. This workshop will be subjected to evaluation, too. Taken together, both workshops focus on a qualitative process analysis of participation that consists of participative workshops with local citizens of the chosen Wienerwald-community Tullnerbach. In addition, guided interviews with a number of regional stakeholders from Rhön and Entlebuch Biosphere Reserves will complete the field study and enrich it with a comparative perspective. It is expected that a hypothesis can be derived from the field study. A Delphi survey with Vienna Woods Biosphere Reserve locals will then review the validity of the hypothesis. All in all, the central target of this deliberative research design is raising information on local citizens' discourse and networking activities and the extent to which this influences local politics.

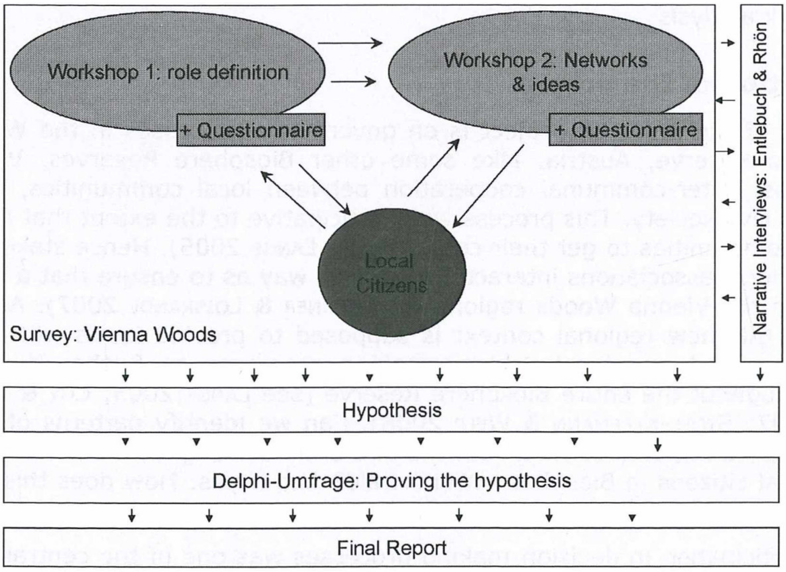

Figure 1: The Methodological Setting

Initial results

As data from the first round suggests, civic engagement that links with the Biosphere Reserve and seeks to influence local politics clearly exists. A central obstacle to becoming more deeply involved in this process is the clearly identifiable lack of information on the part of locals. Nevertheless, local residents tend to see the Biosphere Reserve as an opportunity for deepening civic engagement in their communities. Thus some citizens came up with new ideas for their commune, too.

Discussion

At present, there is some evidence to suggest that locals can significantly influence local politics through getting involved in regional sustainability networks such as Biosphere Reserves. It remains the central targets of this research project to find out why and how that is the case.

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Participative research to develop integrated approaches for a sustainable wildlife management in the Biosphere Reserve Wienerwald

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Keywords

biosphere reserve, conflicts, conflict management, participation, participatory research, decision processes, visitor monitoring, protected area management, sustainable use, wildlife management

Competing interests and conflicting goals between different land use demands, the habitat requirements of wild animals and objectives of a protected area management often cause considerable conflict potentials and conflicts, which may threaten both, conservation and sustainable use of nature and the sustainability of each involved land use sector. While the resulting need for conflict management poses a challenge to the management of any nature protection area, it is particularly pressing in Biosphere Reserves, which have to balance the following three in some cases competing functions: nature conservation, sustainable regional development, as well as education, research and monitoring.

Biosphere Reserves are characterised by a comparatively weak regulatory management regime. Successful resolution and management of conflicts in Biosphere Reserves must therefore rely strongly on stakeholder participation in order to identify conflict potentials and to achieve acceptance of management measures and active commitment to their implementation.

Within the research project "ISWI-MAB Integrated Sustainable Wildlife Management in the Wienerwald Biosphere Reserve" funded by the MaB Program of the Austrian Academy of Science (REIMOSER et al. 2008) a participatory and collaborative research approach (c.f. CORNWALL A. & JEWKES, R., 1995) involving the main land use sectors (forestry, agriculture, recreation, hunting, nature conservation), which influence wildlife resources, was applied to analyse the different levels of conflicts between land use and wildlife, and to develop tools for integrated sustainable wildlife management and land use.

The Biosphere Reserve Wienerwald is a forest-dominated landscape in the proximity of the urban agglomeration of Vienna and it is characterised by high biodiversity richness and high conservation value, but also by a variety of different land use interests. Besides agriculture and forestry, the area is characterised by strong pressures from settlements, infrastructure development and recreation. Due to the manifold overlaps and interactions in a multiple-used landscape, a variety of conflict situations threaten conservation and sustainable use of native wildlife populations and their habitats. The responses of wildlife to these impacts frequently cause multiple feedback mechanisms, retroacting in turn on the land uses within the wildlife habitat. Thus, wildlife itself and many other land uses are connected by an interwoven system of dynamic interdependencies and interactions.

The objectives of the research project were to analyse the interactions between wildlife and sectoral land uses, to identify and evaluate interrelationships that are critical to the regional sustainable development, as well as to develop cross-sectoral approaches to the integration of wildlife management and other major regional land uses into a sustainable regional land use system. Therefore the project used a participatory process that included the following three major stages of participation (Umweltbundesamt, 2006): (i) information, (ii) consultation and (iii) collaboration.

One of the first steps of the research project was the identification of regional stakeholders relevant to the project objectives. Building on existent Biosphere Reserve-related consultancy fora, a multi-sectoral and interdisciplinary stakeholder platform composed of representatives of different forms of land uses (recreation, forestry, agriculture, nature conservation, hunting etc.), land owners, local politicians, members of regional authorities, NGOs, and interested members of the local public was established (fig. 1).

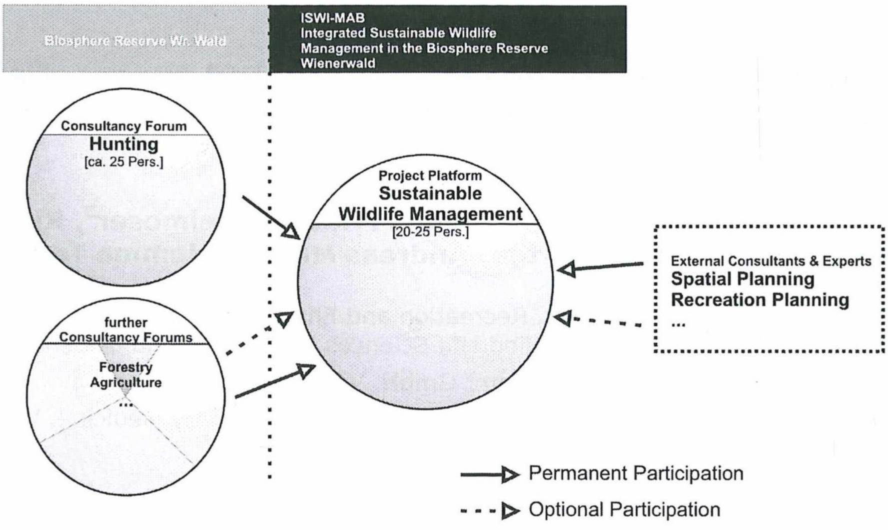

Figure 1: Organisation of the participation panel

The stakeholder panel contributed knowledge about existing conflict potentials and conflicts and provided support to identify relevant experts. Regular meetings of the participation panel had a key role in reviewing and discussing interim and final results and proved crucial to securing applicability of research results and meeting user requirements.

Different socio-empirical techniques were applied to gather further in-depth information on wildlife related interactions and conflicts. Using a structured interview guide, a series of in-depth face-to-face expert interviews with sectoral and local experts was conducted in order to gain insight in key issues related to inter-sectoral land use conflicts and to identify key visitor and land user groups.

For the identified key groups (hikers, mountain bikers, equestrians, forest managers and forest owners, farmers), group-specific questionnaires consisting of both closed multiple choice questions and open questions were developed. Depending on the user group, the questionnaires were delivered using different modes of survey: targeted mail survey, internet survey and on site visitor interviews. 1330 questionnaires were analysed by diverse statistical methods. Beside others in-depth information of frequencies and motivations of visitations, the spatial and temporal distributions and the adherences of management rules were gained. But the main findings were that interviewed actors were not aware of the whole range of troubles they caused carrying out their activities and that a lot of conflicts between the different land user groups were based on different cultural approaches and preconceptions.

Based on the outcomes gained from the stakeholder panel, expert interviews and land user surveys, tools for assessment and monitoring of sustainable use and guidelines for management had been developed and tested by key stakeholders. Main results included operational frameworks of integrated sustainable wildlife management, designed as self-evaluation tools for the investigated land user groups (forestry, agriculture, hunting and recreation management) to evaluate their own influences on sustainable wildlife management.

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Insights from 50 years of research in natural forest dynamics in Switzerland

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Summary

Thirty-seven forest reserves distributed over different vegetation belts of Switzerland have been studied since 1955 to gain a better understanding of forest succession in unmanaged forests. The reserves were founded between 1910 and 1979, but timber harvesting had usually ceased earlier. Reserve size ranges from 0.6 ha to 245 ha. The research method combined periodical measurements of individual trees (diameter at 1.3 m height ≥ 4 cm) on 299 permanent plots (size 0.1-3.5 ha), and full callipering in forest compartments (size 2-8 ha). The number of inventories ranges from 1 to 7, with a median of 3.

Several trends are consistently found in most reserves: a) an increase in basal area and growing stock; b) a decrease in stem number; c) an increase in the number of large trees, and d) a reduction of tree species richness, particularly in deciduous forests. In the reserves studied, only few disturbances occurred. In natural forest succession, these trends would be expected in early- to mid-successional stages ('optimal phase', or 'stem exclusion' to 'understory reinitiation' stages). This is in line with the stand history of many of the reserves which originate from early successional stands.

In 2006, the research program in reserves was refocused. The methods were adapted to meet information needs regarding dead wood and habitat structures such as tree hollows and broken crowns. First results show highly variable amounts of dead wood and densities of habitat structures. Continuous monitoring will reveal whether the trends found so far hold in the long term.

Keywords

Forest reserves, Switzerland, permanent plot, stand structure, habitat structures

Introduction

The value of old-growth, natural or unmanaged forests was increasingly recognized in the last 100 years. The Scatlè reserve in the Grisons, which was assigned a protected status in 1907, was the first forest to be spared on purpose from management in Switzerland. Today, the official goal of Swiss policy is to assign full protection to 5% of the forest area, and management for conservation to another 5%.

Conservation NGO's and scientists had an important role in the establishment of forest reserves in Switzerland. From 1948 to 1982, the chair of silviculture at ETH (Zurich) established contractual agreements about new reserves with >30 forest owners, and conducted research about forest dynamics using repeated forest inventories until 2006. The goal of this research was to understand the structural development of forests in the absence of silvicultural management, and was intended to contribute to close-to-nature silviculture in managed forests, i.e. a management type which uses natural processes as much as possible to reach management goals (Leibundgut 1959, 1962). In this paper, we present selected results this long-term research.

Methods

The research network consisted of thirty-seven forest reserves distributed over different vegetation belts of Switzerland (Fig. 1). Reserve size ranges from 0.6 ha to 245 ha. The research method combined periodical measurements of individual trees ($d_{1.3}$≥4 cm, $d_{1.3}$ = diameter at 1.3 m height) on 299 permanent plots (size 0.1-3.5 ha), and full callipering of all trees in forest compartments (size 2-8 ha). A more detailed description of the methods can be found in Leibundgut (1959) and Institut für Waldbau (1962). The interval between inventories was mostly 10 years. The number of inventories in each plot/compartment ranges from 1 to 7, with a median of 3.

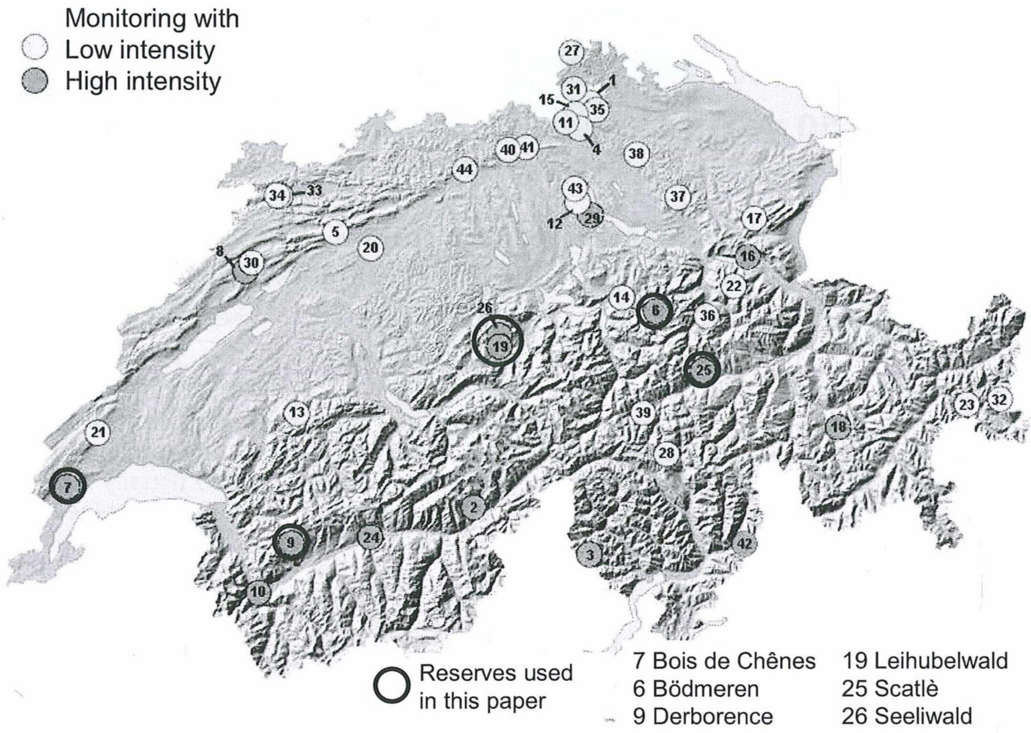

Figure 1: Current network of total forest reserves with monitoring managed by WSL and ETH. The network includes part of the 37 reserves maintained by ETH until 2006. The reserves from which data is used in this paper are shown in

The descriptive data analysis presented in this paper focuses on the six reserves Bois de Chênes, Leihubelwald, Derborence, Scatlè, Bödmeren and Seeliwald (Table 1), with 2 to 11 permanent plots. Plot size ranged from 0.23 to 3.47 ha. The parameters used are the basal area (G, cross-sectional area of all tree stems at 1.3 m height), stem number, tree species richness, and the number of large trees ($d_{1.3} \geq 60$ cm). Rates of change were calculated by using parameter differences between the first and the last inventory available, and dividing them by the time period between these inventories.

Table 1: Site information for the investigated forest reserves.

	Bödmeren	Scatlè	Derborence	Bois de Chênes	Seeliwald	Leihubelwald
Year of establishment of reserve	1971	1910	1956	1969	1972	1972
Forest area in reserve [ha]	5.0	9.1	22.3	83.0	78.6	23.8
Number of permanent plots used / total area [ha]	4 / 4.88	2 / 6.36	2 / 0.98	10 / 7.07	8 / 7.21	11 / 0.99
Altitude [m a.s.l.]	1500	1600-2000	1440-1660	510-570	1355-1550	1080-1270
Mean annual temperature [°C]	3.7	3.6	4.6	8.5	4.0	6.0
Annual precipitation sum [mm]	2300	1550	1490	1200	2000	1770
Aspect		E	NW		NW	E
Geology	Limestone (karstic)	Verrucano	Limestone	Moraines	Flysch	Flysch
Inventory campaigns	1973 1988 2003	1965 1977 1989 2006	1955 1967 1981/82 1990/91	1970/74 1984 1994 2007	1973 1984/85 1996	1973 1983 1995

Results

Several trends were consistent in most permanent plots: a) an increase in basal area; b) a decrease in stem number; c) an increase in the number of large trees, and d) a reduction of tree species richness, particularly in deciduous forests.

Basal area increased by 0.15 ± 0.02 m^2/ha and year (mean ± standard error of mean), while stem number decreased by -9.90 ± 0.12/ha and year. This pattern was found in most permanent plots (Fig. 2). Decrease in stem number was higher in more productive sites (Bois de Chênes, Leihubelwald, Derborence), with means between -15 and -19/ha and year, than in subalpine sites (Bödmeren, Scatlè, Seeliwald), with means between +1 and -3/ha and year. Increase in basal area was also relatively high in two productive reserves (Bois de Chênes and Leihubelwald with means of +0.22 and +0.20 m^2/ha and year, but also in the Seeliwald reserve with 0.18 m^2/ha and year. In the other two reserves, changes in basal area varied from -0.01 to +0.03 m^2/ha and year.

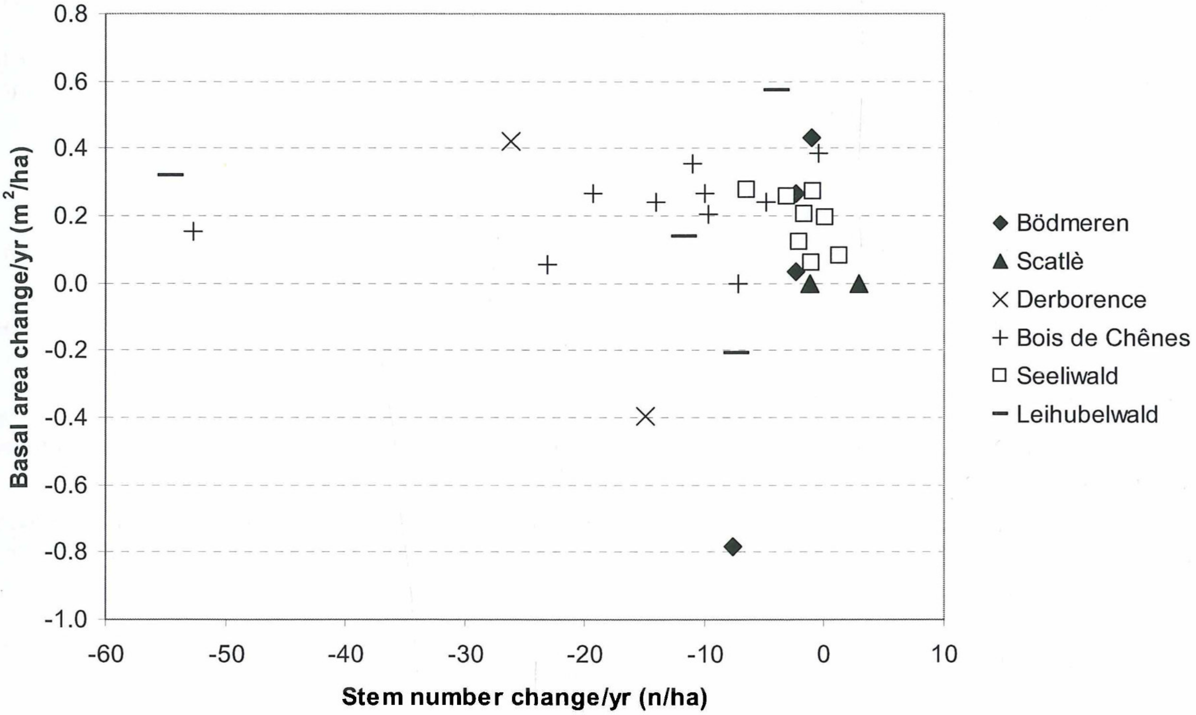

Figure 2: Annual changes in basal area and stem number in 30 permanent plots in Swiss forest reserves. Lower callipering limit for stems was 4.0 cm.

The number of large trees ($d_{1.3} \geq 60$ cm) increased on average by 0.36 ± 0.03/ha and year, with a miniumum of -0.11/ha and year (Derborence) and a maximum of 0.87/ha and year (Leihubelwald).

The number of tree species on each permanent plot varied from 2 to 30. Overall change amounted to -0.046/year. In *Picea abies* forests (Bödmeren and Scatlè), tree species richness remained stable, but decreased by as much as -0.120/ha and year in the lowland forest of Bois de Chênes. Permanent plots in the other reserves had changes between +0.014 and -0.022 species/year.

Discussion

The trends in stand structural attributes found on 30 permanent plots during time periods of 22 to 41 years are in line with what would be expected in early- to mid-successional stages ('optimal phase', LEIBUNDGUT 1982, or 'stem exclusion' to 'understory reinitiation' stages, PICKETT & WHITE 1985): Basal area and the number or large trees increased, and stem numbers increased on average and on most plots. Moreover, the growing stock is in most permanent plots below the levels known from studies in eastern European old-growth forests (KORPEL' 1995). The tree species richness decreased, in particular in shade-intolerant species (HEIRI et al. in press), which suggests that species promoted by former management are increasingly shaded out in the absence of disturbance. Disturbances were rare so far in the permanent plots. In the sample presented here, they occurred in Derborence (several plots, but partly after the last inventory), Bödmeren (one plot) and Leihubelwald (one plot).

The data have only partly been exploited for scientific questions. We are currently checking if the patterns presented in this paper hold for data from all permanent plots and compartments, and analyzing the differential behavior of tree species (HEIRI et al. in press) and tree mortality (WUNDER et al. 2007), as process creating dead wood.

The monitoring methods originating from the 1950s need to be completed to provide answers to current questions. Therefore, we refocused the research program in reserves in 2006, for instance to include an assessment of dead wood and habitat structures such as tree hollows and broken crowns (BRANG et al. 2008), as indicators for organismic diversity. The direct assessment of this diversity seemed, in a countrywide monitoring project with limited resources, unfeasible. Meanwhile, the value of the original data from increases with each inventory.

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Monitoring approach for forest reserves in Switzerland

**Peter Brang, Lukas Rohrer, Brigitte Commarmot, Raphaela Tinner
Harald Bugmann**

Summary

The monitoring in Swiss forest reserves has recently been relaunched based on a Swiss-wide consistent concept. It is intended to provide federal authorities with the basis for controlling in the field of the Swiss forest reserve policy and to enhance the scientific understanding of forest succession without human intervention. The monitoring encompasses forest structure, including dead wood, and tree characteristics that are important as habitat for organisms such as stem cavities with a mulm body, stem cracks and root plates. It should enable a characterization of natural forests in widespread phyto-sociological communities, e.g. those dominated by *Picea abies or Fagus sylvatica*. It combines surveys on 100 ha of permanent plots, which are 0.1 to 3.3 ha large, with an inventory on about 1400 sampling plots, similar to those used in the Swiss and other national forest inventories. In small reserves, a full callipering at the compartment level replaces the sampling inventory. Terrestrial repeat photography is used for documentation purposes. A monitoring of species richness of birds, fungi and insects was originally envisaged, but not implemented due to financial constraints. The monitoring takes place in 15 forest reserves with an intensive and in 29 reserves with an extensive observation program. 33 reserves that have been studied for 20 to 50 years play an important role in the reserve network, as they already enable an analysis of long-term trends in forest succession.

Keywords:

Forest reserves, Switzerland, permanent plot, stand structure, habitat structures, monitoring

Introduction

In Switzerland, systematic monitoring of natural forest dynamics started with Hans Leibundgut, professor for silviculture at ETH Zurich from 1941 to 1979, who created many strict forest reserves for scientific purposes. Since a revision of the federal forest law in 1991, the Swiss Confederation supports the establishment of forest reserves in the context of its forest biodiversity strategy. The federal goal is that 10% of the forest area is declared as nature reserve before 2030, half of it being strict forest reserves which are not subject to any form of human intervention. The effectiveness of this policy shall be evaluated by monitoring. In 2006, WSL was tasked by the Federal Office for the Environment with the elaboration of a monitoring concept for Swiss natural forest reserves in collaboration with ETH Zurich.

Monitoring approach

The main objectives of the monitoring in strict forest reserves are to follow the development from managed to natural forest and to quantify differences in forest dynamics and biodiversity-related structures between forest reserves and managed forests (Brang et al 2008). The monitoring should also increase the scientific understanding of natural forest succession and contribute to environmental education. It focuses on the processes regeneration, competition, ageing, mortality and decomposition, and on habitat structures such as stem cracks and cavities.

The monitoring concept should meet the following requirements: It should be scientifically sound and compatible to similar monitoring programs in Switzerland and abroad, in particular to the Swiss National Forest Inventory and to the existing reserve research by ETH. It should be non-destructive, feasible (payable and workable) in the long term and applicable by different teams and other institutions. Moreover, it should provide results for the most important forest types (vegetation belts) in Switzerland.

The concept elaborated by WSL and ETH is modularly organized. The basic modules include

- a documentation of basic information (maps, ownership, contracts, site conditions, history, information on flora and fauna etc.)

an inventory of forest and habitat structures

a comparison with managed forests

time series photographs and

an event register, in which disturbances or special observations are noted.

A direct monitoring of biodiversity components such as fungi, xylobiontic insects or birds is impossible with the financial means available. Therefore only the assessment of biodiversity-related structures on trees is included in the basic modules. Additional biodiversity modules might be developed together with the respective specialists when required.

The former monitoring of the ETH was mainly based on (subjectively selected) permanent plots of usually 0.1 to 3.5 ha size, in which all living and standing dead trees with a minimum diameter (dbh) of 4 cm were numbered and measured periodically. Additionally, a full inventory (measurement of dbh by species) was carried out in some reserves on a compartment level (2-8 ha). The new concept combines measurements on permanent monitoring plots with a sampling inventory using a systematic grid. Full inventories are continued in small reserves < 30 ha. Permanent plots are best suited to study the spatial relationship and interactions between individual trees and different tree species, whereas the inventory by sample plots provides representative results for a certain area or stratum.

The monitoring concept envisages two intensities of monitoring, which differ in plot number and in the number of time series photographs (Table 1). The intensive monitoring provides representative results for a forest reserve. Extensive monitoring in additional reserves with similar site conditions helps to generalize the findings for each vegetation type. Up to now, 15 reserves have been selected for intensive and 29 for extensive monitoring (see Figure 1 in BRANG et al. 2009, this volume). The total area of permanent plots will be 100 ha, the number of sampling plots about 1400.

Table 1: Planned average number of observation units according to monitoring intensity.

Method	Intensive monitoring	Extensive monitoring
Permanent plots	5	1
Plots in sampling inventory	60-140	20-40
Time series photographs	10	3

The monitoring method for the permanent plots is compatible with the method used in reserve research by ETH (1948-2006) and also with the assessments on the long-term growth and yield research plots of WSL. Thus, many existing long-term data series will be continued. In addition to the previous measurements on permanent plots, the coordinates of the trees will be recorded, lying deadwood will be assessed (full inventory without coordinates) and, in some plots, a sampling of regeneration smaller than 4 cm in dbh is planned.

The method for the sampling inventory is similar to the Swiss national forest inventory. The sample plots consist of two concentric circles of 200 m^2 and 500 m^2 (Figure 1). In the inner circle all trees with a minimum dbh of 7 cm are measured, in the outer circle only trees with 36 cm dbh and larger. Habitat structures are recorded on all trees with a minimum dbh of 7 cm. They include dead wood in the tree crown, crown break, stem break, cracks in the stem, bark lesion, cavities at the tree base with decomposed wood, woodpecker and other stem cavities (Figure 2), polypores and root plates. Snags with a minimum dbh of 36 cm and living trees with a minimum dbh of 80 cm are also considered as habitat structures. The volume and quality of lying deadwood is assessed on line transects (3 transects of 15 m length per plot). Regeneration is recorded on a subplot of 2 or 20 m^2 according to its density.

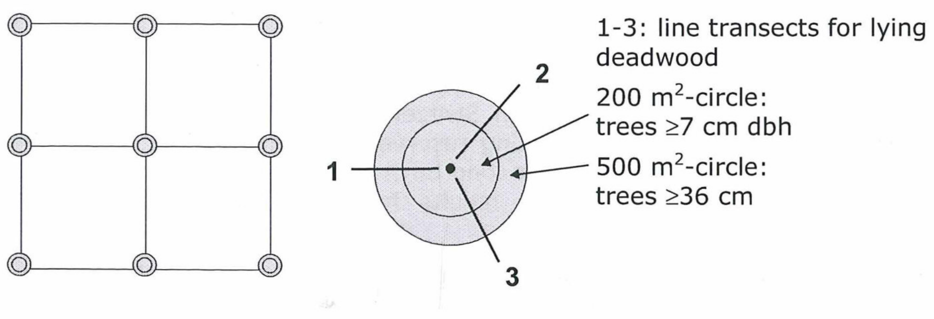
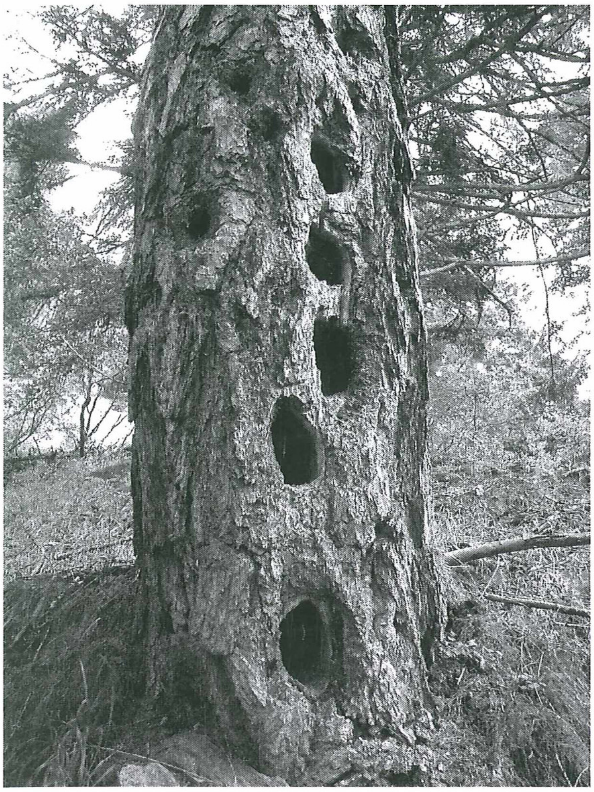


Figure 1: Sampling design for Swiss natural forest reserves



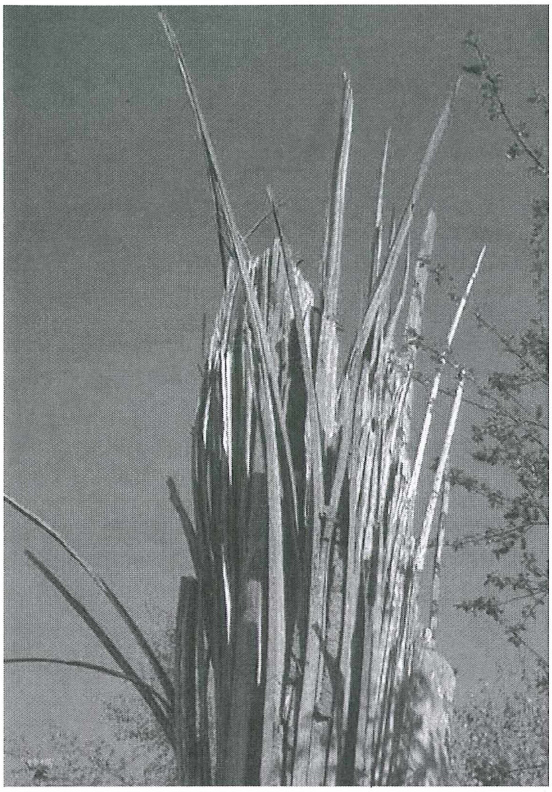


Figure 2: Examples of habitat structures: stem cavities (left) and broken and splintered stem (right).

A detailed description of the methods and the assessed attributes is underway. The data are recorded using FieldMap® software and stored in an ORACLE® database. All information required to understand the sampling is carefully archived to ensure that we and future generations are able to analyze all the gathered data.

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Scenarios for adapting the high Alpine trail network to landscape modifications due to climate change

Florian Braun, Andreas Muhar, Markus Fiebig

Abstract

The paper presents an approach to identify the need for action to adapt the high Alpine trail network to consequences of climate change. Landscape and tourism scenarios were developed for three sections of the Austrian Alps (Glocknergruppe, Venedigergruppe, Ötztaler Alpen). In five workshops these scenarios were discussed with regional stakeholders, who are concerned with summer mountain tourism in the study areas. Facing the ongoing glacier retreat and permafrost degradation, a change of the trail concepts as a whole might be necessary in some high Alpine regions.

Keywords

mountain tourism, climate change, glacier retreat, mountain hazards, trail network

Introduction and aims

The Alpine trail network is the infrastructural basis for summer mountain tourism (hiking, mountaineering) in a mountainous country such as Austria. Landscape modifications resulting from climate change (e.g. glacier retreat, permafrost degradation) affect the accessibility and usability of the trails and of the terrain in high mountain areas, often causing considerable risk for mountaineers (Fig. 1 and 2; see also Behm et al. 2006; Schwörer 2002). The quality of the trail network is a decisive factor for the safety and appeal of summer mountain tourism. Alpine associations work hard to tackle problems once they become acute. Preventive activities on a large scale are not possible since the Alpine associations do not have enough funds and voluntary workers available. The future situation of problematic areas cannot be modelled precisely. Nevertheless general strategic considerations are crucial to facilitate future planning and development of the high Alpine trail network.

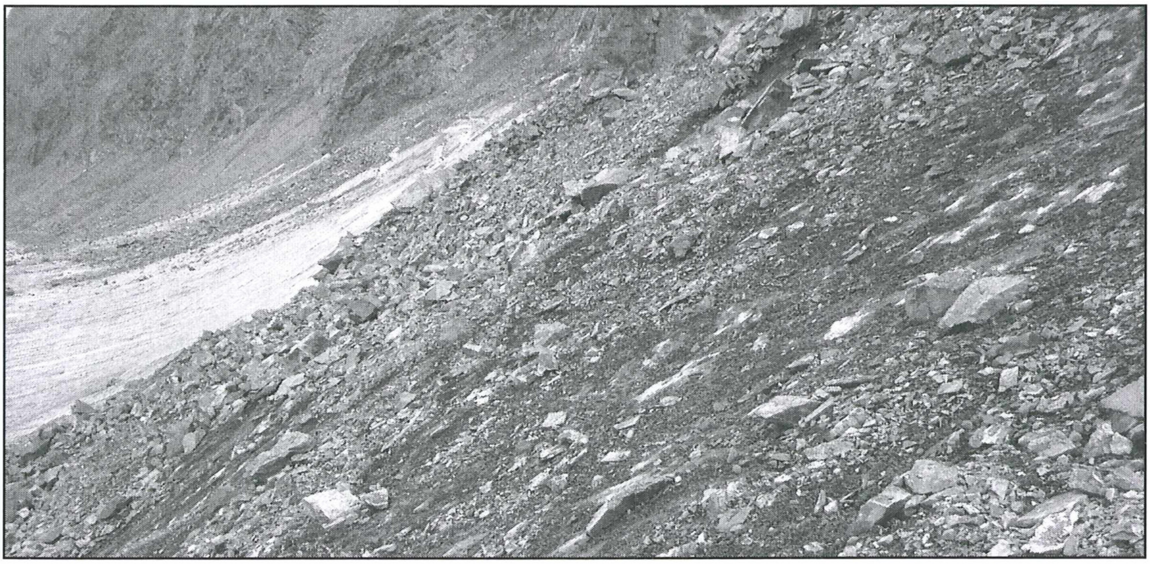

Figure 1: Due to debris-fall and glacier retreat a steep debris-covered ice slope has developed at the margin of a glacier. To reach the summit of Lisener Ferner Kogel mountaineers have to cross this dangerous terrain. Lisener Ferner, Stubaier Alpen (Photo: F. Braun)

Figure 2: Along the route to Piz Buin a retreating glacier uncovered steep rock walls. Fixed ropes are now necessary to climb the route. Ten years ago mountaineers just went up on a snow slope. Wiesbadener Grätle, Silvretta (Photo: F. Braun)

Our approach follows the principles of transdisciplinary research with the goal of integrating scientific knowledge and the experiential knowledge of the case actors (BALSIGER 2004). The practical implementation is conducted in the three most heavily glaciated sections of the Austrian Alps: Glocknergruppe, Venedigergruppe and Ötztaler Alpen. In the context of this paper the term "high Alpine trail network" refers to the marked trail network as well as to frequently used routes across and around glaciers.

Methods

To provide a foundation for the discussion with the stakeholders (e.g. Alpine Clubs, mountain guides, national park management, local tourist boards) we developed landscape scenarios, based on hiking maps (1: 25.000) of the three study areas. Using text boxes and special signatures the scenarios describe possible effects of landscape modifications on the trail network during the next 30 years (Fig. 3). The landscape scenarios are based on the knowledge of current effects on the trail network related to climate change, which have been collected by field mapping and expert interviews. Most of the analyses for developing the scenarios were realised in GIS-software. Main input data were digital elevation models, orthophotos and hiking maps. The expected glacier retreat and the permafrost distribution were both implemented by simplified empirical models.

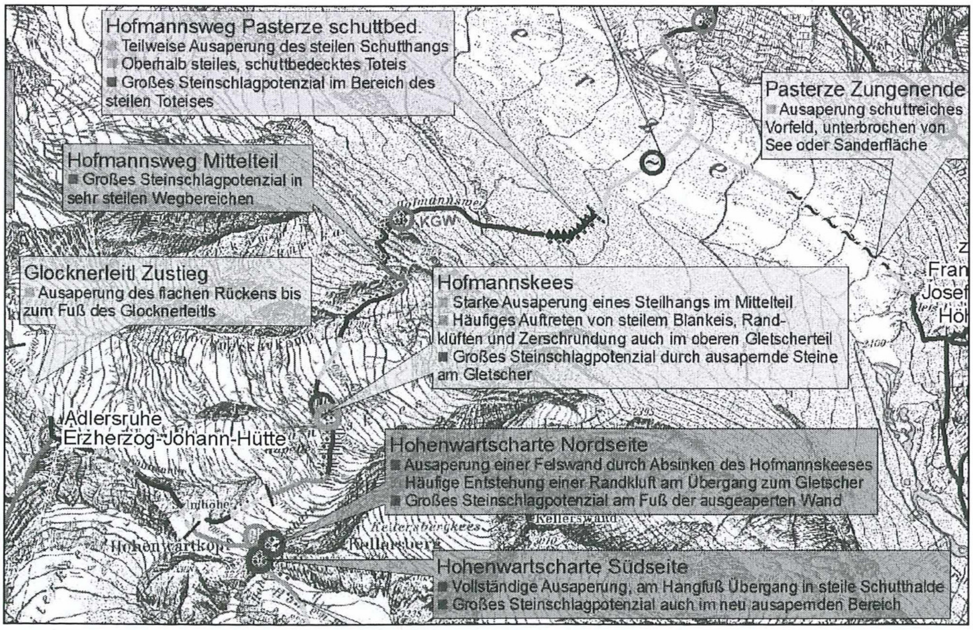

Figure 3: Detail of the scenario map in the surrounding of Großglockner (in German; Background: Alpine Club Hiking Map Glocknergruppe, 2006)

Complementary we developed three tourism scenarios, which are short narratives about the situation of summer mountain tourism in 2040, using a simplified system analysis and scenario planning approach according to SCHOLZ and TIETJE (2002). The tourism scenarios should provide a discussion basis and confront the stakeholders with partly unusual ideas about possible developments of the high Alpine trail network:

In the first tourism scenario "Classical Mountaineering" the stakeholders try to maintain all existing high Alpine huts and trails. To handle the increasing effort all relevant stakeholders cooperate intensely concerning the management of the trail network. Nevertheless the quality of the trail network decreases in some areas due to problems related to glacier retreat and permafrost degradation.

The second scenario is named "Wellness-Hiking" and describes a situation where the stakeholders abandon problematic and little used high Alpine huts and trails. As a consequence, for most tourists some high Alpine areas become accessible only with special training or with guides. In return the Alpine clubs use their now available capacities to upgrade the hiking trail network and the huts in lower areas and at more suited sites.

In the third scenario "High Alpine Adventure" the stakeholders abandon problematic and little used huts and trails similar to the situation in the second scenario. In return suited sites are provided with infrastructure for adventure- and fun-activities. Problematic routes across glaciers are avoided by the construction of new via ferratas (fixed rope routes) leading to high Alpine summits along rock ridges.

Results and discussion

The landscape scenarios show that the potential of routes for being affected by climate change varies considerably. Some routes seem to be very vulnerable, whereas others might not change heavily during the next decades. Of course the scenarios cannot model the detailed future development of single spots, but they are suited to transport a picture of the expected effects on the trail network in the study areas as a whole.

In five workshops the landscape and tourism scenarios were discussed with regional stakeholders representing organisations concerned with summer mountain tourism in the study areas. Most stakeholders evaluated the landscape scenarios either as being realistic or as underestimating the effects of climate change on the trail network until 2040. Discussing the tourism scenarios and the resulting need for action they concluded that an intensive cooperation of all relevant stakeholders will be essential for the solution of the upcoming problems. Facing the ongoing glacier retreat and permafrost degradation, the problems during the next decades cannot be solved just by continuing the current activities. A change of the trail concept as a whole might be necessary in some high Alpine regions. In this context both local and supra-regional needs and surrounding conditions have to be considered.

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Spatial and Temporal Changes in the Morphology of an Alpine Braidplain Characterised by High Resolution Digital Survey

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Abstract

Alpine meltwater streams are characterised by highly variable river flows (both seasonal and diurnal) and large rates of sediment movement. This results in a highly dynamic river environment where channels are constantly shifting position and sediment erosion and deposition are spatially very variable. These characteristiocs have important implications for the management of Alpine river systems which are harnessed for hydro electric power production due to the need for sediment management structures and potentail danage to infrastructure. It is therefore important to characterise the timescales over which these processes operate in order to assess overall rates of sediment transfer and the stability of the channel network. However, the rapid and highly variable nature of Alpine rivers requires frequent, high resolution topographic data to capture this information. In this paper we describe preliminary results from measurements of the changing structure of the Odenwinkelkees Glacier braidplain (Austria). We use a combination of techniques including catchment-scale LiDAR survey; reach-based terrestrial laser scanning (TLS) and local differential GPS topographic survey to capture the variability in alpine channel morphology. In 2008 detailed surveys of the braidplain were undertaken at the start of July and in late August. Results are used to illustrate changes in the pattern of the channel network; the characteristic styles of sedimentation and rates of sediment transfer. Together they form baseline data for use in runoff and sediment routing models which can be used to predict the future impacts of changes in runoff and sediment supply on the river systems.

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A long version will be provided on the website www.hohetauern.at/symposium2009 after the conference.

Multi-scale modelling of spatial variations in perceived wildness in the Hohe Tauern and Cairngorm National Parks

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Abstract

A multi-scale approach to mapping variations in perceived wildness based on application of GIS and Mutli-Criteria Evaluation (MCE) methods is described. Public surveys are used to inform the model about the impacts of four attributes on perceived wildness of the landscape. These include: a) perceived naturalness of the land cover; b) absence of modern human artefacts; c) rugged and challenging natural of the terrain; and d) remoteness from mechanised access. These are combined using a MCE model and weights derived from public opinion surveys to derive maps of spatial variability in perceived wilderness quality. Results from the application of this method to the Cairngorm National Park in northeast Scotland are described and used to inform a re-application of the method to the Hohe Tauern National Park using local data and results from opinion surveys based on a sample of visitors to the Rudolfshutte/Weissee area in 2008/2009. Maps of perceived wildness are compared to the zoning system developed for the Hohe Tauern National Park. Models are up-scaled using to map perceived wildness across the whole of the park. Conclusions are drawn on how perceived wildness may be used in a decision support capacity in managing visitor experience and development. Comparisions are made between the two parks in terms of topography, settlement and landuse patterns, with a view to explaining differences in IUCN Catgeory.

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Protected areas: reservoir of cryptic biodiversity.

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Protected areas are key sites for promoting long-term species conservation and to study biodiversity and evolution of species outside human pressure. In such areas, biodiversity and density of some species can reach extremely high values due to the fact that ecosystems evolved naturally for years (i.e. butterflies, PASCHE et al. 2007). Therefore, these areas also offer a high opportunity to collect and to detect cryptic species. In most biodiversity studies as well as in monitoring projects, correct taxonomic assessment is a fundamental prerequisite to understand, manage and preserve the natural world, especially in the face of the actual biodiversity crisis. Nevertheless, cryptic species, which are morphologically hardly distinguishable (BICKFORD et al. 2007), represent a major challenge to assess correct species identification and a potential bias in biodiversity surveys and conservation plans. We present below an example related to our long-term studies on red wood ants within the Swiss National Park.

Mound building red wood ants (species of the *Formica rufa* group) belong to one of the most studied groups of ants in Europe (see COTTI 1963, 1995, 1996; CHERIX et al. 2006). Red wood ant species - so called because of their reddish and brown coloration and because of their preference for forested habitats have fundamental roles and positive effects in forest ecosystems of the northern hemisphere: they reduce the density of pest species and other invertebrates of the forest floor thanks to their super-predator behaviour (PAVAN 1959, 1981); they are major seed disperser and improve soil aeration processes, favouring plant colonization and growth; they modify their habitat by hunting many other invertebrates and by structuring ant communities (SAVOLAINEN & VEPSÄLÄINEN 1988; SAVOLAINEN et al. 1989); they cultivate and protect honeydew-producing homopterans, which benefit to other species like honeybees (WELLENSTEIN 1960); they are key component of the diet of other animals like the European brown bear (GROSSE et al. 2003); their nests provide an excellent habitat for numerous other species (LAAKSO & SETALA 1997, 1998); they take part to nutrient cycles, like phosphorus and carbon mineralization, by stimulating the transformation of soil organic matter (DOMISCH et al. 2008); they increase soil heterogeneity and are crucial to the functioning of forest ecosystems (JURGENSEN et al. 2008). Therefore, red wood ants are considered among the most promising species in forest ecosystems monitoring (GÖSSWALD 1990). Because of their importance, these species are protected by law in many European countries (GÖSSWALD 1989), including Switzerland (*Loi fédérale du 1er juillet 1966 sur la protection de la nature et du paysage, modifiée le 19 juin 2000*). However, despite this protection, some species are included on the red list of threatened species edited by the International Union for Conservation of Nature (IUCN) (WELLS et al. 1983; AGOSTI 1994; HILTON-TAYLOR 2000) and on the red list of some particular countries like Switzerland (AGOSTI & CHERIX 1994).

One good example of key site for biodiversity studies is the Swiss National Park (SNP), Created in 1914, the SNP is a strict nature reserve (Category Ia IUCN) located in the east of Switzerland in Engadin Valley, Canton of Grisons. It is the largest natural reserve in Switzerland and, until now, its unique national park. It covers a surface of 172,4 km2, from which 100 km2 are forests and alpine and subalpine meadows. It is crossed by 80 km of trails, which are the only accessible places. The SNP and its surrounding area is probably one of the most suitable places for studying red wood ants in Switzerland and in the Alps. All red wood ant species are present within this region and these ants are indeed very abundant within the Park with a density of 1.8 nest/ha in forested habitat (CHERIX et al. 2007). In addition, the Park offers the unique opportunity to study the evolution of red wood ant populations in unmanaged forests.

Our researches showed that the recently described new species of wood ant (*Formica paralugubris* SEIFERT 1996) was found to be also present within the SNP. In addition, a multidisciplinary approach (based on molecular, chemical and behavioural analyses) on red wood ants revealed the existence of an unknown cryptic species in the same area. To date this species has never been observed outside this region. This could indicate that the SNP is either the last refugium or a focus point for a new colonization. These results are of great interest for biodiversity and at the same time for the conservation of these ants.

Our works also highlighted that other potential cryptic species could be hidden in the alpine region and further studies would be useful to verify our hypotheses. Species of the *F. rufa* group should be particularly analyzed in the alpine region. Some authors have indeed highlighted the existence of scattered ice-free areas located within the Alps or at their periphery during the last glacial maximum. In particular, high levels of endemism have been found in the southern, southeastern, easternmost and northeastern Alps (TRIBSCH 2004). Numerous alpine plant and animal species persisted and developed independently in these refugia, which are now seen as centres of alpine species diversity and endemism (STEHLIK 2000; STEHLIK 2003; TRIBSCH 2004; SCHÖNSWETTER et al. 2005; LATALOWA & VAN DER KNAAP 2006; HAUBRICH & SCHMITT 2007; PARISOD & BESNARD 2007; PARISOD 2008; TOLLEFSRUD et al. 2008). Considering this particular situation and thanks to technical advances, more cryptic species of red wood ants might be discovered in alpine valleys in the future.

Therefore, multidisciplinary approach of supposed well-known groups of invertebrates can improve our knowledge of local biodiversity, giving new insights for management of alpine protected areas.

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The attraction of rivers in protected areas for people in search of recreation

Sybille Chiari, Susanne Muhar, Andreas Muhar

Summary

The objective of this paper is to describe in which way recreational use patterns along three alpine rivers (River Enns, River Lech, River Drau) are influenced by the biophysical setting of the rivers and their floodplains. The results show that highest use frequencies were found at close-to-nature stretches being part of a National Park or Nature Park, followed by restored river stretches. Obviously these river stretches provide better opportunities for recreational activities, whereas a lack of similar opportunities was diagnosed on regulated river stretches. From an ecological point of view, use concentration at ecologically valuable stretches is likely to cause adverse effects for endangered species like gravel-breeding birds. One approach to enhance both ecological and social functions of rivers is to counteract the spatial limitation rivers are currently confronted with, e.g. through further restoration efforts on degraded stretches. This could contribute to relieve the strain on close-to-nature stretches in protected areas in the long term.

Keywords

river management, river recreation, use patterns, use conflicts

In Austria only about 20% of the larger rivers are left having a high or good habitat quality (MUHAR, 2000). These stretches are not only a valuable refuge for threatened species but are also very attractive for recreational use (INGOLD & BLANKENHORN, 2005). This poses the managerial challenge of combining both ecological and social functions under limited spatial conditions as they are given in a densely populated country such as Austria.

From an ecological perspective, evaluating possible adverse effects that might be caused by river recreation is rather difficult, as there is hardly any data available on use frequencies and distribution (REICHHOLF, 1999; STETTMER & HINTERSTOISSER, 2001). To start filling this gap is one of the objectives of the project "Future options for the development of riverine landscapes – space requirements for multifunctionality" conducted in the framework of the Doctoral School Sustainable Development at BOKU University Vienna.

On-site data collection was carried out along three alpine gravel-bed rivers - River Enns, River Lech and River Drau which are characterised by a wide range of protection statuses and river based recreation opportunities (Fig. 1).

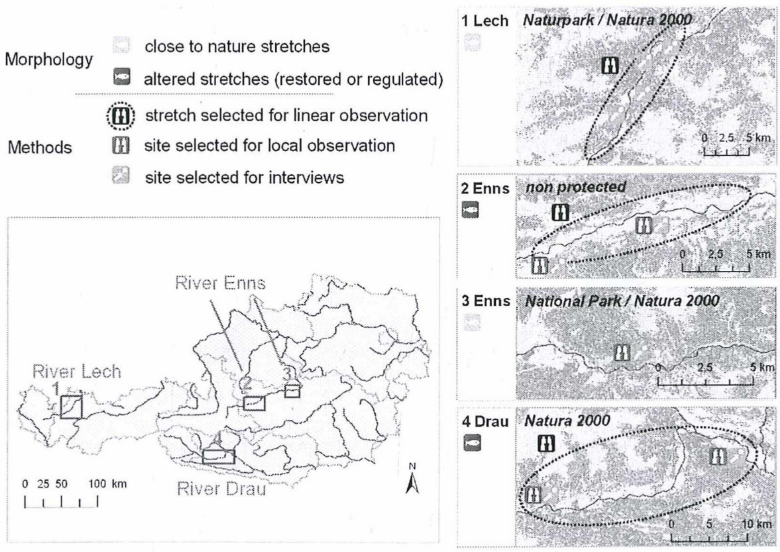

Figure 1: Location and protection status of study sites

To assess interactions between ecological and social functions a multi-method approach was applied. The territories of gravel breeding birds (*Acitits hypoleucos, Charadrius dubius*) were mapped, since they were chosen as indicators to evaluate use consequences from an ecological perspective (FRÜHAUF & DVORAK, 1996). To gain insights into social issues such as recreation use motives, behaviour and distribution, quantitative and qualitative methods were combined, including observations and interviews (CESSFORD & MUHAR, 2003). Concerning data on users' behaviour, observations were carried out at two different scales. At the local scale data was generated by observing recreational usage from fixed points e.g. at gravel banks. In addition to that, data generated by linear observation should help to identify use patterns. This was done by canoeing down selected river stretches (length ranging from 16km to 45km) and documenting spatially explicit the usage observed within these stretches. This method cannot be applied under difficult white water conditions and was therefore not used in the National Park Gesäuse. To learn more about users' motives and preferences a survey using semi-standardised questionnaires was carried out. The sites selected for local observations also served as interview locations.

In order to analyse in which way the biophysical settings influences the attitude and behaviour of river-based recreationists, data were allocated to two groups depending on whether the site's morphology was close-to-nature or altered (Fig. 1). All sites that were found to be close-to-nature were situated in protected areas such as National Park or Nature Park.

A range of differences concerning the motives for river recreation was found between users at close-to-nature sites and those at altered sites (Fig. 1-Fig. 5). The awareness for biophysical issues seems to be higher at close-to-nature sites, where more than 50% of the interviewees stated that nature observation was a very important motive for their stay at the river. Another finding was that three correlating issues adventure, sports and exploring new areas had a significantly higher meaning for users interviewed at close-to-nature sites (level of significance 0,01).

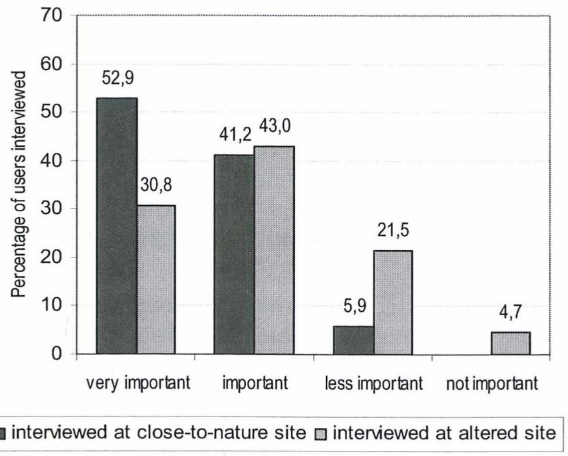

Figure 2: „Observing Nature" as motive for river recreation (n=247)

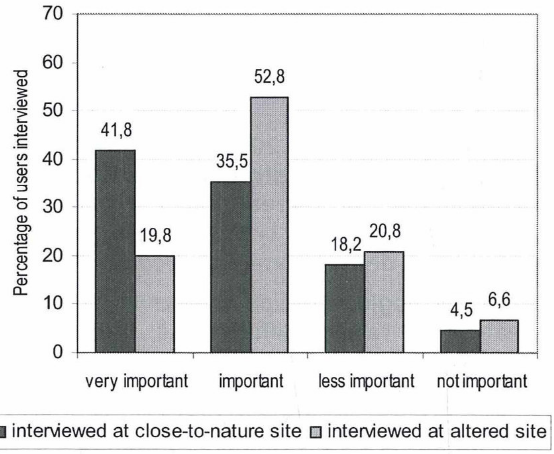

Figure 3: „Sport" as motive for river recreation (n=247)

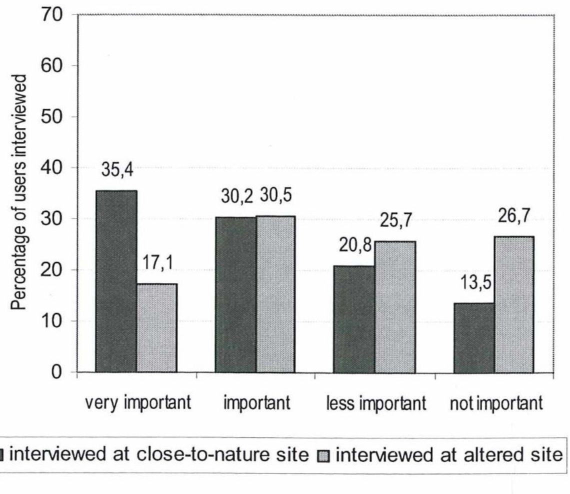

Figure 4: „Exploring a new area" as motive for river recreation (n=247)

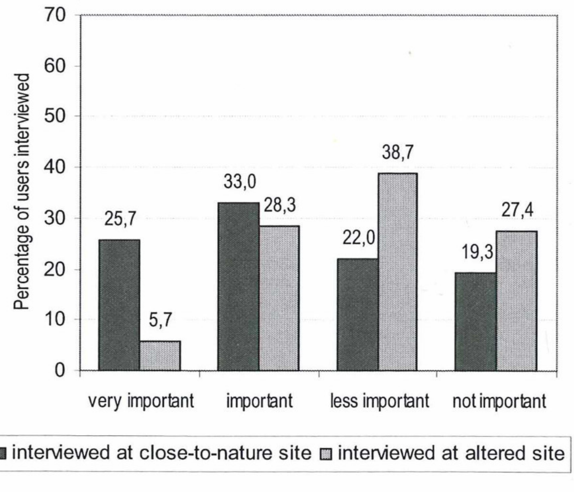

Figure 5: „Adventure" as motive for river recreation (n=247)

Regarding the results of local observation, use frequency at close-to-nature sites was in average three times higher than at altered sites (Fig. 6). This concentration of use at local sites in protected areas can also be seen as an intended effect achieved through guiding measures by the area's management. Results from linear observation substantiate close-to nature-stretches and restored sites to be most attractive for recreational use.

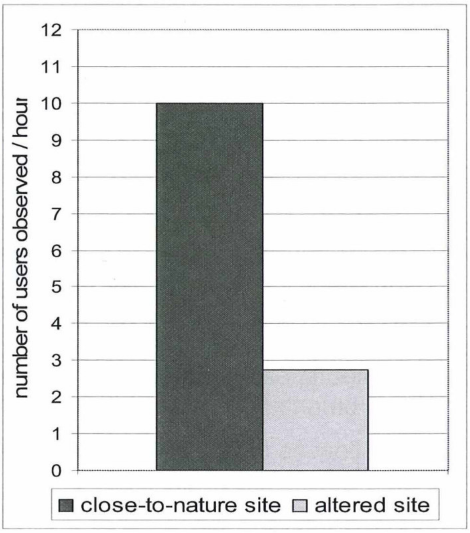

Figure 6: Local observation: use frequency

As long as close-to-nature and restored stretches are spatially in a rather limited condition, use concentration on these stretches is likely to cause adverse ecological effects, as these stretches represent the only habitat available for endangered species like gravel-breeding birds.

This overlap between the ecological value and the recreational appeal could be affirmed by the results of this study showing the need for accurate proactive management strategies.

One approach to improve both the recreational usability and the ecological functionality would be to foster further restoration efforts on degraded river stretches, counteracting the spatially limited situation and helping that way to relieve the strain on protected areas and other valuable sites in the long term.

Acknowledgments

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Promotion of Nature Tourism in protected area in southern Val d' Hérens (Switzerland)

Giovanni Danielli

The "Association des Communes du Val d'Hérens" placed an order to the Institute for Tourism Economy Lucerne (ITW) to carry out a research project on the increase of touristic value of points of attraction in the upper Val d'Hérens. The order contained a representation of the current landscape specialities and of the currently existing touristic points of attraction in Val d'Hérens such as Pyramides d'Euseigne, Vallon de Borgne, Vallon de Réchy, Grande Dixence, Ferpècle and Arolla. As a second step potential future ways of touristic use should be shown for the mentioned points of attraction and ideas for an increase of value creation should be shortly described.

The upper Val d'Hérens has several areas of national as well as of international importance.

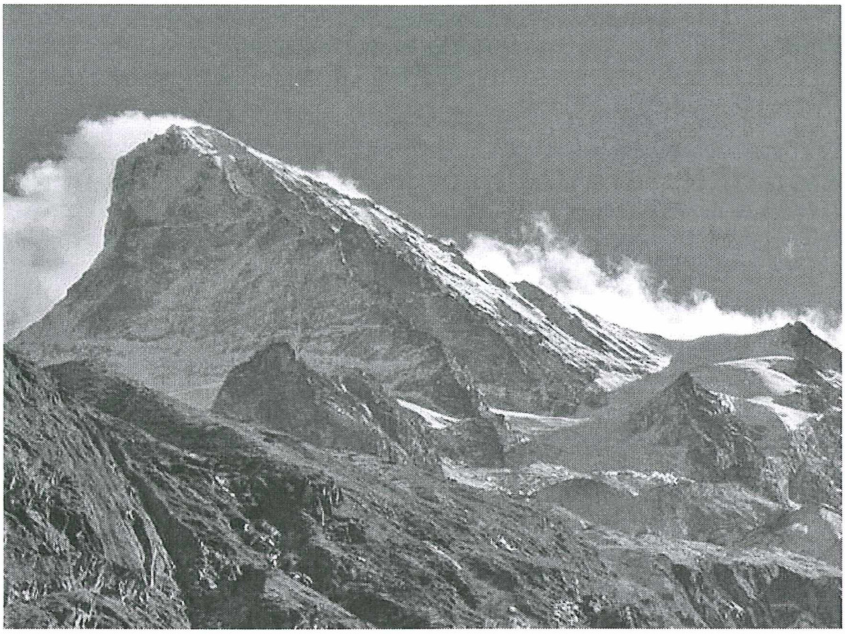
Overall assessment of the points of attraction

	Inventories of the Confederacy BLN	Inventories of the Confederacy Moors/ Floodplains	Geolog. particularities	Distinctive mountain top, glacier, etc.	Tour. Equipment	Unique character	Importance
Pyramides d'Euseigne	3	1	3	2	1	3	National importance
Vallon de Borgne	1	3	2	2	1	2	Regional importance
Vallon de Réchy	3	3	4	1	1	3	National importance
Grande Dixence	2	3	2	2	2	3	National as well as international importance
Ferpècle	4	3	4	4	1	4	International importance
Arolla	2	3	3	3	3	3	National importance

Table 1: Evaluation: 1= minor importance, 2=medium importance, 3= high importance, 4= extraordinary importance

Hereafter the description of ideas for a better marketing of the points of attraction will be shown on the example of Ferpècle.

The area of the Ferpècle basin is part of the Confederacy Inventory of landscapes and natural monuments of national importance (BLN) Nr. 1707 "Dent Blanche-Matterhorn-Monte Rosa." A regional park is being planned. It is a very beautiful and internationally known landscape with huge glaciers. The region gives good indications about the formation of the Penninic Alps. Furthermore there are different states of moraines as contemporary witnesses of the glacial and historical landscape development and a typical high alpine flora and fauna with unspoilt and well preserved Swiss stone pine woods. Partly there is also still a traditional alpine agriculture.



Picture 1: The Ferpècle gorge contains an extraordinary high mountain landscape with the predominant Dent Blanche (4354 m) ("White tooth")

The history of both the **Glacier de Ferpècle** and the **Glacier du Mont Miné** are highly interesting. The development of both glaciers can be traced back through the last 3000 years without any interruption. In 1850 the Glacier de Ferpècle reached down until 1800 meters of altitude. Since then both glaciers retracted, and in 1957 the glacier snouts have separated. In the rear basin of Ferpècle parts of a roman road across the **Col d'Hérens** can still be clearly seen.

The shelter Bricola, the retaining wall, a picnic place and the information panel of the Grand Dixence about the water distribution network are of touristic interest. Furthermore, the valley is remarkable for its native character and because it is free from touristic or other infrastructure. All in all, this is a rather disadvantageous initial position for the creation of value.

But considerung the high landscape value of the valley and the more intensive positioning of natural tourism, the untouched character of the landscape is of central importance and of high value. When being exploited more intensely, this untouched character of the valley should remain in the focus. Ferpècle is a counterpoint to the other regions of the Val d'Hérens where settlements and touristic exploitation has made a big progress partially even up to critical dimensions. This „equalisation zone" must be maintained and protected under all circumstances. Nevertheless the tourism shall and will make use of the valley.

Tourism must be made possible with a priority on keeping the valley intact as a natural beauty. The aim is to position tourism in a very careful way in accordance with nature. In respect for the natural conditions no durably installed buildings shall be made. The valley shall still be reached by pedestrians only, using the retaining wall as a starting point.

<u>Glacier park</u>

The glacier world is the centre of the valley. It can be experienced by the majority of tourists as close as hardly anywhere else in the Val d'Hérens. The concept plans a glacier park, which should not be understood as a "park" in the traditional sense of the word, despite its name. In fact the plain between the reservoir and the glacier of the **Mont Miné** should be a zone where the most interesting and instructing aspects of the glaciers are shown, explained and experienced.

Possible ideas could be:

- Glacier retraction and glacier thickness throughout past centuries (Panel with indication of years)
- Types of glaciers
- Structure of a glacier
- Growing and retracting processes
- Glacier and climate
- The situation in which the glaciers Mont Miné and Ferpècle joined

- Various glacier types such as hanging glacier and forms such as moraine types made visible on the area
- Importance of local glaciers for the water balance system and the reservoir Barrage Grande Dixence
- Glaciers and dangers

Furthermore general information about alpine security could be integrated such as:

- Alpine dangers
- Adequate behaviour in the mountains and on glaciers
- Correct communication of accidents/ alpine emergency signal
- Chart of avalanche dangers
- Evaluation measures prior to a mountain hike

Reactivation of the Cabane Bricola and generation of new all-inclusive offers

The beauty of the valley is most visible in the daytime but it is not limited to it. The experience of changing light conditions in the evening and early in the morning can be communicated specifically. In order to make this possible, it should be checked if the lodging proposition of the Cabane Bricola can be reactivated. If this is possible new and attractive all-inclusive-offers could be created. As a working title, a name such as „Magical glacier night" could be chosen. This title includes an all-inclusive-offer which could contain the following elements:

- Guided walking tour, starting from **La Forclaz** through the glacier plain
- Expert explanations about local mountain and glacier world under consideration of the "Glacier park"
- A Fondue or Raclette dinner on site
- Experiencing of nightfall and wonders of nature amongst others

Conclusions

The tourism economy is very important for the Val d'Hérens. The Val d'Hérens is unable to propose market-relevant special USPs up to now. The existing touristic facilities are to be judged as rather mediocre. There are good exemplary businesses, but then they are scarce. Today's tourist offer is based on a small structured development with a peak in the period from 1975 until 1995. Many tourist offers have grown superannuated and need renewal, and with this goes the need for investment.

The central strengths of the area are natural landscapes and some aspects of the cultural landscapes. But then some of these values are threatened by urban sprawl and by the loss of traditional appearance of the localities. As a first step, the future tourism development needs a clear tourism strategy by the tourism organisations, communities and lead businesses, and performance-related mandates tuned on each other. Local structures must be optimised in order to fulfil future duties in the sense of a common development and tourism strategy. Concepts for development, financing, realisation and marketing must be integrated in the strategic long term orientations.

The authors advise a twofold tourism strategy based on mass tourism for the winter sport business (especially for the northern part of the valley) and nature tourism in summer as well as partially in the southern areas also in winter. Nature tourism should be based on the strengths mentioned above and on projects that are already launched. The currently existing points of attractions should be marketed in a better way. The opening of a regional nature park is the best way to take into account all the aspects of current and future tourism, existing structures and various exploitations in Val d'Hérens. The regional nature park can constitute the primary structure for the touristic development steps. It can be used for orientation. Furthermore it also provides some liberties, as for example the definition of the park perimeter, main content and economic scope of design in order to realise common or individual strategies without jeopardising the overall positioning.

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Spatio-Temporal Dynamics of the Odenwinkelkees Glacier Proglacial River Ecosystem

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Abstract

Alpine stream systems provide unique habitats for riverine biota as a result of their dynamic flow, water temperature and suspended sediment regimes. Understanding how these spatio-temporal physicochemical variations influence macroinvertebrate communities could provide insights into how alpine lotic ecosystems are likely to respond to climate change or other more direct human influences (abstraction/regulation). However, detailed year-round data sets are rare for alpine stream systems, yet such knowledge is clearly a prerequisite to obtaining a holistic understanding of how these ecosystems function. This paper reports findings from year-round data collection (2008-2009) at the Odenwinkelkees Glacier braidplain, Austrian Alps. Analysis of physicochemical data revealed high heterogeneity of flow regimes, water temperature and turbidity both spatially (reach to basin-scale) and temporally. For example the average discharge and turbidity were lower for predominantly groundwater-fed sites compared with meltwater-fed channels but water temperature was higher. This heterogeneity appears to play a key 'filtering' role underpinning spatio-temporal patterns of benthic macroinvertebrates. Gaining a better understanding of alpine stream biodiversity is essential to underpin conservation and management of these unique ecosystems.

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Habitat use and activity patterns of red deer (*Cervus elaphus*) – consequences for Wildlife Ecological Spatial Planning (WESP) in the national park "Hohe Tauern", Austria

Andreas Duscher, Friedrich Reimoser, Ferdinand Lainer

Summary

Conform to national park requirements, a red deer management concept was developed and established in a region of the national park "Hohe Tauern" (Austria) since 1999. With the experience of the originally large-scale Wildlife Ecological Spatial Planning (WESP) for the province of Salzburg the regional management was refined up. The consequences of different management measures were consistently monitored using different field methods including GPS collars. The results serve the adaptive management. The instrument of WESP did work in the study area. With our data we underline the importance of (i) large scale concepts for deer management and culling strategies (harmonizing national park and surrounding areas), and (ii) adequate resting areas (in terms of size, distribution, and habitat quality). Supplementary feeding during winter, as a technical crutch temporary on certain places, can help to manage and control populations in small areas to minimize the negative impact on the vegetation, if other management tools are not feasible.

Keywords

Red deer, national park, management, spatial planning

Aims and duration

Wildlife Ecological Spatial Planning (WESP) is an instrument for integrative wildlife and habitat management based on ecological and socio-economic principles (Reimoser, 1999). It comprises a large-scale spatial planning framework with regard to wildlife populations (population areas, sub-population regions, different management zones, monitoring system), and a detailed regional planning, that can be further adapted to specific local conditions. All zoning is to be understood as a dynamic process (adaptive management). With the experience of the originally large-scale concepted WESP a sustainable wildlife management in the national park should be developed and established.

Area of study

The study area was located in the hunting territory "Koetschach-Valley", in the eastern part of the national park "Hohe Tauern" near the village of Bad Gastein in the province Salzburg (Austria). The valley is running from SE to NW at an elevation from 1,280m to 1,080m above sea level. It is surrounded by mountains up to 3,000m. From the total hunting area of 3.878 ha, 2.557 ha (66%) were national park core zone, 738 ha (19%) buffer zone and the rest of 583 ha (15%) were regular hunting ground outside the national park.

Methods

Since 1999 we established annual red deer counts in the model area of the national park and in the surrounding areas relevant for red deer management. The census was done annually on the same spot at about the same time. Three mid-summer census areas were in high altitudes and one winter area was at a supplementary feeding station in the valley. In addition to the counts we started a GPS telemetry project in 2003 to get a better insight in the spatial migration and the seasonal activity of red deer.

Results

The results from our counting areas showed a more or less stable red deer stock at the feeding station during winter. In the first half of the project we counted a mean of 108 individuals, at the second half we counted a mean of 115 individuals. Deer numbers of neighboring feeding stations showed also a stable red deer stock. In summer, in the open areas of the altitudes significant more red deer became visible in the second part of the project (see figure 1) when these areas were more and more known by the animals as resting areas without relevant disturbance. No matter which half of the project was chosen, the sum of the summer areas did not match with the respective means of the winter area. The results of the telemetry project showed a strong migration from the winter areas to the specific summer ranges.

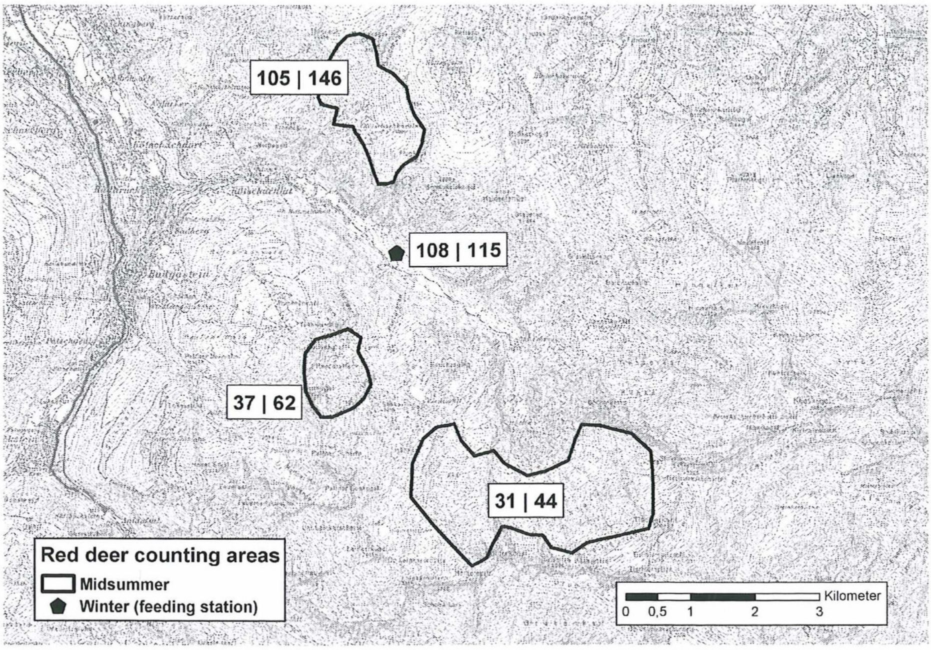

Figure 1: Mean values of annual red deer counts summer and winter. Figures on the left = mean of first 4 project years, figures on the right = mean of the second 4 project years.

Discussion

The results show the importance of considering the respective red deer population area as suggested in WESP for better and sustainable management actions. Only a part of the summer red deer stock is present in the study area in winter as well. The additional "summer" individuals immigrate from neighboring regions. So our counting results strengthen a large scale basis for management actions.

The existing summer areas are located above the treeline and provide the primary natural habitat for these large herbivores. During the project duration no culling activities were taken in these areas so the disturbance by human influence was kept at a very low level. This led to less shy individuals and a better visibility (increasing numbers). All culling activities were done highly efficient in special designed space and time dependant regulation areas like the wildlife management zoning in WESP. It also underlines the importance of quiet resting areas for red deer. With this zoning the negative impact on the vegetation can be kept at a very low level.

Also important for this low level of game damage is the supplementary feeding station. The deer migrated within a short time frame from the station to their summer ranges and vice versa. This kept the length of stay in possible susceptible forest to game damage as short as possible. In this case, professional supplementary feeding was used as a tool to steer and control the population.

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Impact of supplementary feeding on winter home range size and activity patterns of female red deer (*Cervus elaphus*) in alpine regions

Andreas Duscher, Flurin Filli, Friedrich Reimoser, Ferdinand Lainer

Summary

From 2003 to 2007 we collared and tracked six red deer hinds with GPS-GSM collars in our 4.000 hectare study area at the Nationalpark "Hohe Tauern", Salzburg (Austria). We wanted to get a better insight to the seasonal deer migration from their winter to the summer ranges. A supplementary feeding station was run close to the border of the national park core area from November to April. Former observations suggested an exchange between the feeding station in winter and some specific open, treeless areas in high altitudes in summer. The collars were additionally equipped with activity sensors and so we drew a fine scaled picture of the habitat use in this alpine area and the activity patterns of deer during day, month and year.

The results showed that there was a strong deer migration from winter (feeding station) to specific summer ranges. The individual winter home range size (Dec. – Feb.) varied from 5 to 340 hectares, the deer were strongly bonded to the feeding station (altitude 1160 m). During the summer months (especially when they are hot and dry) the deer were trekking to habitats in high altitudes up to 2500 meters. In the Austrian study area the size of the individual summer home ranges (June – August) varied from 130 to 790 hectares. In the Swiss national park (without supplementary feeding) we got a remarkable different picture of habitat range. In winter the individual Minimum Convex Polygon (MCP) varied from 150 to 8990 hectares. In summer the MCP varied from 170 to 5350 hectares.

The main activity phases of the deer during the summer months were strongly linked to sunrise and sunset. In both populations (with and without supplementary feeding) the activity increased rapidly within a few days at mid April. In the Austrian population the activity maximum was reached in mid June, minimum at the end of December. During the winter months their daily activity was at a very low level except the phases of feeding through the local hunters. In the Swiss population the maximum was reached at beginning of June, the minimum at beginning of January.

Keywords

Red deer, GPS collars, activity, spatial use, supplementary feeding

Aims and duration

Results of a former long time running management project in our Austrian research area suggested an exchange between a supplementary feeding station in winter and treeless areas in high altitudes in summer. To optimize management strategies according to IUCN Guidelines (see poster "Managing red deer populations according to the IUCN requirements in the national park Hohe Tauern, Austria") we started the telemetry project to get better insight into the seasonal deer migration from their winter to the summer ranges. Within this project we focused especially on the effects of the 4 to 6 months lasting supplementary feeding on the spatial use and the activity patterns of female red deer.

The presented results refer to the first part of the telemetry project from 2003 until 2008, the second part of the project is still running.

Area of study

The Austrian study-area is located in the eastern part of the national park Hohe Tauern near the village of Bad Gastein. All collaring was done at in the "Koetschach-Valley", which is running from southeast to northwest at an elevation from 1,280m to 1,080m above sea level. The valley is surrounded by mountains up to 3,000m. A supplementary feeding station is run by local hunters near the border to the core area of the national park.

The Swiss data were collected in Il Fuorn in the Swiss National Park. The elevation runs from 1,400m to about 3,200m above sea level.

Methods

We used GPS-GSM collars from Vectronic Aerospace, Germany. The collars were equipped with a GPS device, a GSM module, a temperature logger and an activity sensor. The GPS schedule was set every three hours and after seven positions have been recorded the data was sent via SMS to the base station. The sent text file included date, time, longitude, latitude, height, temperature of the collar and several parameters describing the accuracy of the GPS position. Inaccurate GPS positions were filtered out (ADRADOS et al. 2003).

The activity sensor consisted of a two dimensional acceleration sensor and measured the acceleration every eight seconds. So only the physical activity was measured. The mean of five minutes was recorded and stored on board. This led to 288 values per day. To send this amount of values in text file via SMS was too energy and time consuming. So the activity data had to be retrieved directly from the collar via a link manager. The GPS data were processed with ArcGis 9.3 from Esri, the activity data were processed with Microsoft Excel. All collaring in Austria was done at the supplementary feeding station in the Kötschach valley.

Results

Up to now we collared six female red deer from 2003 to 2008 in Austria. We were able to retrieve several collars and renew them. Thus three females could be collared over more than one year. From three collars we could read out activity data so far.

The results of the GPS data showed a strong deer migration from the feeding station (winter) to the high altitude summer ranges and vice versa (see figure 1). Depending on the climate conditions (especially snow cover) the feeding started in November or December and lasted until the end of April. The deer were strongly bonded to the feeding station particularly from January until March. The individual minimum area of the calculated Minimum Convex Polygon in winter (December till February) was 5 to 340 hectares (Table 1). In April red deer started to explore areas aside of the feeding station where the snow has retreated. These are especially meadows at the bottom of the valley. The main migration to the high elevated alpine meadows took place in May. From June to September the deer stayed in the high regions. In summer (June till August) the calculated Minimum Convex Polygon reached 130 to 790 hectares. The deer started to migrate to the feeding station in October again.

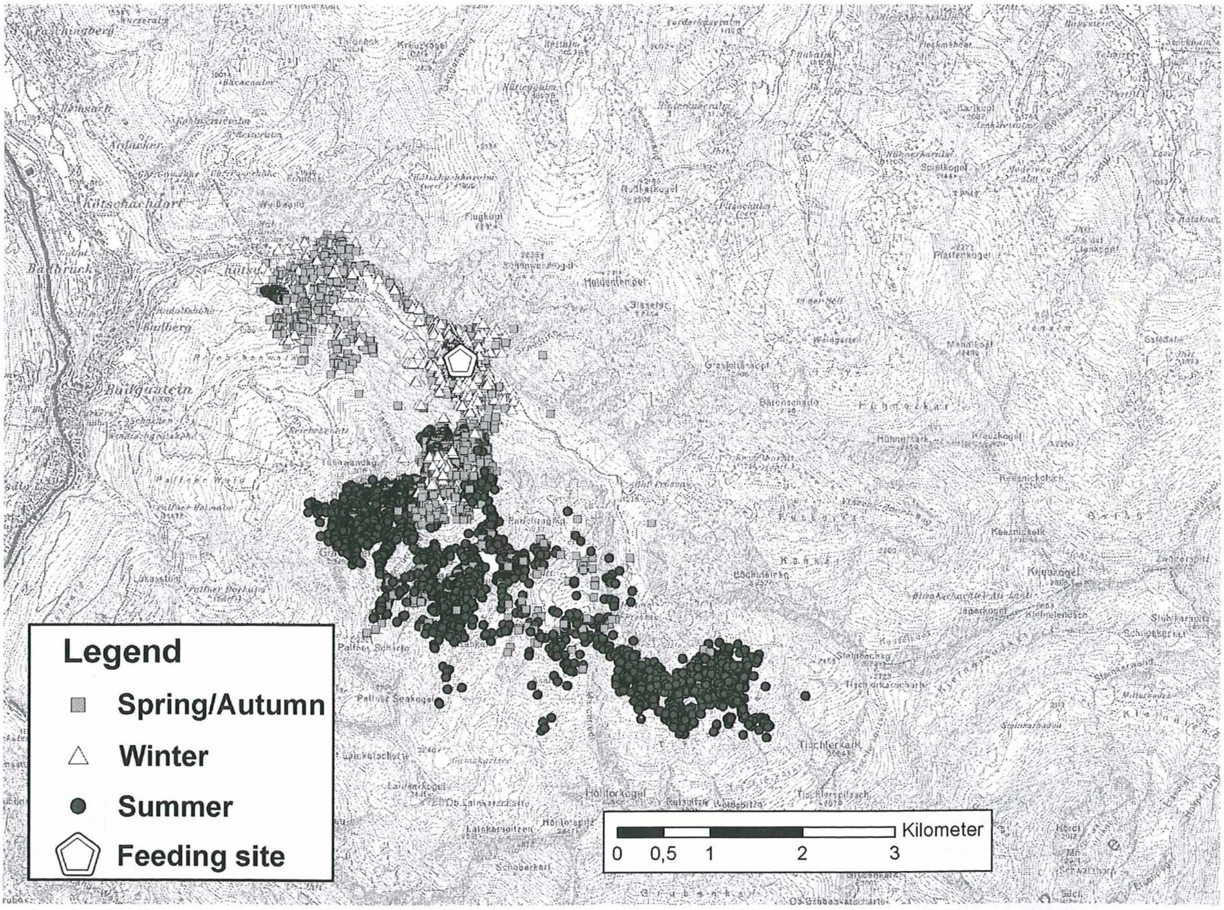

Figure 1: Spatial distribution of 6 collared female red deer.

In the Swiss national park (without supplementary winter feeding) in winter the individual Minimum Convex Polygon (MCP) varied from 150 to 8990 hectares. In summer the MCP varied from 170 to 5350 hectares. In spring and autumn, when red deer changed from summer to the winter habitat, the MCP size reached much higher amounts in the Swiss National Park compared with NP Hohe Tauern, where red deer was bonded at the supplementary feeding station (1160 m altitude).

Table 1: Seasonal range size of adult female red deer in the National Park Hohe Tauern (Austria) and the Swiss National Park (individual maximum and minimum area calculated with Minimum Convex Polygon method).

	NP Hohe Tauern (with suppl. winter feeding)		Swiss NP (without suppl. feeding)	
Number of collared female red deer	6		9	
	MCP size (ha)		MCP size (ha)	
	Min.	Max.	Min.	Max.
Winter (Dec. - Feb.)	5	336	150	8986
Spring (Mar. - May)	110	807	115	16897
Summer (June - Aug.)	128	792	172	5345
Autumn (Sept. - Nov.)	197	753	229	14576

The activity data (see Figure 2) showed differences between populations without supplementary feeding (Swiss National park) and with supplementary feeding (NP Hohe Tauern, Austria). As soon as the deer were present at the supplementary feeding station and accepted the feeding, they showed activity maxima during the late morning hours when the feeding took place. In this respective winter season the feeding started at the 2nd of November and was stopped at the 30th of April. The individual shown in Figure 2 came by at the 20th of December and stayed around the feeding site until the 12th of April. Within this timeframe the activity shifted to the morning hours, the rest of the day it stayed at a very low activity level. Within the non-fed Swiss population the collared individual showed no activity maxima during the morning hours in the respective time frame. The main activity phases took place in the early evening hours.

In both populations the activity throughout the rest of the year (spring to autumn) is similar. The main activity phases a strongly linked to the sunrise and the sunset. During daytime there is lower activity during the noon hours and constant level of activity during the night hours.

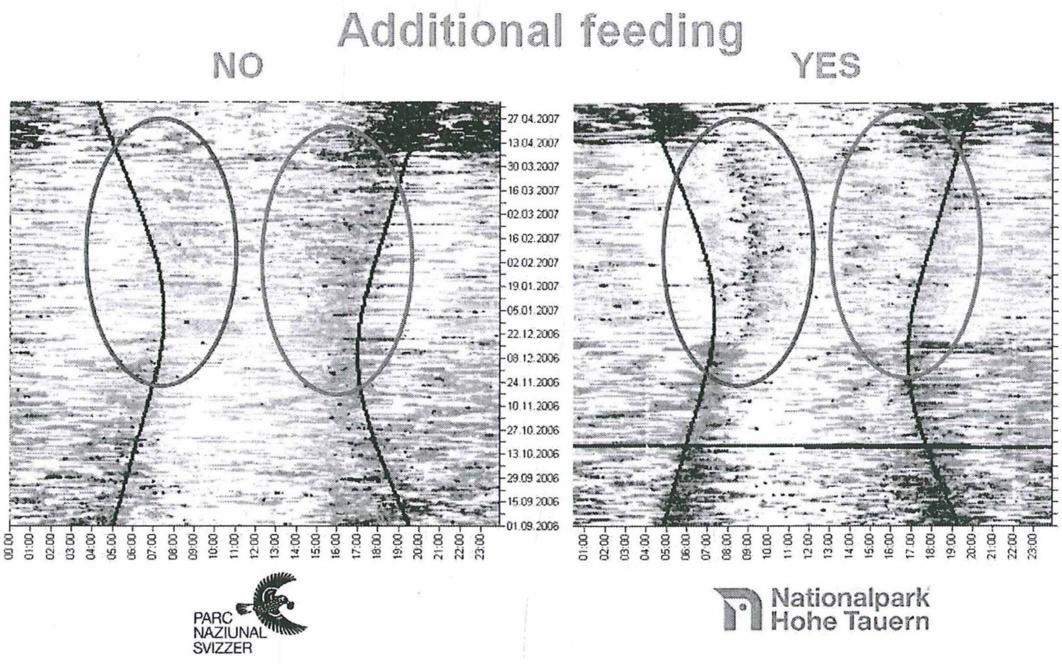

Figure 2: Actogramm of two individuals representative of each population. Left: Swiss National Park without supplementary feeding, Right: National Park Hohe Tauern with supplementary feeding in winter. Black lines: sunrise and sunset. White: no activity, the darker the colour the more active the individual.

In addition, another interesting new result showed up: Both individuals (in Switzerland and Austria) suddenly raised their activity pensum more or less at the same day around the 13th of April to a very high level. Even though the Swiss deer started to increase slightly since the end of December, it changed abruptly to a high activity level after the mentioned date. This change is stronger within the Austrian deer with supplementary feeding. Within one day the physical activity peak in the morning hours was neglected and the activity shifted to a complete new daily rhythm (peaks around sunrise and sunset, constant activity during night). It seemed that red deer "accepted" the additional feeding during a certain time frame and was strongly attracted during that period. Although the feeding was kept going until the end of April it abandoned the feeding site earlier and changed its rhythm. With additional data we might be able to evaluate the physiological consequences of this behavior and the influence of additional feeding.

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Managing red deer populations according to the IUCN requirements in the National Park Hohe Tauern, Austria

Andreas Duscher, Friedrich Reimoser, Ferdinand Lainer

Summary

The Austrian national park "Hohe Tauern" initialized a telemetry study from 1999 to 2006 to develop management plans to control and regulate the population density of red deer according to the IUCN guidelines. Therefore a maximum of 25% of the national park should be used for regulation by culling. An elaborate management concept led to a stable and sustainable red deer stock. Considering the spatial and seasonal migration patterns the culling activities were most effective within the recommended regulation areas. This led to less shy deer in their optimal habitat above the timberline during summer months and a good visibility to visitors. In addition the impact on forest vegetation (browsing, bark stripping) could be reduced.

Keywords

Red deer, management, national park

Aims and duration

Establishing a red deer management according to the requirements of a national park is essential to attain the status of international acceptance by the IUCN. With the results of a telemetry study from 1999 to 2006 a management plan was developed to control and regulate the population density of red deer in a model area. To keep the human impact on the core area as low as possible the surrounding areas of the national park should be included in the management actions. Additionally the impact of the deer on the forest vegetation should be kept at a tolerable level.

Area of study

The study area was located in the "Koetschach valley" in the eastern region of the National Park Hohe Tauern near the village of Bad Gastein (province Salzburg, Austria). The valley is running from southeast to northwest at an elevation from 1,280m to 1,080m above sea level, and is surrounded by mountains up to 3,000 m. The valley was part of the hunting territory "Koetschach" that includes a part of the national park. From the total hunting area of 3.878 ha, 2.557 ha (66%) were national park core area, 738 ha (19%) buffer area and the rest of 583 ha (15%) were regular hunting ground outside the national park.

A supplementary winter feeding station for red deer is situated near the border to the core area of the national park.

Methods

Red deer counts were established in the model area of the national park and in the surrounding areas relevant for red deer management. The census was done annually on the same spot at about the same time. Three mid-summer census areas were in high altitudes and one winter area was at a supplementary feeding station in the valley. The consequences of different management measures were consistently monitored using different field methods including GPS collars to get a better insight in the spatial migration and the seasonal activity of red deer. The results serve the adaptive management.

Results and discussion

The results showed a strong deer dislocation from winter to summer ranges and vice versa. At the end of April, when the feeding station was closed down, the deer started to migrate to the high altitude areas above the treeline. These alpine meadows provided the optimal summer habitat for these large herbivores, far away from woodland with a high susceptibility to wildlife damage like browsing or bark stripping. They stayed the summer in these areas and started to disperse in lower altitudes again in September. In October they showed the first tendencies to get back to the supplementary feeding station and a group of 40 to 50 individuals was fed as from November. The total sum of supplementary fed individuals of 120 was fed from January to March.

We combined these space and time dependent migration patterns with the zonal classification and the respective IUCN guidelines and developed an elaborate management concept for our research area including the surrounding hunting areas.

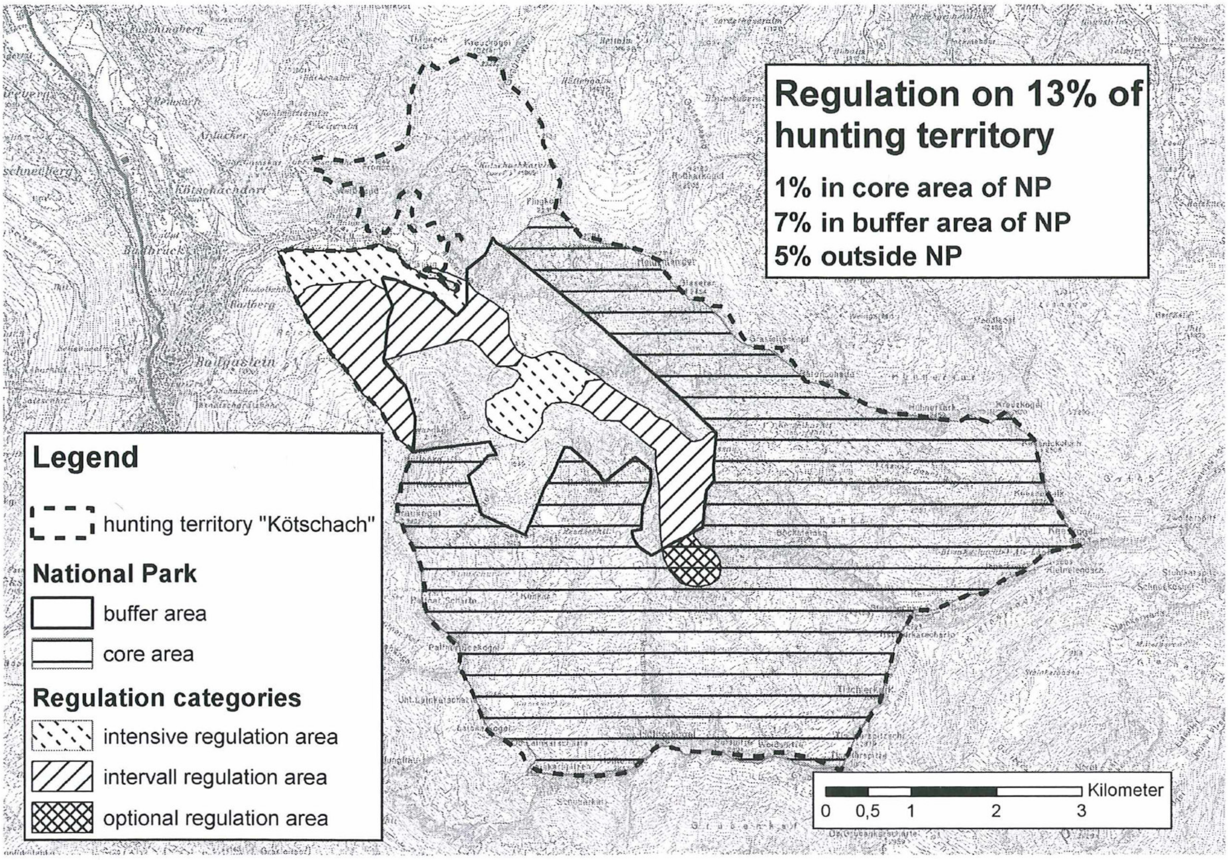

Figure 1: Regulation categories within the hunting territory "Kötschach"

Due to the spatial distribution throughout the year the deer stayed only a very short time on potential hunting ground. This was, on the one hand, in May, when they left the feeding and went in the high altitudes. On the other hand, it was on their way back from the summer ranges to the feeding site in Autumn. Thus, the legitimate shooting quota of the hunting area could only be done in May and from October to November, the effective regulation time frame is shortened to 10 weeks instead of 6 to 5 months (depending on sex and age). To optimize this shortened time frame, following management implications were taken:

No culling activities (resting areas) in the central and most important summer habitats (high altitude areas) as well as winter habitats (near the feeding station).

Establishing of space-time dependent regulation categories: Intensive regulation areas (strong and permanent hunting pressure in that area) and interval regulation areas (alternating hunting activities and recovery phases)

Culling of yearlings mainly in May (within the forested areas before red deer migrate to high summer habitats)

The professional realization of these implications led to a stable and sustainable red deer stock within several years. All regulation activities took place on only 13% of the hunting area, most of the culling was done in the buffer area or outside the park. This strengthened the importance of including the surrounding areas of a national park in an applicable and sustainable management concept. With displaying and executing space-time dependent regulation categories and the main focus on hunting the yearlings in May the reduction to a tolerable (in terms of the deer impact on the vegetation) red deer stock could be achieved in a most efficient and sustainable way. The short periods of hunting and the associated short period of disturbance by the hunter minimized the risk of damage caused by red deer. Furthermore the deer became less shy in their optimal habitat above the timberline during summer months with herds up to 200 individuals, the visibility to visitors was improved.

Contrary requirements to all appearances could be combined in this project: the reduction of a red deer stock to a tolerable minimum on the fraction of the possible area in a small period of time. The professional realization outside the core area led to a manageable red deer stock with positive effects for the whole area (less impact on forest vegetation, better visibility). This concept played an important role for the international acceptance of Austria's oldest national park.

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Modelling of permafrost in the region of the "Hohe Tauern", Austria

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Summary

Alpine permafrost responses very sensitive to climate change. Thus, it is of great interest to estimate and assess its distribution in high mountain areas. In densely populated and developed mountain areas (e.g. ski resorts, etc.) mapping and modelling of permafrost distribution is an important prerequisite to assess and prevent natural hazards and risks. Furthermore, permafrost related topics have to be more present within the media to gain the interest of the public.

A pilot study shows that possible and probable permafrost areas of the Austrian Alps comprise 1600 km², which corresponds to an area of approximately 2 % of the federal territory. In some regions a significantly higher proportion of permafrost can be expected. The new project permalp.at is focused on the accurate modelling of permafrost distribution within the area of the Hohe Tauern based on a new approach. By analysing the relation between slope, altitude, aspect and visible permafrost indicators, a new map showing the probability of permafrost occurrence in the Hohe Tauern will be developed, replacing previously applied "hard" lower borderlines and therefore raises the quality of the assesment. This map will be based on field data of permafrost distribution gathered throughout the mountain range in several test sites. Data acquisition includes BTS, ground-temperature measurements and field-geophysics.

Keywords

Alpine Permafrost, Hohe Tauern, Indexed Simulation

Introduction

Permafrost (permanently frozen ground) is defined on the basis of temperature and time. In permafrost areas ground temperature remains at or below 0°C for at least two consecutive years (Washburn, 1973).

The Intergovernmental Panel on Climate Change predicts a significantly higher temperature rise for the Alps compared to the average. Within the context of changing climate conditions, detailed knowledge about permafrost becomes more and more important since steep talus slopes and rock walls can become instable.

Permafrost research in Austria is still a young scientific field compared to Switzerland, where the first permafrost related topics were already published in the 70s of the last century. Besides intensive data gathering, international collaboration and exchange of significant data and knowledge is important to enlarge the sample size (Haeberli & Gruber, 2008) and compare meaningful results.

Pilot Study

Until recently, the permafrost distribution in Austria has been mapped and modelled only for a few local regions. Previous studies in the Austrian Alps have shown that on average permafrost occurrence must be expected above 2500 m (Lieb, 1998). It is obvious that in Austria permafrost areas have their maximum extensions in the western federal states due to a decline of absolute heights of mountain ranges from west to east.

Since empirical values for the simulation, namely lower limits of possible and probable permafrost distribution related to altitude, aspect, slope and slope foot were originally deduced and calibrated for the Upper Engadine in the eastern Swiss Alps, they have been adjusted to the eastern Alps using empirical values of probable permafrost distribution in Austria generated by Lieb (1998) for the pilot study.

Table 1: Values used for the simulation in the pilot study.

	Permafrost possible (sporadic)		Permafrost probable (discontinuous)	
	Steep Slopes	Foot-slope positions	Steep Slopes	Foot-slope positions
N	2300m a.s.l.	1690m a.s.l.	2500m a.s.l.	2410m a.s.l.
NE	2450m a.s.l.	2100m a.s.l.	2600m a.s.l.	2500m a.s.l.
E	2575m a.s.l.	2220m a.s.l.	2720m a.s.l.	2520m a.s.l.
SE	2700m a.s.l.	2230m a.s.l.	2850m a.s.l.	2630m a.s.l.
S	2900m a.s.l.	2340m a.s.l.	2900m a.s.l.	2690m a.s.l.
SW	2650m a.s.l.	2230m a.s.l.	2850m a.s.l.	2630m a.s.l.
W	2600m a.s.l.	2160m a.s.l.	2700m a.s.l.	2510m a.s.l.
NW	2530m a.s.l.	2120m a.s.l.	2580m a.s.l.	2470m a.s.l.
Flat areas	Permafrost possible (sporadic)		Permafrost probable (discontinuous)	
Wind-exposed	2590m a.s.l.		2710m a.s.l.	
Sheltered from wind	2640m a.s.l.		2900m a.s.l.	

First modelling results show that in Austria 1600 km² can be assigned to mountain permafrost (Ebohon et al., 2008). This corresponds to an area of approximately 2 % of the federal territory but in some regions a significantly higher proportion of permafrost can be expected. Although a small scale regional map has inherently a limited accuracy, it allows approximations of the permafrost distribution on a nation wide scale. For the simulation routines of PERMAKART and PERM were used applied on a DEM with a resolution of 50 m.

The first results were promising but a lot of questions still remain and some problems unsolved. Therefore more data has to be gathered and a DEM with a higher resolution is needed for the simulation.

The new project "*permalp.at*"

A major objective of the project *permalp.at* is focused on the accurate modelling of permafrost distribution within the area of the Hohe Tauern based on a new approach:

By analysing the relation between slope, altitude, aspect and visible permafrost indicators, a new map showing the probability of permafrost occurrence in the Hohe Tauern will be developed. This map will be based on field data of permafrost distribution gathered throughout the mountain range in several test sites. Data acquisition includes BTS, ground-temperature measurements and field-geophysics.

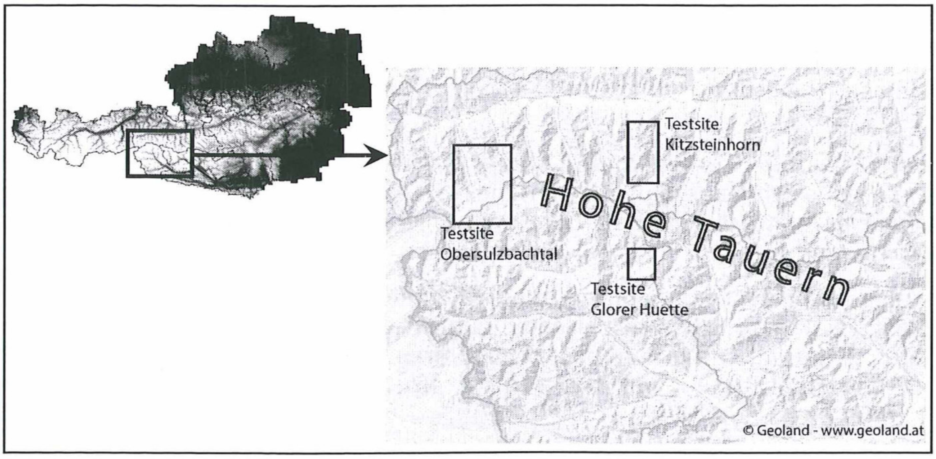

Figure 1: Study Site and preliminary defined local test sites of the project *permalp.at*; Data: BEV, Geoland

Methods

The BTS-method (basal temperature of snow cover) was firstly applied by Haeberli (1973, 1986). It is based on the assumption that a snow cover thickness of more than 80 centimetres insulates the ground from atmospheric influences due to low heat transfer capacity. Consequently undisturbed ground temperature could be measured at the bottom of the snow cover during the late winter. Values below -3°C indicate that permafrost in the ground is probable while values between -3°C and -2°C signal that permafrost occurrence is possible. In areas, where values above -2°C are measured, permafrost is improbable (Keller, 1994).

In two test sites (Glorer Huette, Obersulzbachtal) UTL-data logger are already installed at different heights and aspects in fall 2008 to measure the ground temperature. Other test sites will be equipped throughout the course of the project.

Within the last decade the use of geophysical techniques has become more widespread in geomorphology, especially in the field of permafrost research. These techniques can help to understand the internal structure of the ground, as well as to detect the presence and absence of permafrost. Every method is based on the measurement and interpretation of contrasts in physical properties of the subsurface material. Consequently only a combination of two or three different geophysical methods allows conclusions of the subsurface conditions since every technique has its own limitations and particular inaccuracies (SCHROTT & SASS, 2008). Permafrost delivers characteristic parameters from the geophysical survey.

For example, the DC (direct-current) resistivity methods detect changes in electrical resistivity at different depths in the subsurface. Tomography (ERT - electrical resistivity tomography) is commonly used in high mountain areas for the detection of permafrost. Concerning separation between permafrost and its surrounding material, permafrost areas show a very high resistivity (10^3 - 10^6 Ωm) since most of the pore water is frozen (HAUCK & KNEISL, 2008). It is well known, that an intense increase in resistivity can be recognised at the freezing point and that ice, in contrary to water, can be seen as electrically nonconductive (KNEISL et al., 2008).

In the project permalp.at BTS and long-term ground-temperature will be monitored and combined with local geophysical surveys (applying ground penetrating radar, electric resistivity tomography, seismic refraction) and detailed geomorphological mapping of permafrost related landforms. These new data serve to validate the model and adapt the Swiss "rules of thumb" to Austria.

Modelling Alpine Permafrost

In geomorphology simulation modells represent one of the operative links between process studies and the study of landforms. When the relationship between landscape dynamics and causing physical or chemical processes is known, a model can be developed through simplification of these processes (KIRKBY, 1996). Model validation can help to check if the pictured processes are the driving forces or if some important variables are still missing. As soon as a model is well calibrated it also allows simulations of future scenarios up to a limited extent.

In the Alps the fist digital permafrost-model was realised in 1994 by F. KELLER. Since then modelling approaches where constantly developed further. The new approach improves existing previous models in two ways: Firstly, the resulting map will include a probability index between 0 and 100 which replaces previously applied "hard" lower borderlines of the subdivision "probable", "possible" and "no permafrost" and therefore raises the quality of the forecast. Secondly, the implementation of snow cover effects on the distribution of permafrost will be achieved to improve the accuracy of distribution modelling. Furthermore the simulation will be realized on a DEM with a resolution of 10m.

Outlook

The resulting permafrost distribution map will be an important tool for all decision makers concerning infrastructure in the area of Hohe Tauern and will inform about science-based knowledge concerning Alpine permafrost. Furthermore it is planned, to implement a web based map to make data accessible to the general public. Results of the pilot study can already be seen on the homepage www.permalp.at visualised in a web GIS. The duration of the project *permalp.at* covers a period of three years.

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The lab above the clouds
Aerosol chemistry at the Sonnblick Observatory

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Keywords

Aerosols, particulate matter, sulfate, total carbon, levoglucosan, trajectory analyses, Sonnblick Observatory

Introduction

Atmospheric aerosols (particulate matter) play an important role in terms of health issues as well as climate. Especially during the cold season reports on aerosols and related health issues have become an important topic. Air quality standards set for particulate matter in ambient air (PM10; particulate matter smaller than 10 µm a.d.) are exceeded in many regions in Europe. It has been shown (PUXBAUM et al. 2004) that at least in a number of cases these limit violations are already driven by elevated background concentration levels, which leave little tolerance for emissions in source regions, e.g. densely populated cities. Conditions at the Sonnblick Observatory (SBO) are definitely not the ones which can be attributed to possible violations of limit values of PM10. On the contrary, the sampling site in the remote mountainous region of the Alps offers the opportunity for the determination of background concentrations. These results can also be used for assessing the influence of background concentrations of aerosol particles on climate issues.

Here we summarize the experimental setup and selected results of a two year sampling campaign of atmospheric aerosols at the Sonnblick Observatory.

Methods

Sampling was performed between 2005 and 2008 with a Digitel High Volume sampler on quartz fiber filters (Pallflex, 150 mm). Sampling intervalls were one week to assure sufficient filter loadings.

Water soluble inorganic anions (chloride, nitrate, sulfate) and cations (sodium, ammonium, potassium, calzium, magnesium) were determined by ion chromatography. Analysis was performed by standard procedures using Dionex equipment. To determine short chain organic acids gradient anion analysis was carried out as well.

For determination of Total carbon (TC) aliquots of the filters were combusted at 1000°C in an oxygen stream. The evolving carbon dioxide is detected with a NDIR monitor (Maihak SIFOR 200). To determine elemental carbon (EC) aliquots of the filters are precombusted in an oven at 340°C in an oxygen atmosphere for two hours to remove all organic material. The remaining carbon is quantified as described above for TC. Organic carbon (OC) is calculated by subtracting EC from TC. Carbonate carbon (CC) is calcutaed based on the calcium content determined by ion chromatography.

Additionally the EC/OC split was estimated by a thermo-optical method for a limited number of samples. Therefore the sample is heated from room temperature to 800 °C with a rate of 20 °C /min. The evolving carbon dioxide is detected with a NDIR monitor. To account for charring the transmission of the filter is monitored by a laser. Thus it is possible to observe the beginning of carbonisation and the combustion of EC.

Selected filters were also analysed for anhydrosugars (e.g. levoglucosan – a tracer for wood burning) using liquid chromatography and pulsed amperometric detection (CASEIRO et al. 2007) and cellulose (tracer for plant debris) by enzymatical analysis followed by photometrical detection.

Aerosol mass is determined by weighing the filters prior and after sampling according to EN12341.

Results

Annual cycles determined for the major ions as well as TC, OC and EC showed low values during summer and elevated concentrations in the warm season. During winter the influence of the free troposphere is more pronounced, while the influence of boundary layer air becomes more important during summer and a modified mixing layer is formed. In case of major ions this was already seen during earlier measurements starting in 1991 and 2002. (e.g. KASPER & PUXBAUM 1998). Regarding the present measurements sulfate concentrations range from 0.2 to 2 $\mu g/m^3$ (related to $0^\circ C$ and 1013 mbar) in summer and 0.1 to 1 $\mu g/m^3$ in winter. Based on the available data the summer to winter ratio between the concentrations of the major components is about 5. Results of TC are 0.2 to 2.5 $\mu g/m^3$ in summer and around 0.3 $\mu g/m^3$ in winter. The average ratio for TC/SO4 is about 2.5. Monthly averages of the TC/SO4 ratio range from 0.9 to 3 with no specific trend observed throughout the seasons.

Gravimetric analysis of the aerosol mass indicated an annual average from 5 $\mu g/m^3$. During an event of long range transport of Saharan dust the aerosol concentration increased strongly. This event was also characterised by thermo-optical analysis and calculation of backward trajectories.

The analysis of a limited number of samples showed small amounts of levoglucosan, 4 to 26 ng/m^3. These concentrations contribute to 3 to 19 % of OC. Cellulose concentrations determined for a small set of samples come up to 25 to 85 ng/m^3, which equals 6 to 22 % of OC. Earlier measurements of these tracer compounds are given in PUXBAUM et al. (2007) and SANCHEZ-OCHOA et al. (2007).

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The role of protected areas in ungulate research

Flurin Filli

The role of ungulates in the natural development of ecosystems in protected areas has always been subject of controversies (BOYCE 1991). The question of habitat over-utilisation is often discussed. Elk *Cervus canadensis* in the Yellowstone National park serve as a good example, as their population size and impact on ecosystem properties has fueled many heated debates (CHASE 1986, KAY 1990). In national parks that allow natural dynamics to take place, the problem of habitat over-use is not an issue (COUGHENOUR & SINGER 1991), especially because it assumes a balance between vegetation and ungulates, which can only be achieved by human control. Due to the complex interactions between ungulates and their environment, these animals are difficult to study. This is in particular accentuated in and around protected areas, since not only the ecological environment must be considered, but also the social environment involving conservationists, national park visitors, hunters and land owners must be considered.

For large herbivores in European alpine ecosystem LOISON et al. (2003) outlined the future research in an overview. They pointed out:

1. Large herbivores in mountainous areas may have an increasing impact on ecosystem functions and dynamics through their interactions with plant communities, their role in shaping habitat, and their importance for large carnivores. Changes occur rapidly, and as this review suggests, there are large gaps in our knowledge of mountainous ecosystems.

2. A traditional research approach based on single-species studies is necessary. However, an integrated approach, using long-term studies (and experiments where applicable), should focus on (1) interspecific competition, (2) interaction between domestic and wild ungulates, (3) the role of predation, (4) the role of wild ungulates on plant communities, (5) the effects of space, landscape patterns and their changes on the dynamics of ungulates, (6) the evaluation of climatic variation on population dynamics, and (7) defining management strategies (e.g. through culling) to satisfy multi-user management objectives.

Given the above facts the role of protected areas in ungulate research seems to be obvious. The controverse discussion about the role and management of ungulates in protected areas shows in addition that scientifically sound data are needed. An example for such a process are the red deer *Cervus e. elaphus* in the Swiss National Park (HALLER 2002). Such information could be provided by protected area staff in collaboration with research institutes. Protected area can also guarantee the long time aspect of the studies, which is an important factor in studying long living species and ecosystems. In most of the protected areas the native ungulates are present, so that interspecific competition could or should be investigated. The protection status, especially in Biosphere reserves allows comparative studies of interactions between domestic and wild ungulates. The role of predation, in turn, can only be studied if the necessary basic knowledge of ungulates and their environment is available, which is the case in many protected areas. Investigations on ungulates-plant community interactionsat the ecosystem and landscape level require broad environmental data, which often is given for protected areas.

Ungulate research, especially long term, requires a lot of perseverance. For such projects a good organisation is more then helpful. For the data interpretation a well working GIS containing the complementary information and adequate meteorological data are needed. Remote sensing data, as for example HABITALP data (LOTZ 2006) furthermore allows a comparison of several alpine protected areas.

Another important issue are the visitors of protected area. For example, 72.7 % of the visitors of the Swiss National Park come to see wild animals. Their preferred creatures are large ungulates like red deer or ibex *Capra i. ibex*. Thus, the high public interest expectation to see ungulates is much higher then the one to spot, for example, a cute marmots *Marmota marmota*. Thus, the high public interest in ungulates of protected areas can be an excellent platform for communication of new knowledge from actual research projects and visitors could be sensitized, for example, for habitat requirements of ungulates, even in other, non-protected areas. Also, the possibility to consume venison from the region as in Biosphere Reserves can promote the market for natural and sustainable products.

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Habitat carthography using color infrared and hyperspectral images

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Abstract

This study sought to deepen the information derived from hyperspectral (MIVIS) and multispectral (IR) images to obtain a map of meadow-pasture types and a map of the biomass amount present in the Nature Park of Mont Avic.

MIVIS (Multispectral Infrared and Visible Imaging Spectrometer) is a modular tool with four spectrometers which covers visible, near infrared and heat wavelength (102 bands). The pixel size is lied to flying height, in our case (altitude 2000 meters) is equivalent to 4 meters for 4 meters square while IR images were aquired with a Zeiss RMK TOP 30 camera that returns a better soil resolution (15 cm), but cover only the infrared wavelength.

MIVIS georeferenced images using the software Trafo (ReSe applications) and the warp of ENVI were initially pre-treated by the MNF (Minimum Noise fraction) and then be classified using samples collected in situ and incorporated into a specific algorithm called SAM (Spectral Angle Mapper) where we have find eight classes; IR georeferenced images were classified using the biomass indicator's NDVI (Normalized Difference Vegetation Index) and then separated in three classes with stretching (low, intermediate and high).

MIVIS classification was validated through the verification of accuracy on 158 samples collected randomly in the area.

Finally we have obtained a first MIVIS classification with eight classes and a first NDVI classification which included in the Park's Geographic Information System have improved the territory's knowledge.

Keywords

Remote sensing, Geographical Information System, MIVIS, NDVI, IR, infrared, multi-spectral images, hyper-spectral images, cartography, SIC, Park, Mont Avic

Introduction

The "vegetation analysis, statistics and multitemporal of hyperspectral data (MIVIS) and multispectral (visible, infrared), compared with the database of the Natural Park of Mont Avic Information System " project was financied by Fondazione CRT in Turin behind the "Alfieri" project with the collaboration of the Mont Avic Natural Park; during the year of funding (June 2008 June 2009) hyperspectral images (MIVIS) were processed in order to produce a first herbaceous typologies map. Especially the analysis of grass-pasture typologies was focused on the south, south-west of the Park because there was a greater concentration of these elements. In parallel another analysis was conducted, where IR images were used to gain in relative terms the biomass values through the use of the NDVI vegetation index.

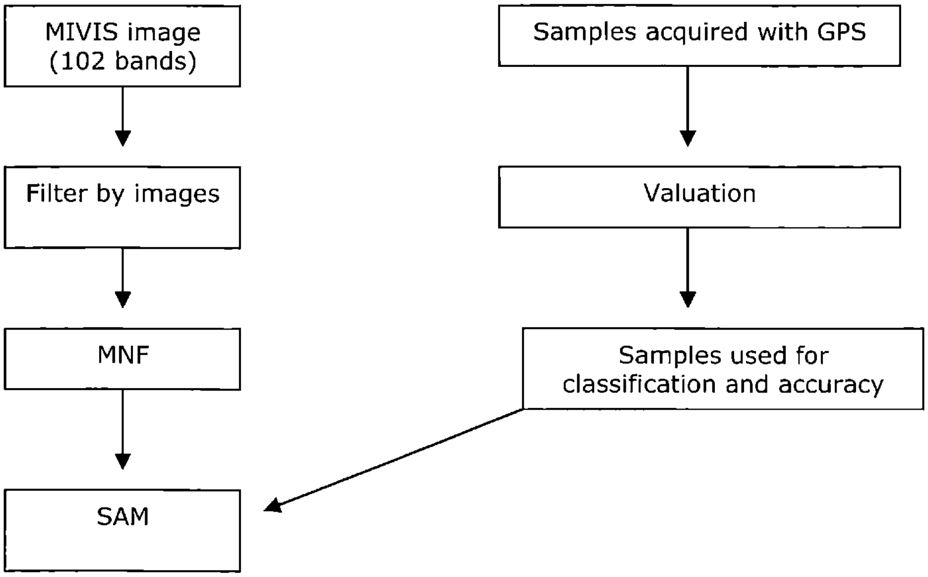
Mont Avic Natural Park is born on 1989 to conserve and protect environmental, natural and historical resources; initially the Protected Area consisted in 3522 ha situated on Champdepraz municipality but after may 2003 the territory increase to 5747 ha including Dondena Valley on Champorcher municipality.

Methods

Starting from the thesis work "Remote sensing in support of the management of a protected area: the Mont Avic Natural Park " it was possible to use hyperspectral images (MIVIS) georeferenced by software PARGE (Parametric Geocoding e Orthorectification for Airborne Optical Scanner Data by ReSe applications Schläpfer e RSL, University of Zurich), correlating images with data acquired at time of flight (ancillary file), ground control points and digital terrain model (DEM) has given an image comparable with Park's layer. Where geometric distortions were more pronounced, particularly near elevation changes, it was further correcting images through warping. The use of additional control points has reduced georeferencing error, reaching thus a 3 pixels maximum.

MIVIS non-georeferenced images are initially filtered considering the 102 bands individually. It was then applied a specific algorithm of noise reduction called MNF (Minimum Noise Fraction) which helped to improve the classification's accuracy. Parallel analysis was carried out in situ, which has allowed the acquisition of ROI (Region Of Interest) with GPS used for the classification.

ROI and images MIVIS treated are included in a classification algorithm called SAM (Spectral Angle Mapper) which determining the spectral similarity between the two spectra by calculating the 'corner' which they form, thus treating them as vectors in a space with dimensions equal to the number of bands. Angular parameter is the algorithm tolerance, with a small angle value the classification is more accurated therefore algorithm detects and classifies all pixels whose signature spectral part of this tolerance.



Samples are catalogued into eight classes ("Guide des milieux naturels de Suisse" DELARZE R., GONSETH Y. (2008)) and validated by the botanist:

- Elynion
- Nardion
- Festucion variae
- Caricion curvulae
- Salicion herbaceae
- Juniperion nanae
- Loiseleurio-vaccinion
- Drabo-seslerion

In order to confirm the data acquired, we have considered other factors such as height and lighting. We have also decided to use a fixed angle for all classes in order to maintain greater homogeneity on classes.

Classification was finally georeferenced, mosaics and inserted into a geographical information system where layers already presents have made possible a first data verification.

The statistical analysis was conducted on 5 classes that were available to the greater amount of data to the ground.

In order to remove the maximum error of GPS (8 meters) and georeference (12 meters equivalent to 3 pixels) was chosen for the creation of a twenty meters buffer strip with the following results:

ALLIANCE	SAMPLES	ERRORS	ACCURACY
CARICION CURVULAE	39	0	100
ELYNION	22	2	91
FESTUCION VARIAE	35	6	83
NARDION	45	7	84,5
SALICION HERBACEAE	17	0	100
TOTALI	158	15	

Using information in near infrared derived from the flight IR HABITALP directly correlated to the vegetation, we have decided to use a specific biomass indicator, NDVI (Normalized Difference Vegetation Index) based on reflectance values; it measure green cover and is directly related to photosyntesis. The leaf structure affects the relationship between the absorption spectrum of chlorophyll in the red (0.63 µm - 0.69 µm) and reflection in the near infrared (0.76 µm - 0.90 µm).

$$\text{NDVI}=\frac{IR-R}{IR+R}$$

We have calculated NDVI on each table and then get a mosaic of the entire area of the park, displayed in three levels of stretching.

The excellent resolution of the instrument made possible to produce a biomass map of the Park; in order to facilitate the subsequent application we have chose for three different maps:

stretching "broad" where we moved deliberately limit the amount of biomass per pixel to very high values in order to understand if in some pilot areas there may be a correlation with fauna, not obtainable with other levels of stretching;

stretching "tight" where we tried to give a card that put in evidence in "quantitative" biomass found throughout the park, thus providing a tool used throughout the Park;

stretching "medium" produce of the average values obtained from the two previous limit.

Results

Georeferencing of the adjoining park in 2003 and named "Dondena Valley " for a total of 2225 ha.

Classification of eight types of grass-pasture Park through images MIVIS for 1999, calibrated and verified through a survey carried out in situ in the summer of 2008.

Assessment of the amount of biomass present in the park through the indicator NDVI applied to the IR HABITALP flight and return of 3 levels obtained through the stretching of images.

Establishing a Geographical Information System that contains the information layer of the Park and data processed.

Discussion

Hyperspectral and multispectral images have a great amount of ground data. In particular, the advanced level of detail achieved in discriminating grass-pasture types has helped to first base in the transposition of information still difficult to interpret the photo. The use of vegetation index (NDVI) was also to create a database widely used in future studies related to fauna, allowing to relate more of the variables in the environment system. The vast amount of information generated will facilitate the future of the environment, providing an effective means interfaced with the data already present.

The products obtained thus far can provide a basis for further study, including:

Analysis of the classification of lithologic present in the park by using more detailed data and verification in situ.

Evaluations of detail in specific areas of spectral response "distorted" in order to analyze and solve problems associated with sensor

Analysis of classes derived from the biomass of the vectorial NDVI emphasis on possible correlations with maps produced.

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Species traits in the alpine stream fauna: a promising tool for freshwater monitoring

Leopold Füreder

Summary

Alpine river ecosystems above the treeline are generally fed by glacial icemelt, snowmelt, and groundwater, share common features (e.g. steep gradients, high flow velocities and dynamics) and support a unique flora and fauna, including endemic and threatened species adapted to harsh environmental conditions. Alpine river ecosystems are under major pressure from climate change, altered hydrology with retreating glaciers and shrinking snow cover, and increasingly from a variety of anthropogenic influences including hydroelectric power, water abstraction and tourism that are expected to change biodiversity and ecosystem structure and function. Although various attempts have been made to characterise diversity in alpine streams, little is known about the relationships between catchment characteristics, diversity and ecosystem function at higher altitudes. In preliminary investigations for a river monitoring in the Hohe Tauern Nationalpark, we found that glaciation in the catchment turned out to be a major factor for defining the hydromorphological conditions, the degree of harshness to influence taxa richness and diversity of the aquatic fauna. Subsequently, we tested the effect of glaciation on the bottom fauna in applying a set of species traits, indicating strategies and adaptations of resilience and resistance as well as to face environmental harshness. We extended the application of species traits to a larger variety of river systems. As current climate change scenarios propose major impacts at high altitudes considerable changes within the faunal assemblages including their functional organisations are to be expected. In this respect, the application of species traits in combination with traditional indices will build a useful methodology in environmental monitoring.

Keywords

ecosystem structure and function, climate change, environmental conditions, aquatic conservation

Background and Aim of the Investigation

River systems in alpine and arctic environments are a dominant feature of the landscape, receiving and distributing water, solid substances, nutrients and other material. They are responsible for landscape alterations and a dynamic change of riverine and adjacent environments. The dimensions of change strongly depend on river size, discharge and flow dynamics as well as the water-source contributions. Between the permanent snowline and the treeline, streams may be either glacier-melt dominated, seasonal snowmelt-dominated or spring-fed, often alpine and arctic stream networks comprise a complex mosaic of these stream types (Ward, 1994; McGregor et al., 1995; Füreder, 1999). Each differs in environmental conditions and is known to support a somewhat different assemblage of organisms (Brown et al. 2003). These differences among assemblages reflect the distinct environmental conditions that are characteristic of the individual stream types, such as degree of glacial influence, geology of the watershed and disturbance timing and intensity (e.g., seasonal floods from snow-melt versus more stable flow from groundwater inputs: e.g. Milner & Petts, 1994).

The environmental conditions in alpine glacial streams and rivers exert a severe constraint on the successful colonization and persistence of aquatic macroinvertebrate species. Therefore, the occurrence of a particular species is a direct expression of this species' ability to tolerate or adapt to the existing conditions (Füreder, 1999). Although the stream fauna of glacier-fed streams is greatly reduced, downstream faunal changes are distinct and predictable (Milner & Petts, 1994; Ward, 1994). The differences among assemblages may reflect the high degree of specialization of species in alpine streams – many of these species have a narrow tolerance range for a number of environmental variables (e.g., temperature, current, nutrient concentrations) relative to related species in other types of streams. Survival under the harsh environmental conditions in alpine streams requires physiological and/or life cycle adaptations. As a result, the duration of life cycles, larval growth and egg/larval development is to be expected to be different compared to less extreme environments. These adaptations have hardly been studied in ecological investigations in alpine freshwater habitats.

In order to define a comprehensive monitoring tool for the identification of climate-change effects on alpine riverine ecosystems (including geomorphology, ecology, biology and species-adaptation characteristics) we primarily focused on potential effects of glaciation on habitat characteristics and faunal assemblages using various datasets (details in FÜREDER et al., 2002; FÜREDER, 2007). Considering the paucity of information on trait-related studies for glacier-fed rivers and the variety of these running waters (BROWN et al., 2003), the goals were (1) to provide information on the variability of alpine stream types in terms of hydromorphological and type-specific characteristics, (2) to assess the glacial influence on habitat characteristics and the faunal assemblages, (3) to specifically concentrate on species traits along a gradient of glacial influence and (4) to present a conceptual model for alpine and arctic river ecosystems under environmental and climate change.

Study Areas, Datasets and the Selection of Species Traits

The study areas comprise the Hohe Tauern National Park (NPHT), which is situated in the Austrian Central Alps with an area of 1800 km^2, and other non-impacted areas near and above the tree-line. For the realization of a freshwater monitoring, an inventory of existing freshwaters was already established for the NPHT (FÜREDER et al., 2002), including 279 streams (981 km stream/river length, catchment area >1 km^2) and 136 lakes and alpine ponds. Based on habitat assessments, including catchment and river-morphology characteristics, stream and river types were defined. For the definition of stream/river types in the alpine region, 161 stream sections that reached natural or near-natural habitat quality were selected and classified. For the characterization of alpine stream invertebrate assemblages the data used were drawn exclusively from non-impacted, natural or near-natural stream sections. Using our own data and that from various other sources we assembled information on 60 sites from 37 different rivers. For this presentation, a major focus was on the importance of glacial influence on stream insect assemblages, taxa richness, abundances, diversity and evenness, as well as resistance, resilience and environmental harshness traits within the assemblages. A total of 297 aquatic invertebrate taxa had been identified in earlier studies and were compiled into the data set. Species traits from published data, unpublished theses and personal communications from experts were available to characterize life-history traits for each of these species. The definition of species traits is outlined in FÜREDER (2007).

Environmental Conditions and the Invertebrate Fauna of Alpine Streams

The dataset of the freshwater inventory of NPHT provided information on catchment properties and river morphology at various scales (catchment – reach – site). Several physico-chemical parameters were shown to affect ecosystem structure and function of running waters at higher elevations or latitudes. Cold temperature, strong annual and diurnal discharge fluctuations, channel instability and low nutrient levels, together with limited food availability, are among the most important limiting factors in glacial rivers. For the present analyses, the degree of glaciation was set as a surrogate factor, on the assumption that, with increasing glaciation, water flow dynamics and channel instability increase and water temperature generally decreases. Consequently, with increasing glaciation, fewer species occur and at lower densities. Along the gradient of increasing glaciation, general decreases in diversity, richness and abundance were observed.

Traits of Resilience, Resistance and Environmental Harshness

The invertebrate taxa of glacier-fed rivers were shown to be equipped with several physiological and biological attributes that enable them to survive and successfully complete their life-cycles in the harsh environment. With increasing glaciation, these specific abilities within the invertebrate assemblage are increased in their relative proportions. As hypothesized, where environmental harshness reaches its highest levels, most taxa are very specifically and well adapted to these conditions.

A Conceptual Model for Alpine River Ecosystems Faced with Environmental and Climate Change

Results of our investigations, as well as from other groups working in similar systems, demonstrate how alpine running water systems and their biota can be regarded as catchment-scale integrative monitors for a set of hydrological, thermal and biotic variables – variables that are expected to be modified by climate change. Since current climate change scenarios indicate proportionally more detectable impacts at both high altitude and latitudes, alpine running waters can be regarded as research foci in the context of climate change and their communities considered to be as much under change as other biological communities.

Alpine streams may play a specific role within the scenario of environmental and climate change effects on the abiotic factors and, consequently, on the structure and function of aquatic biocenoses (Fig. 1). Alpine streams are positioned along the right slope of a harshness-ecosystem-structure-and-function curve (Fig. 1A), where environmental harshness is moderate to extreme, depending on the glacial influence. In glacial streams ("kryal" river reaches) environmental factors, such as flow dynamics, temperature and nutrient/food levels, reach their most extreme levels and therefore only a few but highly adapted species are found. Recent investigations and results presented here indicate that habitat diversity, food availability, taxon richness, invertebrate diversity and abundance follow the gradient of decreasing glaciation ("glacio-rhithral"). The variability of species traits is also affected, being low where the environmental harshness is extreme but higher when harshness is moderate. In spring-fed streams ("krenal") and in snowmelt and rainfall induced systems ("rhithral"), more species can co-exist because of moderate and more favourable environmental conditions. Only when the environmental harshness is low freshwaters can get very productive. Then single species are promoted, resulting in lower species numbers but usually with high abundances. Environmental and climate change effects (Fig. 1B) would alter the situation: glacial retreat would reduce the glaciation of the catchment and diurnal and annual dynamics of flow would decline. The duration of snow cover is expected to be reduced. As a consequence, production would increase in both the stream and in the catchment and, consequently, favour nutrient and food availability for the aquatic fauna. The same would be true for other environmental change effects that result from water diversion for artificial snow generation and hydropower. Decreasing environmental harshness (e.g., due increasing groundwater influence, decreasing glaciation, reduction of environmental extremes in temperature and flow dynamics) will favour overall biodiversity, as a potential effect of climate change. The relative contribution of the channel types that provide numerous refugia for the aquatic fauna will increase with the continued glacial retreat.

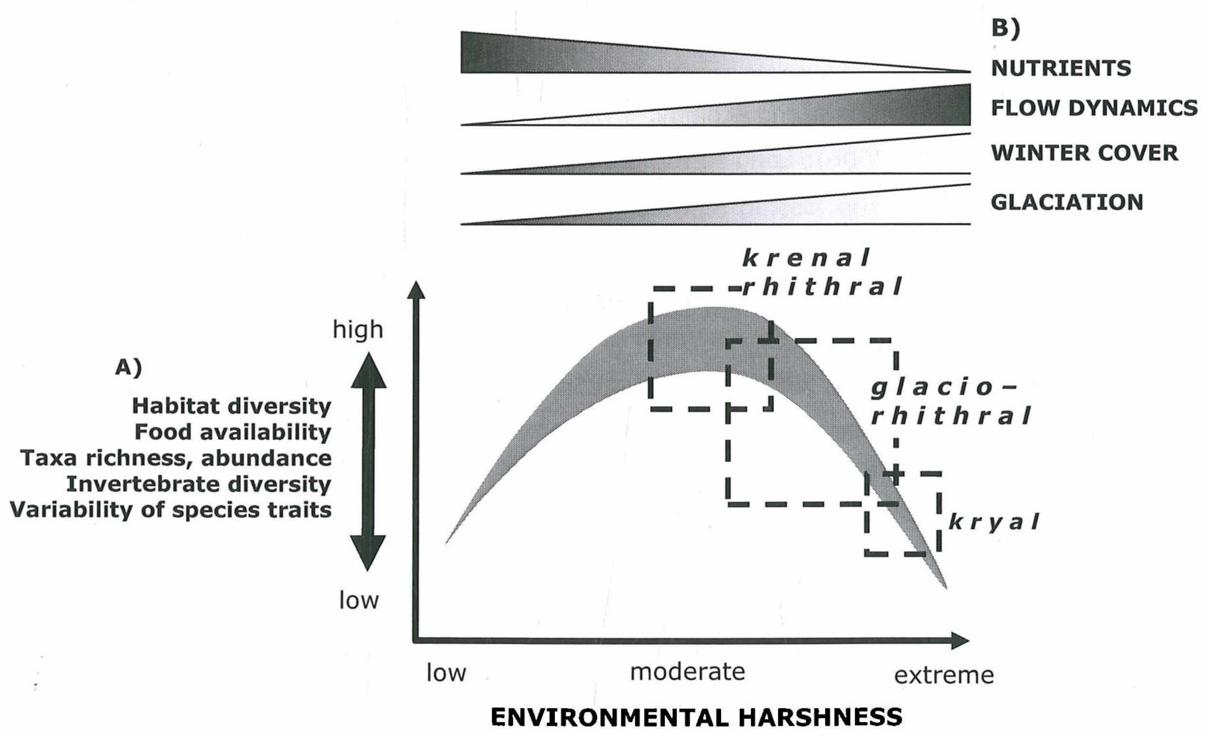

Figure 1: Scenario of environmental and climate change effects on key environmental conditions and consequently on the structure and function of the invertebrate fauna in alpine streams (from: Füreder, 2007; modified).

Climate change is expected to influence the hydrological regime of arctic, alpine and mountain streams in a variety of ways but the influence on glacier meltwater may be particularly significant (McGregor et al., 1995; Füreder, 2007; Milner et al., 2009). Changes in the magnitude and variability of a range of climate determinants of glacier behaviour, as a result of an enhanced greenhouse effect, will have important implications for the future hydrogeomorphological, runoff dynamics and temperature regimes of glacial streams. Water resources developments, such as water diversions for hydro-electric power, water abstraction and land-use changes, will also have marked impacts upon these stream ecosystems, particularly on benthic communities. Stream macroinvertebrate communities are widely used to monitor these changes in water quality as a result of human impact, notably with regard to organic pollution and acidification (Jackson & Füreder, 2006). As has been outlined in several other studies in rivers from other climate and geographical regions, the herein presented application of species-traits methodology, with detailed knowledge of environmental templates determining macroinvertebrate distribution, is a promising technique for using benthic invertebrates as bioindicators of environmental change in arctic and alpine running waters. Among the potentially sensitive ecological systems, alpine and arctic running waters may serve as models to examine the consequences of climate changes, regarding them and their biota as catchment-scale integrative monitors for a set of hydrological, thermal and biotic variables that might be modified by environmental and climate change.

Given the enormous amount of natural and near-natural riverine systems in protected areas in the Alps, the application of herein presented methodologies will provide an outstanding opportunity for freshwater monitoring. Similar research activities in alpine running water ecosystems would add important knowledge for the assessment of biodiversity in mountain areas. With proposed methodologies, the information about diversity, abundance, rarity and endemism of invertebrate taxa would be complemented with functional attributes which all together build essential information for the understanding and interpretation of climate and environmental change effects on aquatic ecosystems.

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Sediment budgets for two glacier forefields (Pasterze & Obersulzbachkees, Hohe Tauern, Austria) - conceptual approach & first results

Martin Geilhausen, Jan-Christoph Otto, Lothar Schrott

Summary

Within the national park Hohe Tauern studies are carried out in the glacier forefields of Pasterze and Obersulzbachkees in order to establish sediment budgets. The sediment budget approach provides a useful mean to quantify sediment storages and transfer processes within a landscape. In glacier forefields, sediment budget studies are of specific scientific interest due to high sediment availability and rapid reworking. The linkage of sediment storage volumes with present-day sediment transfer rates can contribute to i) an understanding of previous landscape development and ii) to the prediction of future topographic evolution. The conceptual approach, aims and objectives of a recently started research project and preliminary results from the Pasterze are presented. The glacier forefield represents a typical composition of glacial, gravitational and glacifluvial landforms and processes. The glacial melt water stream is the dominant path of sediment output.

Keywords

Sediment budget, Glacier forefields, Sediment routing, Sediment thickness, Hohe Tauern.

Introduction & Aims

Retreating alpine glaciers expose landscapes with partly unconsolidated, loose and potentially unstable landforms (e.g. moraine slopes), which are not in equilibrium with changing environmental conditions and therefore susceptible to a rapid topographic modification. In this regard, sediment budget studies on relative short time scales within glacier forefields are of specific scientific interest. The sediment budget approach helps to identify and quantify sediment sources, storages and transfer processes. Furthermore, coupling and decoupling of system components is regarded. Linking sediment storage volumes with present-day sediment transfer rates can contribute to both, an understanding of previous landscape development and the prediction of future topographic evolution.

In this paper we present preliminary results of a research project on sediment budgets for two glacier forefields. The aims of the project are:

1. to integrate present day fluxes and temporarily stored sediments,
2. to compare glacier and sediment dynamics,
3. to describe the sediment routing system and
4. to validate the conceptual model of paraglacial landscape adjustment.

This requires high resolution data on sediment transfer and storage in proglacial areas with rapidly changing sediment budget conditions.

Study Sites

Both study sites are located in the national park Hohe Tauern, Austria (Fig. 1). The selection of the study sites was influenced by the availability of long term data sets on glacier retreat and hydrological (e.g. discharge) conditions (SEELAND, 1880; RICHTER, 1883; RUDEL, 1911; PASCHINGER, 1948; PASCHINGER, 1969; PATZELT, 1973; SLUPETZKY, 1993; WAKONIGG & LIEB, 1996; NICOLUSSI & PATZELT, 2001). Both glaciers are listed by the WGMS. An overview of the study site characteristics is given in table 1. Data on catchment size and glacier area represent the real surface area and are calculated using digital elevation data. This is a crucial consideration as the planimetric area underestimates the real catchment size in steep alpine basins.

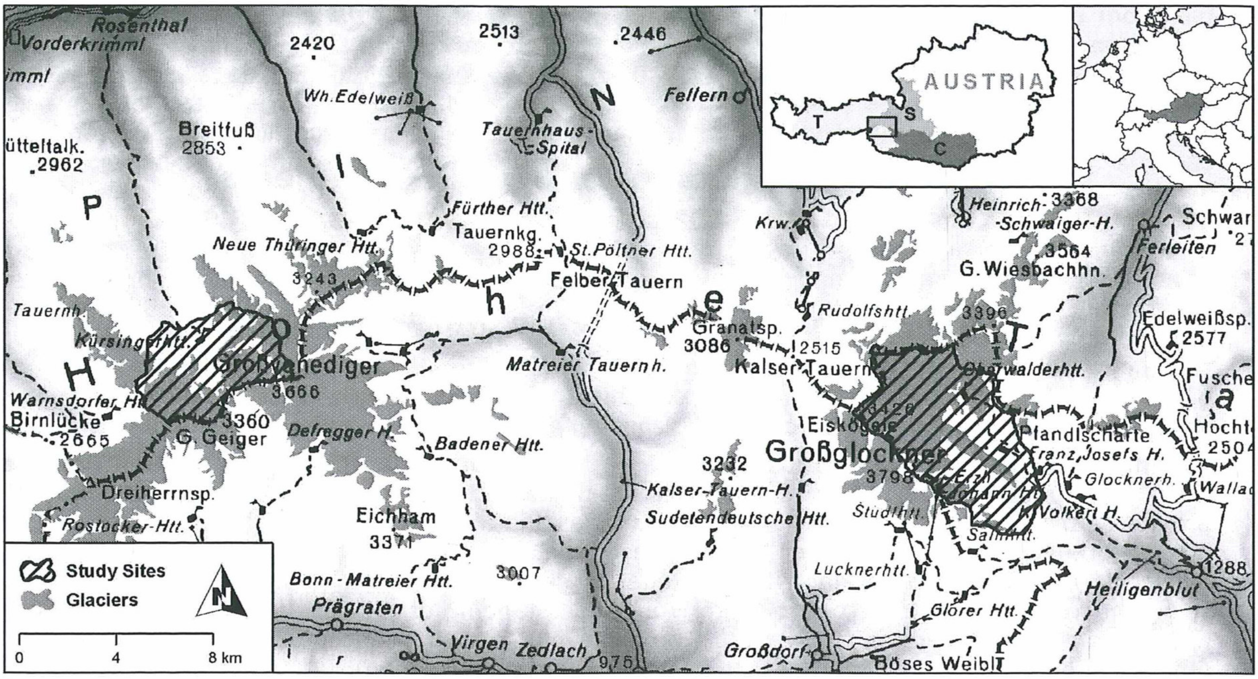

Figure 1: Location of the study sites in Austria (insets, provincial codes S: Salzburg, T: Tyrol and C: Carinthia) and the Hohe Tauern range (base maps: topographic map of Austria 1:500 000 and SRTM data, glaciers: Corine 2000 data)

Table1: Study site characteristics (* after WGMS, 2008; RY: reference year; SY: survey year)

	Obersulzbachkees	**Pasterze**
Altitudinal range	1975 - 3656 m a.s.l.	1980 - 3789 m a.s.l.
Catchment size:	22.4 km²	38.6 km²
Glacier area (2007):	11 km²	21 km²
First RY*	1871	1879
First SY*	1815	1880
Oberservations*	89	124
Lithology:	metamorphic rocks	
	mainly tonalite and gneisses	mainly prasinite, amphibolite, calcareous mica schists & gneisses
Geomorphic processes:	glacial, gravitational and glacifluvial processes	
Storage / sink elements	valley fills, debris-/talus-/avalanche cones, debris/till covered slopes	

Methodological approach

The methodical approach includes orthophoto-interpretation and detailed geomorphological field mapping to identify sediment storages and sediment transfer processes. Data on sediment thickness and the internal structures of sediment bodies will be achieved by a combination of field geophysics, in particular ground penetrating radar (GPR), refraction seismic tomography (RST) and electrical resistivity tomography (ERT). The total sediment volume stored in the forefields will be modelled by means of GIS techniques using morphometric and geophysical data complementary. Present day sediment fluxes will be monitored by hydrological methods (valley bottom, measurement of discharge, bed, suspended and solute load) and repeated terrestrial laser scanning (valley bottom and slopes). An overview of the methodological approach including the data basis, the subsequent data processing and objectives is shown in Fig. 2.

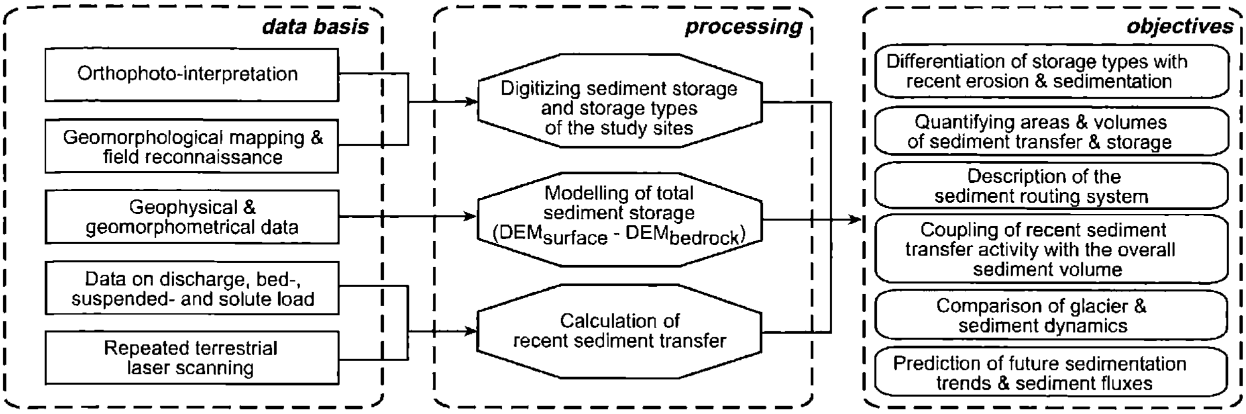

Figure 2: Flowchart of data basis, processing and objectives

Preliminary results (study site Pasterze)

Geomorphological situation

A simplified geomorphological map covers the lower part of the glacier forefield between the glacier snout and the outlet of the sandur (Fig. 3). Further mapping customized for sediment budgets will be carried out in 2009 covering the entire catchment. The catchment area excludes the hydropower reservoir (Margaritze) below the glacier.

Bedrock, glacial debris and blockfields are sediment sources on the slopes and active processes involve debris flows, avalanches, rock falls and rill erosion. In addition solifluction and landslides occur on the north facing slope. Sediments are partly reworked but also transferred to the valley floor. Affiliated to the glacier, the valley floor is characterised by gravel, variable channel patterns and small scale topographic modification. The subsequent almost round sandur is dominated by fine grained sediments. The sandur is a former lake that has been exposed by retreat of the Pasterze since the late 1950s and completely filled up by continuous glacifluvial sedimentation. The current size of the sandur is appr. 12,000 m², mean sediment thickness of the sandur area is 6.15 m, delivered by geophysical surveys. This results in a calculated volume of 785,700 m³ and mass of 1,571,400 t of sediments. To avoid high sediment input rates to the Margaritze water reservoir, the outlet of the sandur was twice dammed artificially which consequently caused high sedimentation rates.

Qualitative sediment flux model & sediment availability

The study site is roughly divided into three subsystems: (1) the slope subsystem, (2) the glacier subsystem and (3) the glacier forefield subsystem (Fig. 4). Each subsystem represents a unique set of sediment sources, transfer processes, regulators and sediment storages and creates output of material and energy that will enter one of the subsequent subsystems (CHORLEY & KENNEDY, 1971). Subsystem connectivity is provided by processes (e.g. rock fall) and influenced by regulators (e.g. slope angle). Within the subsystems, growth, persistence or degradation of sediment storages mainly depends on the processes. The spatial distribution of debris has been digitized on the basis of digital orthophotos (year 2007) and joined with the subsystems.

Current sediment fluxes in the glacier forefield

The glacial meltwater stream is the dominant path of sediment transfer through the system. Preliminary measurements of suspended load indicated that the suspended sediment budget seems to be balanced even though a specific sedimentation pattern could be revealed. During periods of decreasing discharge suspended sediment input into the sandur appear to exceed output, whereas increasing discharge causes higher sediment output. In contrast, the slope processes seem to play a negligible role for sediment output of the forefield system. The valley floor receives material through avalanches and debris flows, which remains in the valley floor and is currently not coupled to the meltwater stream. From the current observations we assume that no significant clastic output (bed load) occurs at the outlet of the forefield system, which therefore appears to be partially closed.

Discussion and perspectives

First results indicate the dynamic sedimentary situation at the Pasterze that will be linked and compared to the glacier fluctuation in the next step. Future work will mainly focus on the quantification of sediments stored in the catchment and the measurement of present day sediment transfer. By linking these recent transfer rates with both, the available sediment and the sediment routing network, we aim to predict the future sedimentary evolution.

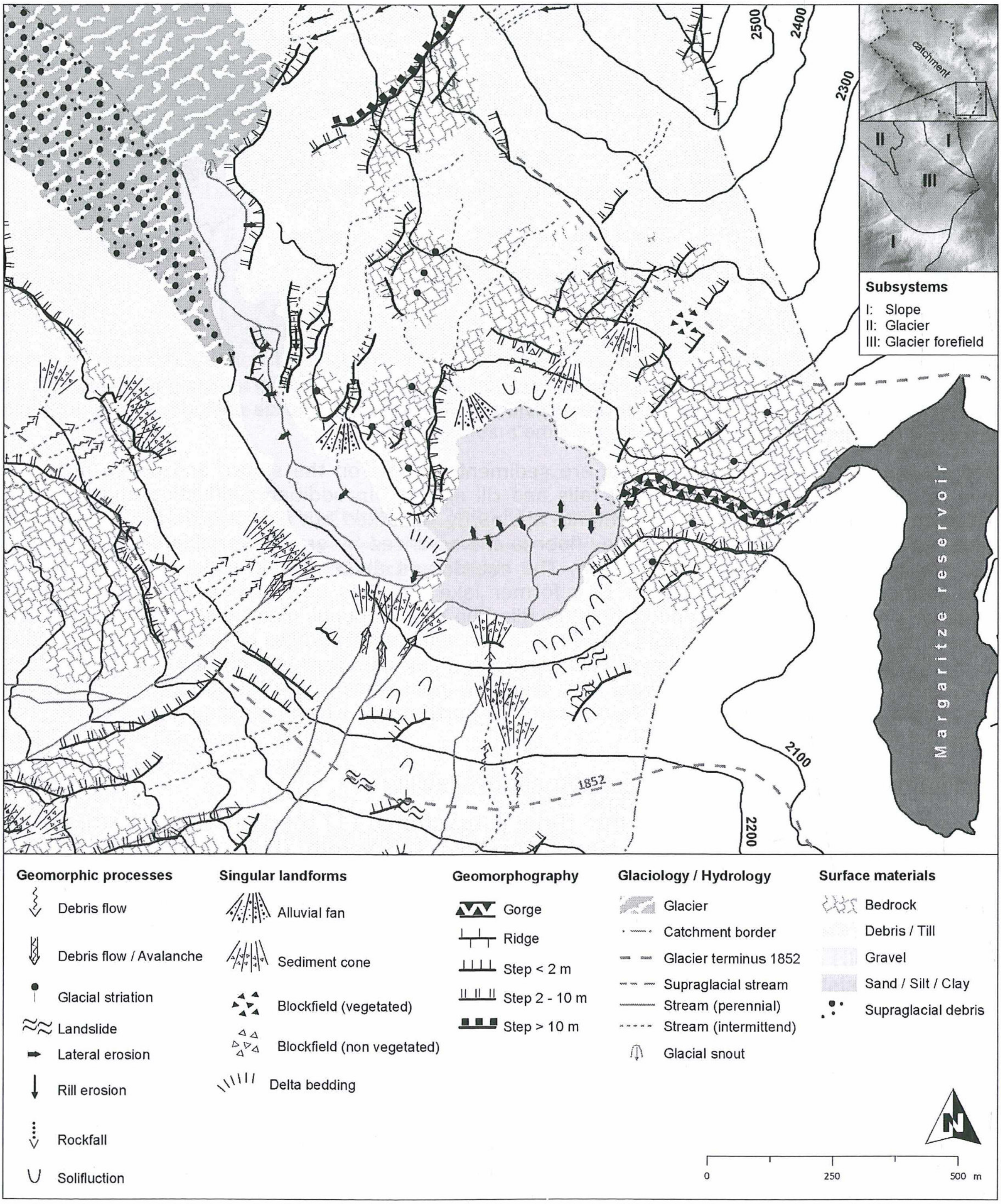

Figure 3: Simplified geomorphological map of the forefield of Pasterze glacier, data on geomorphic process domains, slope angles and curvature are not presented

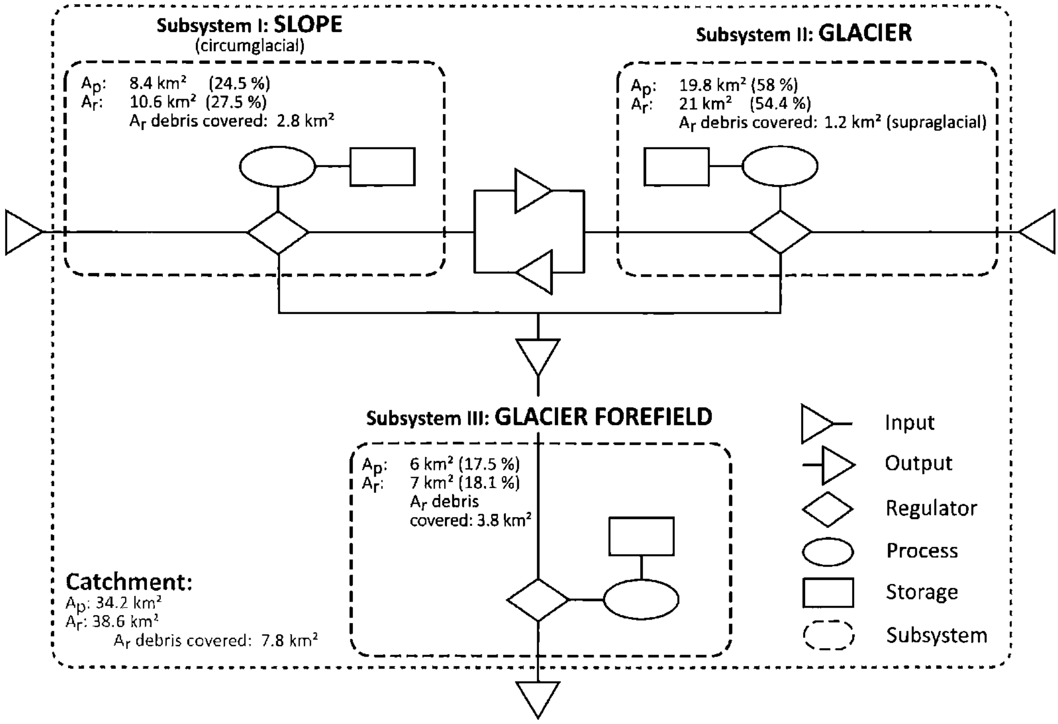

Figure 4: Qualitative sediment flux model of the forefield of Pasterze glacier. Spatial extent of the catchment and subsystems is depicted in planimetric (Ap) and real surface area (Ar), the percentage of debris cover also represents real surface areas

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Decreasing effectiveness of protected areas due to increasing development in the surroundings of U.S. National Park Service holdings after park establishment

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Keywords

protected areas; park effectiveness; road development; housing growth; landscape fragmentation; U.S. Great Lakes

Table 1: Percentage of area disturbed by roads and buildings and size of the largest contiguous undisturbed area for Indiana Dunes and Pictured Rocks National Lakeshores inside the park area, the 3.2km zone around the parks, and the total area between 1938 and 2005.

		Indiana Dunes		Pictured Rocks	
		Disturbed area (% of total area)	Largest undist. area (km^2)	Disturbed area (% of total area)	Largest undist. area (km^2)
park area	1938	14.7	3.38	1.7	176.61
	1966	16.2	3.24	3.6	83.08
	2005	17.5	2.86	3.2	143.69
3.2 km zone	1938	23.8	10.30	4.3	26.36
	1966	38.2	6.89	4.8	25.97
	2005	52.4	6.42	5.8	30.25
total area	1938	22.8	13.98	2.9	242.28
	1966	35.7	6.74	4.2	94.43
	2005	48.6	7.26	4.5	186.82

Summary

Protected areas are cornerstones of biodiversity conservation, but protected areas are in danger of becoming islands in a sea of human dominated landscapes. It has been hypothesized that protected areas may foster development in their surrounding area by providing specific amenities, thus partially causing the isolation that limits their functioning. In our study we assessed road development and building growth within and around Indiana Dunes and Pictured Rocks National Lakeshores in the U.S. Great Lakes region before and since the establishment of these two parks in 1966 and estimate the effects of park creation on changes in landscape patterns. Roads and buildings were mapped for 1938, 1966 and 2005 from aerial photographs and topographical maps for both the park area and a 3.2 km zone around each park. U.S. census housing density data from 1940 to 2000 were used as a baseline to compare observed changes with those in the broader landscape. Additionally, we quantified the effects of building growth and road development on landscape fragmentation. Our results show that park establishment was effective in reducing and stopping the fragmenting impact of development within park boundaries. However, increased

amenity levels led to enhanced development in the 3.2 km zone around both parks following park establishment with rates of change much higher than in the broader landscape. The potential amenity effect was up to 14,900 new buildings in the 3.2 km zone around Indiana Dunes between 1966 and 2005. For Pictured Rocks the absolute effect was smaller but still 20% of the observed building growth was potentially due to amenity effects. Our findings highlight the need for conservation planning at broader scales, incorporating areas beyond the boundaries of protected areas.

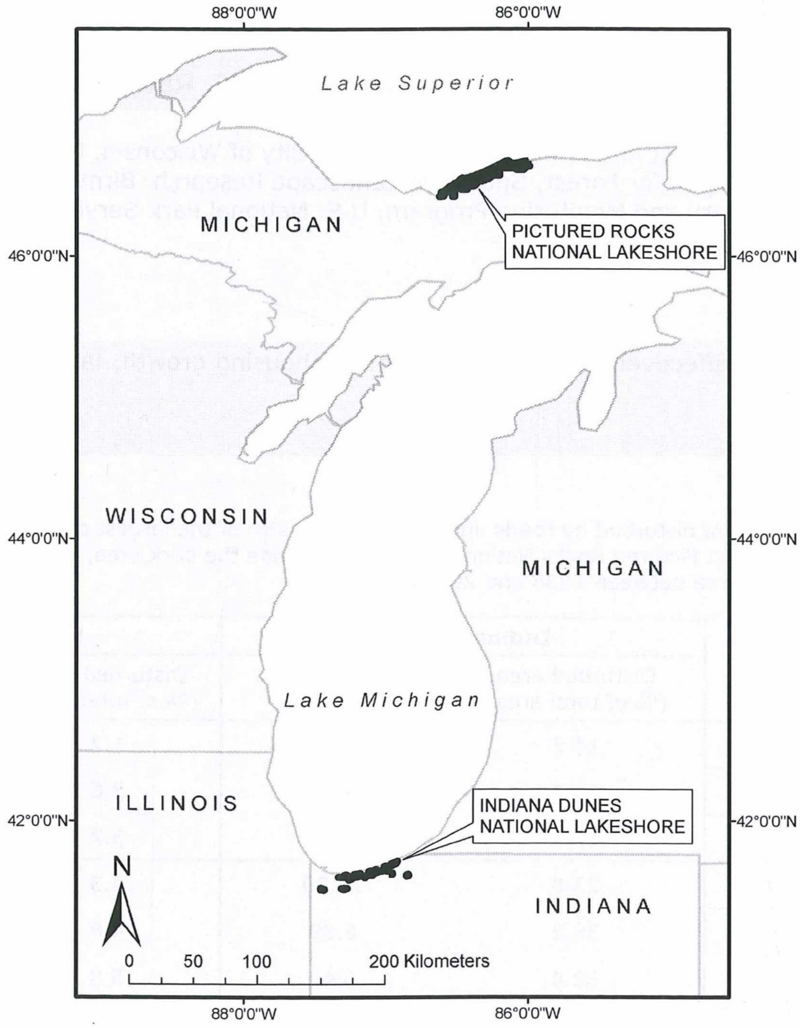

Figure 1: Location of Indiana Dunes and Pictured Rocks National Lakeshores in the U.S. Great Lakes region

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Biocultural Diversity Monitoring - The use and management of biodiversity of wild gathered plant species in the Biosphere Reserve Großes Walsertal (Vorarlberg, Austria)

Susanne Grasser, Christoph Schunko, Christian R. Vogl, Brigitte Vogl-Lukasser

Summary

Biosphere Reserves are known for their rich biodiversity. In the Sevilla Strategy 1996 it is claimed to *"reflect more fully the human dimensions of Biosphere Reserves"* (UNESCO 1995). A three years project aims to document the inextricable link between biological and cultural diversity in the Biosphere Reserve *Großes Walsertal.* From the beginning, the research process is linked to local actors and initiatives. Based on the results from 36 *Freelist* interviews (*Cultural Domain Analysis*) about gathered plant species a questionnaire was developed to send pupils from primary schools out for interviewing their parents and grandparents about topics related to gathering plants. 506 men and women from the valley participated in the survey. Almost all 20 plant species from the questionnaire (96%) were known by local people, 81% of the listed plant species were answered to be used as food or drink, in folk medicine, for customs and ornamental purposes. Semi structured interviews combined with participatory observation deepened a qualitative understanding for the cultural context in which gathering of wild plant species is embedded. This investigation provides a baseline for an ongoing monitoring process of local peoples' knowledge about wild gathered plant species in the *Großes Walsertal* to support various local initiatives and the Biosphere Reserve Management in their efforts for sustainable conservation and use of Biosphere Reserve resources.

Keywords

biocultural diversity, ethnobotany, local knowledge, gathered wild plant species, participatory methods

Duration of the project

15.05.2008 - 30.04.2011

Area of study

Biosphere Reserve *Großes Walsertal*, Vorarlberg, Austria

Introduction

In the Biosphere Reserve *Großes Walsertal* the diversity of wild gathered plant species is closely linked to local peoples' culture, profession and preferences. The establishment of the *Großes Walsertal* as UNESCO Biosphere Reserve in 2000 certainly increased local people's awareness of the value of nature. This project aims to raise people's consciousness for the worth of their local knowledge about nature, especially plants gathered in the wild, and promotes inter-generational transmission of knowledge about these plant species and their uses. It shall also highlight the role of women as users of biodiversity and their distinct forms of local knowledge. The project supports local initiatives in the Biosphere Reserve in their efforts for sustainable conservation of biodiversity and the Biosphere Reserve Management in the sustainable management of Biosphere Reserve resources.

Methods

In summer 2008, the first phase of field research, 36 persons (2 male, 34 female between 27 and 89 years old) living in *Großes Walsertal* were asked to list all plants they know which are gathered in the Biosphere Reserve (*Freelisting, Cultural Domain Analysis*; WELLER & ROMNEY 1988, BERNARD 2002, VOGL-LUKASSER et al. 2006). Sampling of the respondents was done as *snowball sampling* through recommendation (BERNARD 2002).

With the 20 most frequently mentioned plant species a questionnaire was developed for the second phase of field research to find out if these plant species are collected and used by the inhabitants of the valley. In spring 2009 all primary schools in the *Großes Walsertal* were involved with a special program for the children. After prior informed consent of the school authorities and the parents, 189 pupils were sent out for interviewing their parents and grandparents. In total 506 respondents were accessed by these pupils (146 male, 360 female between 7 and 84 years old).

Additionally, semi structured interviews and participatory observation (Bernard 2002) deepened a qualitative understanding for the cultural and historical context in which gathering of wild plant species is embedded (Grasser 2006).

Data analysis was carried out in MS Access (Microsoft 2007a), MS Excel (Microsoft 2007b), Anthropac (Borgatti 1996) and SPSS (SPSS Inc. 2006). Mann-Whitney and Kruskal-Wallis tests were applied to test if people with different sociodemographic characteristics have significantly different knowledge and habits of wild plant gathering.

Results

In the *Freelist* interviews 142 different plant species were mentioned as being gathered in the Biosphere Reserve *Großes Walsertal*. The 20 most frequently mentioned plants were *Alchemilla alpina, Alchemilla vulgaris agg., Calendula officinalis, Sambucus nigra, Achillea millefolium agg., Hypericum perforatum, Rhododendron sp., Urtica dioica, Rubus idaeus, Mentha sp., Plantago lanceolata, Arnica montana, Primula sp., Abies alba, Matricaria chamomilla, Thymus sp., Salvia officinalis, Trifolium pratense, Taraxacum officinalis, Vaccinium myrtillus* (Table 1).

Table 1: The most frequently mentioned wild gathered plant species in the Biosphere Reserve *Großes Walsertal* (Freelists, n=36, frequency >15, in total 892 plants were mentioned).

German Name	Scientific name	Frequency	Rank	Smith's S
Silbermantel	*Alchemilla alpina*	30	8.233	0.588
Frauenmantel	*Alchemilla vulgaris agg.*	30	8.800	0.575
Ringelblume*	*Calendula officinalis*	29	10.621	0.490
Schwarzer Holunder	*Sambucus nigra*	29	13.931	0.388
Johanniskraut	*Hypericum perforatum*	28	11.893	0.465
Schafgarbe	*Achillea millefolium agg.*	28	10.821	0.474
Alpenrose**	*Rhododendron sp.*	26	11.308	0.413
Brennnessel	*Urtica dioica*	23	11.348	0.382
Himbeere*	*Rubus idaeus*	22	15.227	0.301
Pfefferminze*	*Mentha sp.*	21	10.762	0.379
Schlüsselblume***	*Primula sp.*	20	12.050	0.343
Arnika	*Arnica montana*	20	10.400	0.350
Spitzwegerich	*Plantago lanceolata*	20	10.300	0.358
Kamille*	*Matricaria chamomilla*	19	15.789	0.235
Tanne	*Abies alba*	19	12.947	0.316
Salbei*	*Salvia officinalis*	18	14.611	0.228
Wilder Thymian	*Thymus sp.*	18	12.778	0.275
Rotklee	*Trifolium pratense*	17	12.588	0.266
Heidelbeere	*Vaccinium myrtillus*	16	17.250	0.167

* Respondents were asked for „wild species gathered". Nevertheless respondents also mention species i) gathered in the wild earlier and now grown in gardens and ii) cultivated species.

** Under the term *Rhododendron sp.* are sub summarized *Rh. ferrugineum* and *Rh. hirsutum* as the respondents do not seem to distinguish in their local name "Alpenrose" between these two species. Some respondents use it as the generic term, for some respondents they are just the same plant. Only a few would distinguish between *Rhodedendron ferrugineum* and call it "Alpenrose" and *Rhododendron hirsutum* and call it "Steinrösli".

*** Under the term *Primula sp.* are sub summarized *Primula elatior* and *Primula veris.* Only few respondents distinguished between Primula elatior which they call "Schlüsselblume" and *Primula veris* which they call "Himmelschlüssel". Usually the local name "Schlüsselblume" and "Himmelschlüssel" were used similarly.

In the survey done by pupils almost all of these 20 plants (96 %) were known by local people. 81 % of the listed plants were answered to be used for drinks and as food, in human folk medicine or veterinary folk medicine and in customs, a few for "other purpose" (e.g. fertilizer, decoration) (Figure 1, Table 2). First results show that women know (Mann-Whitney-Test, p=0,000) and use (p=0,000) more plants than men. Older people know (p=0,000) and use more than younger ones (p=0,014).

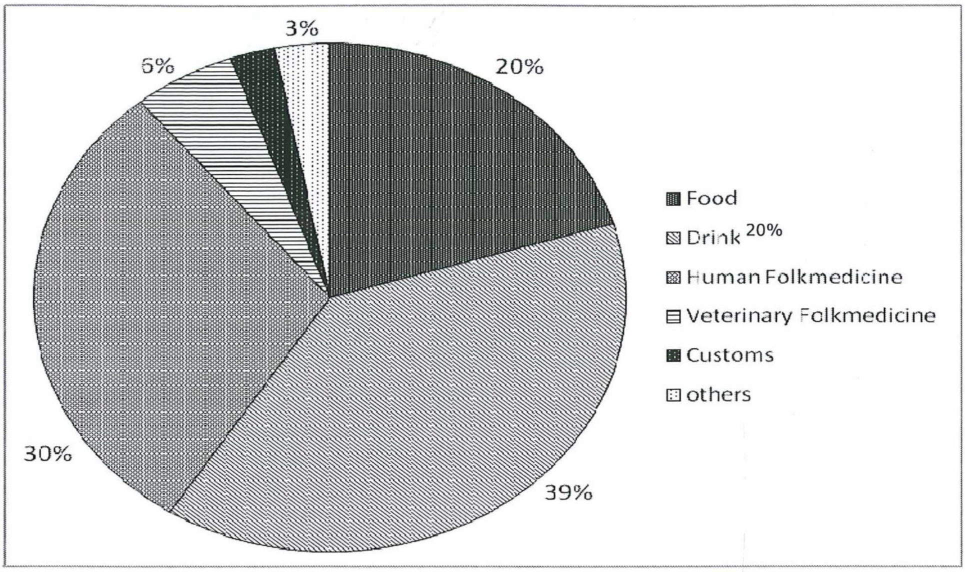

Figure 1: Percentage of mentions of different uses of plants classified according to different use in the Biosphere Reserve Großes Walsertal (Questionnaire, n=506)

Table 2: Use categories, examples of uses and of wild gathered plant species used in the Biosphere Reserve *Großes Walsertal* (Questionnaire, n=506, in total 2186 uses for the 20 plants were ticked, multiple answers possible)

Category of use	% of mentions	Examples of use	Examples of used plants
Drink	39%	tea	leaves from *Melissa officinalis*
		syrup	flowers from *Sambucus nigra*
		liqueur	berries from *Vaccinium myrtillus*
		schnapps	roots from *Gentiana lutea*
Human folkmedicine	30%	tea against cough	flowers from *Tussilago farfara* or *Primula veris*
		ointment	flowers from *Calendula officinalis*
		oil	*Hypericum perforatum*
		schnapps	flowers from *Arnica montanum*
Food	20%	"honey"	young sprouts from *Abies alba*
		"spinach"	*Urtica dioica*
		salad	leaves from *Taraxacum officinalis*
		spices	*Thymus sp.*
Veterinary folkmedicine	6%	tea against diarrhoea	flowers from *Matricaria chamomilla*
		ointment	
		oil	
		schnapps	roots from *Osthruthium peucedanum*
Customs	2%	„Alpabtrieb" incense	*Rosmarinus officinalis, Juniperus communis*
		blessed herbs (e.g. at Easter)	*Salix sp.*
others	3%	insecticides against moths	*Lavandula angustifolia*
		decorations such as bouquets	*Rhododendron sp.*
		flowers in salad bathing, hair washing	*Bellis perennis, Urtica dioica*
		herb-cushions	*Valeriana officinalis*
		"Krisimann"	*Prunus avis*
		incense in the beehouse for disinfection	*Tanacetum vulgare*

Additional comments in the questionnaire point out the importance of transmitting plant knowledge to the children (*"dass das Wissen über Kräuter und deren Verwendung den jungen Menschen weitergegeben wird"*). Interviewees also highlighted the great treasure of nature which has to be appreciated and which requires a respectful and sustainable management in use (*"dass die Kräuter, Gräser und Früchte der Natur geschätzt und in Ehren gehalten werden; dass auch unsere Kinder lernen, dass es etwas besonderes ist und unser Gott das alles uns gibt"*). They seem to have a great awareness for their environment and high ethical perception when gathering wild plants (*"dass meine Kinder behutsam mit der Natur umgehen"*). Therefore it often was mentioned to take good care of nature also when you are taking something away from it.

People's respect for plants is also demonstrated in traditional sayings:

"Vorr m a Holderbomm sött ma da Huad aobneh."

(translated as: "You should pull your hat and bow to an elder tree.")

As one example, people in the valley use the flowers, berries and leaves of the elder tree (*Sambucus nigra*) for different purposes and seem to adore it as a very beneficial and valuable, almost sacred plant. Furthermore, some respondents explain that if an elder tree is growing close to your house the lightning won't strike it. Hence, as shown with this example, plant knowledge and use is closely linked with cultural beliefs and values.

Conclusion

The intergenerational transmission of knowledge is an indicator for the value and vitality of knowledge. This has significant implications for the continued use, and thus sustainability, of aspects of culture that contribute to biodiversity conservation (MAFFI 2008).

Involving schools in data collection raised the consciousness of many local people in the Biosphere Reserve *Großes Walsertal* concerning the issue of plant gathering and use. When children and grandchildren asked older people about plant gathering, the adults became aware that their knowledge is not "just common and nothing special", as they often mentioned, but absolutely worth to be transmitted. The children themselves got curious about plant gathering and started to perceive their surrounding nature with more open eyes. The results were disseminated to and through the children in schools and in the local newsletter from the Biosphere Reserve to carry on the discussion. The school project initiated a process of exchange and transmission of knowledge which is now continuing "by itself". Children are tomorrow's generation!

Figure 2: Discussing plant species by means of puzzle-pictures, dried and fresh gathered plant species and several products made from wild gathered plant species with children in the primary school Blons, Großes Walsertal (Photo: Stähele 2009)

Figure 3: Woman collecting „Bärlauch" (Allium ursinum) (Photo: Grasser 2009)

Figure 4: „Alpabtrieb"- going down with livestock from Alpe Laguz to Raggal (Photo: Grasser 2008)

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Markus and Steff – Ibex Research in the Hohe Tauern National Park and the Swiss National Park

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Summary

Ibex have been radio tracked in the Swiss National Park and the Hohe Tauern National Park. The scientific interest was mainly to get data about the using of habitat, but also to find out whether there are differences in the utilisation of natural habitats lying in different alpine areas with diffferent climatic conditions. At the moment there are approximately 1,000 ibex living within and close to the park-borderlines of the Hohe Tauern National Park and another 300 animals within the Swiss National Park. It can be said that ibex preferably use mountainsides facing south or south-west in the Hohe Tauern Region as well as in the Swiss National Park. The area of activity is larger in the Hohe Tauern but migrations before the mating season are done by older males in the Swiss Park. Future scientific research will discuss the question whether different categories of nature conservation and/or population structures are responsible for this different behaviour.

Key words

ibex, habitat use, migration, Swiss National Park, Hohe Tauern National Park

Area of study and methods

Ibex have been radio-tracked in the Swiss National Park since 2003 as well as in the Hohe Tauern National Park since 2005. The climate and the weather conditions in the Swiss National Park can be characterized as an „inner alpine dry zone" while the total annual precipitation in the Hohe Tauern range is much higher especially in the northern parts of the park. In order to document the migrations of individual animals and also the connections between meta-populations, ibexes in both areas were equipped with GPS-GSM transmitters which deliver periodically the geographical position of every single animal every four hours via mobile communications network to different institutes, where these data are collected and scientifically discussed.

Results

As the first results show, the areas of activity of males range from 2,000 to 13,600 hectares in the Hohe Tauern and is on average of larger size than in the Swiss National Park (analysis via MCP) where areas between 1,960 and 3,590 hectares could be identified. What also could be seen so far is that in both national parks mostly young males are exploring their home ranges by covering great distances. Significant translocations take place especially before winter and summer. Before the rutting season some males move around over wide distances. In this case interestingly the males in the Swiss National Park in average are older then the males in the Hohe Tauern National Park. This difference may be caused in the dissimilar age structure of the populations.

In the Hohe Tauern National Park also a male could have been radio tracked before its release. Another male was captured two years after its release. Both males have been born in a zoo. In comparison to ibex born in the wilderness these two males show much smaller home ranges. It seems that the largeness of their home range is growing up with the length of their living in wilderness. As the data show, probably traditions built up near to the release place are playing a big role for these animals. So the home range of the male released with the transmitter represents only an area of 300 hectares in the first six months. But these area was already affected by a migration which takes one week. The rest of the time the male remained always near the release place. The two released males are sometimes also remain in different, lower seated altitudes than other ibex. It seems that this fact is also influenced through the site of the release place.

Discussion

Not only the deviant behaviour of male ibex, also the analysis of a maybe different use of habitats situated in nature reserves of different categories is of great scientific interest. The Swiss National Park is listed as IUCN-Kategory I (Wildnerness) without any human influence while the Hohe Tauern National Park is IUCN-Category II, which means that human influence is possible and also takes place in The Hohe Tauern (especially alpine livestock farming). Does human activity have any impact on the use of habitats by ibex? The upcoming research work will focus on this topic. One reason for the behaviour of the ibex in The Hohe Tauern Range, namely that there is a competition between ibex and livestock, cannot be excluded so far. Therefore detailed investigations concerning the questions which habitats are used by ibex and which by livestock are necessary. The basis therefore is a standardized surveying and mapping of habitats, which already exists spatially inclusive and comprehensive.

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No sustainable conservation of biodiversity without connectivity

Establishing Ecological Networks throughout the Alps

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The Alps are one of the largest natural regions left in Europe and therefore of particular importance for biodiversity; but they are also home to 14 million people and one of the most visited areas in the world. This is not without impact on biodiversity. Habitat loss and fragmentation, climate change, changes in agricultural practices and pollution are among the most important reasons for biodiversity loss and landscape destruction in the Alps. The creation of a functioning ecological network in the Alps can help to conserve extraordinarily rich alpine diversity. Two closely linked initiatives are working together to implement an ecological network: on the one hand the Ecological Continuum Project initiated in June 2007 by the Alpine Network of Protected Areas (ALPARC), the World Wide Fund for Nature (WWF), the International Scientific Committee on Research in the Alps (ISCAR), and the International Commission for the Protection of the Alps (CIPRA); on the other, the Ecological Network Platform of the Alpine Convention and the European Interreg (ETC) Project ECONNECT gathering more than 16 partners.

The concept of ecological corridors

Naturally and sufficiently large habitats constitute the core areas of an ecological network. These core areas can be connected to one another, for example through "ecological corridors" (Figure 1). Ecological corridors are linear connection elements allowing the passage of species between different living spaces, thus enabling genetic exchange between populations. Corridors are made of landscape elements and small features such as field ditches, forest strips or forest edges, dry stone walls, and rock piles. Sustainably managed farm- and woodland can also function as a corridor, and small but well preserved biotopes create stepping stones in a corridor system. Especially in areas where human land use has created barriers, connecting elements must be preserved or re-established. Ecological networks are not only beneficial for fauna and flora but also for people. Meadows and pastures lining a stream contribute effectively to flood protection; revitalization of water courses can turn jogging or a Sunday hike into an exciting nature experience; sustainably managed forests provide effective protection against avalanches; in heavily settled valley floors, ecological corridors act as green lungs and therefore provide better air and attract tourists. A well-structured landscape can define the character of an entire region. However, networking can also entail risks: endemic species —i.e. species occurring only in the Alps— can be threatened by invasive species dispersing along the connecting elements. The quality of ecological corridors therefore plays a crucial role in minimizing this risk.

A multisectoral and multilevel challenge

Ecological connectivity is best attained through sustainable land use as well as harmonious coexistence of humans and nature, rather than restrictions or prohibitions. Many nature protection measures can contribute to ecological networks, provided they are promoted and supported by policy-makers at local, regional, and national levels in a coherent way:

Land use and traffic planning: Even if ecological networks cannot be established without high-level decision making, their implementation requires local consensus. Land use and traffic planning play a key role in this context. Connectivity and other land use interests have to be considered on equal terms, at the outset of the local and regional planning process (municipalities, regional authorities).

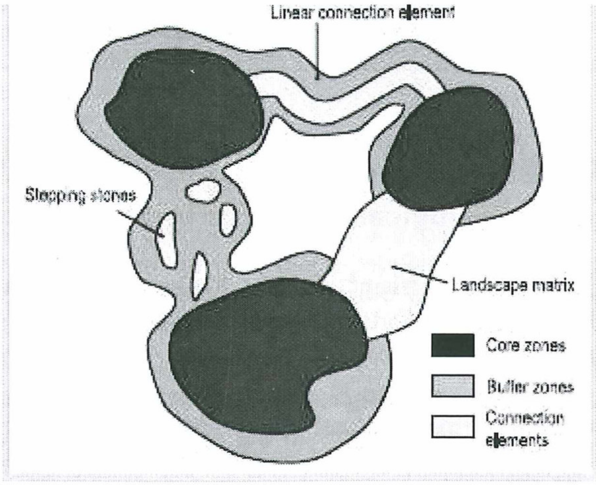

Figure 1: The concept of ecological corridors
(© Continuum Project)

Agriculture—the backbone of the landscape: Farming has a crucial impact on biodiversity in the Alps. Many habitats originated from traditional human land use (Figure 2). Intensive agriculture and urban expansion on valley floors can create obstacles to fauna migration. On the other hand, traditionally farmed fields at higher altitudes have outstanding biodiversity value. The latter are increasingly threatened by abandonment of farming practices. It is therefore crucial to engage farmers in networking projects. Thorough information will make farmers aware of the importance of connecting habitats. Their work practices can thus be adapted to the needs of biodiversity and connectivity.

Hunters and foresters: Hunters and foresters can be ambassadors for ecological networks based on their traditional role and activities. Sustainability plays a significant role in their line of work. In this respect, they play an important role in raising people's awareness of the importance of sustainable forest and wildlife management.

Water management: Water courses are considered linear connecting units in ecological networks, providing animals with shelter and food. They also help in orientation during migration. This important role can be secured in the long run only by conserving well-maintained river courses, ensuring high-quality water, and revitalizing riparian zones. Functional floodplain forests and wetlands play an equally important role.

People: Ecological networks are not only a large-scale matter. Everyone can contribute, for example by tending a near-natural garden, using areas in a sustainable manner, or hiking in a more nature friendly way.

Well connected habitats are important beyond the local scale. Some species, such as the wolf, the lynx, and the bear, need wide natural areas. This also applies to large ungulates such as deer, and large birds such as the bearded vulture and the golden eagle. To conserve these species in the Alps, collaboration is needed. Concrete actions for the establishment of an ecological network, however, will occur predominantly at the local level. The impact of global phenomena such as climate change is increasingly significant and therefore requires the development of a pan-Alpine strategy. Establishing an ecological network can be a cornerstone in a consistent response to global climate change. Facilitating the passage of species displaced by shifting climatic zones will help them find new suitable habitats and allow them to modify their range, thereby improving their chances of survival.

The Ecological Continuum Project

ALPARC, CIPRA, ISCAR, and WWF's European Alpine Programme have been carrying out joint activities for the conservation of Alpine biodiversity since 2002. The 4 organizations introduced a new approach to Alpine nature conservation by looking at biodiversity from an Alps-wide as opposed to a national perspective. Taking this approach a step further, a new project— the Continuum Project financed by the Swiss MAVA Foundation for Nature—was started in June 2007 with the aim of creating or restoring ecological connectivity between important areas for nature conservation. Foundations are currently being developed in a pre-project (until end 2008) for long-term implementation of a consistent ecological network in the Alps. The findings of the Swiss National Research Programme NRP48, "Landscapes and Habitats of the Alps," are being integrated.

One important objective of the pre-project is to elaborate a joint Alpine methodology for connecting important areas and develop a catalogue of possible measures to enhance connectivity. In a first step the Continuum Project evaluated and assessed methodological approaches currently used or proposed for establishing ecological networks. Four approaches—the Pan-European (PEEN), the Swiss Ecological Network (REN), WWF's Ecoregion approach, and ALPARC's Protected Area approach — assessed by 16 experts (scientists as well as members of the Ecological Network Platform), based on a questionnaire. The suitability of the 4 approaches differs clearly regarding aims, scale, data needs, and implementation. The results of the expert assessment were verified in a workshop in December 2007 in Zurich (Switzerland), leading to recommendations on priorities (where are ecological networks most needed), methodology (what are the most appropriate approaches to achieve the different goals), and procedure (how can regional projects for ecological networks be developed). A second objective of the Continuum Project is to carry out initial concrete actions in 4 pilot areas. The areas are dispersed across the Alpine Arc (Figure 3, showing the Alpine Arc and one pilot region).

Figure 2: A well-structured landscape offers a habitat for a variety of species
(Photo courtesy of Continuum Project)

Berchtesgaden–Salzburg transboundary region:

This comprises the Hagengebirge, the Salzburger Kalkhochalpen nature reserves, and Natura 2000 sites. The area is of great environmental interest and part of one bio-geographical entity. Many transboundary cooperation projects such as data exchange and scientific research already exist. With the Continuum Project this cooperation is now being broadened.

The eastern Austrian region:

The region around the Kalkalpen and Gesäuse national parks, with its large forest cover, small cultural landscape structures, low fragmentation, and high biodiversity is perfectly suited for the project. In addition, the area is an important link to other Alpine regions and the Carpathians (Figure 3). Based on the results of the 2004 ALPARC study, the Kalkalpen and Gesäuse national parks and other protected areas have already initiated the establishment of an ecological network.

Engadin–Alto Adige–Valle dell'Adige:

This pilot region will consider connectivity in two areas at the border between Italy and Switzerland. The first area runs along the Adige River valley, which is densely populated and intensively used by irrigated agriculture, and the Inn valley, which crosses migration routes from the south and east. The second area aims to connect existing protected areas: Adamello Brenta–Stelvio–Swiss National Park, and from the Nature Parks in South Tyrol (Italy) to the Hohe Tauern National Park in Austria. For these protected areas a main concern is to establish transboundary ecological networks to assure biological exchange and large migration areas (eg for brown bear).

The French Département de l'Isère:

The Département de l'Isère in the French Rhône-Alpes region is an intensely anthropized area with a strong need for rapid intervention to prevent human settlement from spreading continuously from Valence to Geneva. The valleys of this region are main migration routes of pan-Alpine significance—especially for birds; they are also of great importance for local migration of individual species between the regional massifs and the main large protected areas (Les Ecrins National Park, and Vercors, Chartreuse, and Bauges nature parks). The Département de l'Isère has been working on ecological networks since 1996. A map of all ecological corridors in the region has been serving as a basis for various implementation activities such as bridges and tunnels for game, speed limits, public relations work, and integration in planning processes. For all future Alpine projects it is extremely valuable to capitalize on this experience.

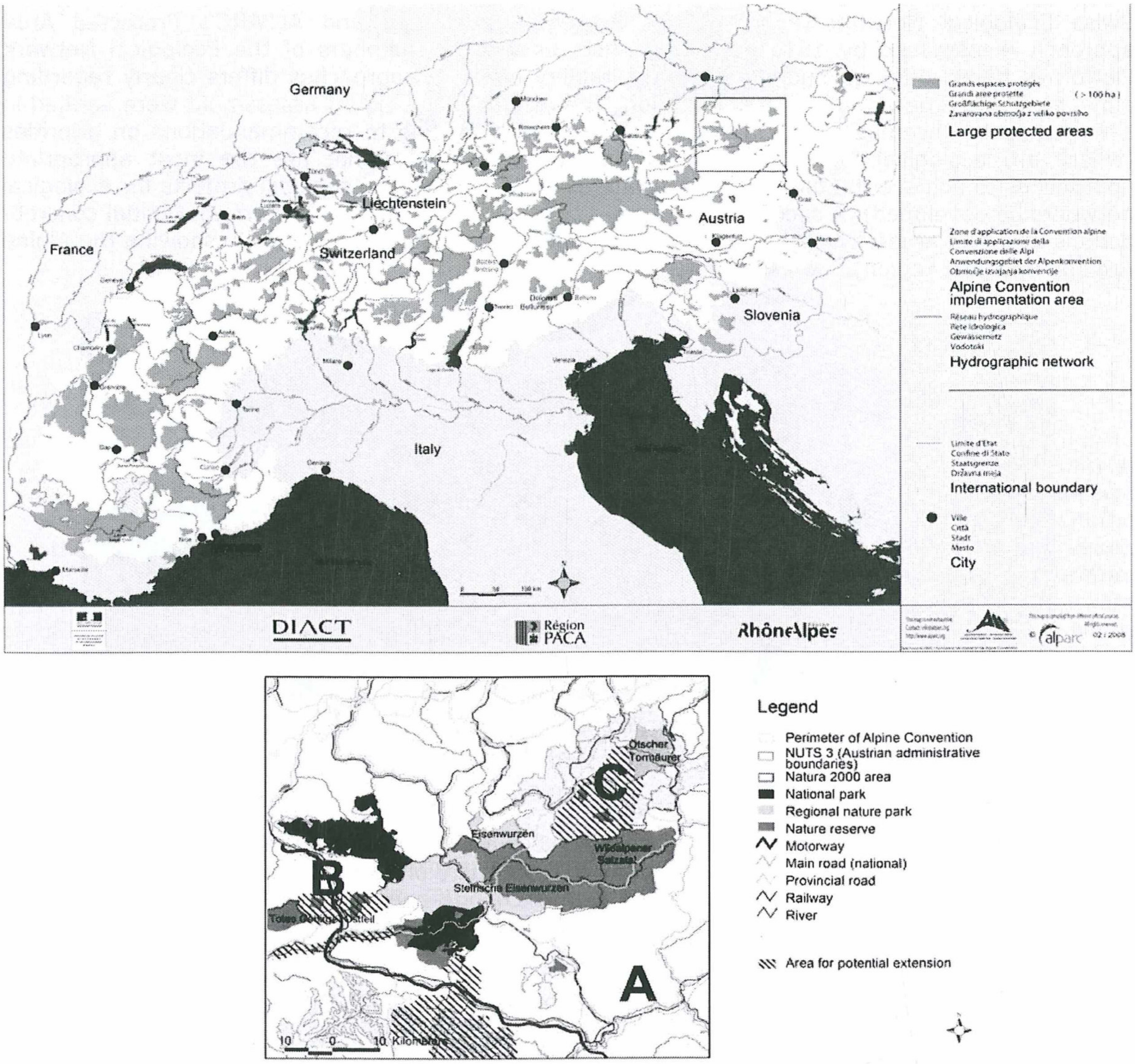

Figure 3: Protected areas in the Alps and location of one of the 4 pilot areas
(© Continuum Project)

The Ecological Network Platform

The Ecological Network Platform is a key instrument for implementation of the nature protection goals of the Alpine Convention; its aim is to help partners advance work on an Alps-wide ecological network. The Platform was established under the Alpine Convention in 2007. The Platform members are expert governmental staff from all Alpine countries, as well as observers from the Alpine Convention and NGOs. The goal of the Platform is the establishment of an Alps-wide transboundary network of protected areas and their respective connecting elements by engaging with experts, policymakers, and other relevant groups. Through the Platform, crucial information on measures and methodologies are being shared, refined, and compared between all Alpine countries. The Platform provides an important link between policymakers, the scientific community, and practitioners, and also enables efficient cooperation with other sectors. Within the Platform, experts work in 3 key activity areas: scientific support for the establishment of an ecological network, project-oriented implementation, and promotion of an Alpine-wide ecological network. Concrete tasks are the enlargement and integration of transboundary protected areas within the framework of existing activities, for example the development of the Natura 2000 and Emerald networks; the elaboration of methodologies for the connection of habitats, and support for the implementation of connection measures for Alpine species and habitats. Some regions have already started transboundary work. These efforts are being supported and further developed through Platform activities.

The fist phase of the platform (2007-2008) can be seen as build-up phase, where the focus was on promoting the platform and its possibilities, gaining new members and associates and initiating first activities. Due to the approval and start up of two extensive projects in the field of the ecologic networks in the Alps during the build-up phase of the platform (Ecological Continuum project and ECONNECT), funds were available to elaborate basic information and to carry out concrete measures. For the platform as a permanent body in the frame of the Alpine Convention, the following general role emerges:

as interface for the cooperation between actors working on research and development and national and international political decision-makers and administrations (communicating scientific outcomes and the needs for action to decision-makers)

as "think tank" for the identification of further important steps towards the construction of an ecological network in the Alps

as coordinator for potential project partners

This role emerges from the unique composition of platform members and associates and should be further developed in future. In regard to the mandate for the platform's first phase mentioned above, the following tasks arise for a future mandate (2009-2010):

supplementation of the catalogue for measures for the implementation of the ecological network and support on its use

development of indicators for efficiency control of the implementation of the ecological network in cooperation with partners

nomination and support for additional pilot areas on the basis of the selection and nomination concepts (e.g. scientific steering of beginning processes for exemplary implementation of networking measure in the pilot regions

further determination of financial sources for measures to implement the ecological network and identification and as the case may be elaboration of recommendations for joint projects within the platform

continuing the exchange and cooperation with different projects, relevant initiatives from the EU COM and the Council of Europe as well as the Carpathian Convention and the CBD

Furthermore the following activities are recommended for the period between the X. and XI. Alpine Conference:

further implementation of the Memorandum of Cooperation between the Alpine and Carpathian Convention and the CBD

using the year 2010 as UN year of biodiversity to advert the activities for the establishment of an ecological network in the Alps (e.g. participation in conferences and other events).

the experiences and results reached so far in the implementation of an ecological network in the Alps shall be documented as a toolkit for implementation in the series "Alpensignale" and by this be brought to a wider public in the alpine languages

implementation of the platforms communication strategy and further development of the website

support coordination in the field of data management as currently carried out by different initiative (EU, ECONNECT, Ecological Continuum, SOIA, etc.) and e.g. offering a workshop for experience exchange

in order to fulfil the specific function of the platform as interface to decision makers, ensure the participation of contracting parties to the Alpine Convention in platform meetings (if necessary through representatives).

The ECONNECT project

Conservation of biodiversity by an integrated and cross-sectoral approach for improving the ecological continuum within the Alpine region is the over-reaching objective of the Econnect project. Econnect is financed mainly by the EU Alpine Space Programme. Sixteen partners from six Alpine countries joined to implement a common methodology for the conservation of the natural heritage of the Alps: ecological connectivity will be enhanced by overcoming legal and ecological barriers while considering cross-boundary and super- national needs for action. The project's emphasis is on the implementation of measures in pilot regions in order to then magnify the results by way of guidelines and best-practice dissemination. The ECONNECT project has became operational in September 2008 and will run until the end of August 2011.

Two new Pilot regions are part of the ECONNECT project additionally to the 4th already existing ones of the Continuum project:

The area of "Hohen Tauern":

In this region the south Tyrolean Natural Parks as well as the National Park "Hohe Tauern" builds the largest cohesive protected network area in the Alps. Therefore this region is central for the alpine arc and an important intersection between the northern Alps and the southeast foothills in Slovenia which are specifically important for the large birds of prey. This area also represents the transition from the greater areas of the dolomites to the "Hohen Tauern".

South-east Alps – Mercantour/Alpi Marittime:

This pilot region is located at the southwest end of the alpine arc in the French region Provence-Alpes-Côte-d'Azur and the Italian region Liguria and Piedmont. The Natural Park Alpi-Marittime on the Italian side and the National Park Mercantour on the French side together build one geographical unit. Both regions are also close to each other culturally, so that one can speak of a single local unit. Therefore the transboundary cooperation in this region has a long tradition. The area plays an important role as a connection to the other Italian mountain ranges (Apennines).

Benefits beyond the Alps and for global biodiversity conservation

While endeavoring to establish or maintain an ecological network in the Alps, connectivity to adjacent mountain ranges cannot be neglected. The Alps–Carpathians corridor, for example, is vital for large carnivores. Connections with the Balkan mountain areas or the Apennines, as well as the French Central Massif, the Pyrenees, and the Jura play a key role for the dissemination of many species. Admittedly, the idea of ecological networking is nothing new. Many conventions, agreements, and initiatives already exist, although awareness of these is sometimes lacking. Internationally, all Alpine countries have committed to the conservation and sustainable use of biodiversity through the Convention on Biological Diversity (CBD). Mountain regions belong to the areas in the world with the highest biodiversity; ecological networks extending over the whole Alpine Arc can therefore make an important contribution to fulfilling global commitments. At the European level, things are becoming even more concrete: a pan-European ecological network is currently being established, in which the Alps will play a key role. The identified Natura 2000 or Emerald sites in the different countries are important building blocks of this project. International collaboration is particularly important for ecological networks. The governments of the Alpine countries are therefore collaborating with conservation organizations and the scientific community within the framework of the Alpine Convention for the implementation of ecological networks enabling undisturbed natural processes. A comparable process is on the way in the East European Countries within the framework of the Carpathian Convention and the Carpathian Network of Protected Areas (CNPA)

Further information

Website of the Ecological Network in the Alps: www.alpine-ecological-network.org

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Between propaganda and preservation: The Italian National Parks in the Alps

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Summary

This essay looks at the early history of the two most ancient Italian Alpine national parks: the Gran Paradiso and the Stelvio. Central in this investigation is the analysis of the role of preservation, tourism and propaganda in the constitution of both parks, with comparative remarks to other planned parks and paying attention to conflicts between parks and local population under Fascist rule. As a general trend the early history of Italian Alpine preservation shows that the parks have not always followed ecological interest, but often just the aims of propaganda and tourism promotion.

Keywords

Gran Paradiso, Stelvio, tourism, mountaineering, national identity, rare species

Even if traditionally Italy lacked an Alpine culture, and wilderness in general was perceived as dangerous and unhealthy, there are at least two symbolic reasons and a practical one that have stimulated the attention for nature preservation on the Alps: their role as "wardens of the fatherland", the value of some particularly rare animal species, such as the ibex or the brown bear, as icons of the uniqueness of Italian nature, and the promotion of tourism.[1]

Nonetheless, the idea of national parks did not have an easy start in Italy. One prominent preservationist, mainly interested in landscapes and natural monuments, even wrote: "I do not think that the presence of an ibex makes the natural framework more beautiful".[2] However in the 1910s the idea got momentum and about twenty-five parks were proposed, including at least four Alpine parks: one in the Graian Alps, two in Trentino, and another in the Venetian Alps.[3] One of the earliest, unsuccessful, plans was for a park in the Livigno area, that would have constituted a sort of buffer area for the Swiss National Park. The project obtained the support of some important Italian preservationists, even if they held that in the area there were no peculiar elements of flora or fauna to preserve and that the valley was geographically not part of Italy. The idea was probably that any park was better than no park.[4]

The first Italian national park, the *Parco Nazionale Gran Paradiso*, was established only in December 1922 in a completely different area: the Graian Alps, north of Turin. The debate about the institution of a park in this region, at the same time physically at the extreme periphery of the Italian state and symbolically at the centre of its history because of its bonds to the Royal House,

[1] G. Andreotti, *Scorci di uomini in movimento. Migrazioni, Pellegrinaggi, Viaggi* (Trento: Valentina Trentini, 2006), 256; G. Zanetto, F. Vallerani, S. Soriani, *Nature, Environment, Landscape: European Attitudes and Discourses in the Modern Period, the Italian Case 1920-1970* (Padova: Università di Padova, 1996), 66-67; J. Sievert, *The Origins of Nature Conservation in Italy* (Bern: Peter Lang, 2000), 101-16. The quotation is by Quintino Sella and cited in A. Pastore, *Alpinismo e storia d'Italia. Dall'Unità alla Resistenza* (Bologna: il Mulino, 2003), 18.

[2] Giovanni Rosadi, quoted in F. Ventura, Alle origini della tutela delle «bellezze naturali» in Italia, in *Storia Urbana* 40(1987), 26.

[3] J. Sievert, *The Origins of Nature Conservation*, cit., 173; L. Piccioni, *Il volto amato della Patria. Il primo movimento per la protezione della natura in Italia 1880-1894* (Camerino: Università degli Studi, 1999), 198.

[4] A. F. Saba, Cultura, natura, riciclaggio. Il fascismo e l'ambiente dal movimento ruralista alle necessità autarchiche, in A.F. Saba-E. Meyer (eds.) *Storia ambientale. Una nuova frontiera storiografica* (Milano: Teti Editore, 2001), 81; F. Pedrotti, *Notizie storiche sul Parco Nazionale dello Stelvio* (Trento: Temi Editrice, 2005), 46; R. Pampanini, Per la protezione della flora italiana. Relazione presentata alla riunione generale della Società Botanica Italiana in Roma (12-16 ottobre 1911), in *Bullettino della Società Botanica Italiana*, XX, 7(1911), 57; Lino Vaccari, Per la protezione della fauna italiana. Comunicazione alla Società Zoologica Italiana, in *Bollettino della Società Zoologica Italiana,* s. III, I, 1-4(1912), 60.

had gained momentum because of the King's 1919 decision to donate his hunting reserve on the Gran Paradiso massif, provided that the State created there a park. Managed by an autonomous scientific commission the park focussed on research and the conservation of ibex. As the previous Royal hunting reserve, it was however based on a complex system of tenancies with private landowners, an issue that led to a state of constant conflict about hunting and grazing rights between park and local communities. This partially jeopardized the park's ability to pursue its tasks in nature conservation.[5]

The government lost soon interest in the park, and the management was left to the scientific commission, which obtained a rather positive record: ibex population increased between 1922 and 1933 by more than 60%, reaching 3865 units.[6] Disrespect for the park's role as wildlife refuge under Fascist rule went as far as allowing the Army to perform military drills within it and starting in the 1930s the sale of hunting permits. In 1934 the park's autonomous administration was disbanded and put under the control of the paramilitary *Milizia Forestale Nazionale*, as to allow the regime to create an eminently Fascist approach to nature conservation. This marked the temporary end of the park's role in ibex conservation and the beginning of a period of decline: by the end of WWII the ibex population had plummeted to only 419 units. Moreover the change caused a renewed upsurge in conflict with local population.

The *Parco Nazionale dello Stelvio* in Trentino was established in April 1935, with the statutory aim to preserve the environment and promote tourism, in an area that – having been until less than 20 years before under Austrian rule – was particularly representative of the role of the Alps as ramparts of Italian national identity. Various plans for a similar endeavour, focussing however mainly on the neighbouring Livigno valley or the Adamello-Brenta massif, had been made since the beginning of the century. In the case of Livigno, the area was preferred, as we have seen, because of its continuity with the Swiss National Park and, not incidentally for the plans made before WWI, because it was already part of Italy. The first of many projects for a national park on the Adamello-Brenta, hosting an endangered brown bear colony, was drafted in 1919.[7]

Even if the area presented some exceptional natural features, such as the only deer colony in the central Alps, the real aim of the Stelvio park, planned by representatives of the *Club Alpino Italiano* and the *Touring Club* and then managed by the *Milizia Forestale Nazionale*, was not conservation but to foster outdoor leisure activities and mountaineering through the improvement of the recreational infrastructures, within a major plan drafted by the regime in those years to promote mass tourism. Another aim was to accord the *Milizia Forestale Nazionale* a further scenario to practise its power politics.[8] Even the name of the park had been chosen because it was shorter than Ortles-Cevedale, the actual name of the massif, and more effective as a marketing tool. Only fleeting hints were made to the area's environmental features, while the aim was to create a park that did not demand too much in terms of limitations as regards, for example, public works and transports. Later, one of the proponents even affirmed that he was ready to sacrifice the growth and conservation of a chamois herd if it would allow to build a road with the money saved for bans, signposts, and wardens.[9]

As a consequence of the limited role of the Stelvio park in actually preserving its natural assets, from a first cursory survey in the archives it seems that it was not felt as a direct menace to the local population's customary rights to use natural resources. Nonetheless, there were conflicts between the municipalities and the park about the issue of land management, but it seems to me that these conflicts regarded more issues of principle rather than a real impact of the park on the mountain-dwellers' rights of access and use. As far as may be confidently stated at this early point of my research it seems that the *Milizia Forestale Nazionale* was focussed on a business-as-usual policy, without even taking notice of the area's fauna, flora and natural monuments.[10]

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[5] W. Graf von Hardenberg, *Fascist Nature. Environmental policies and conflicts in Italy, 1922-1945*, Ph.D. Dissertation (Cambridge: Department of Geography, 2007), 122-183.

[6] The data on ibex population are taken from *Diagrammi delle variazioni degli stambecchi, delle guardaparco e degli amministratori del Parco Nazionale del Gran Paradiso dal 1922 al*, not dated (Archivio PNGP XI/2)

[7] F. Pedrotti, *Notizie storiche sul Parco Naturale Adamello Brenta* (Trento: Temi, 2008), 143-178,

[8] G. Bertarelli, Il gruppo dell'Ortles-Cevedale (Alpi Retiche Centrali), in *Le vie d'Italia*, XXXV, 8(1929), 621-630; P. Dogliani, Territorio e identità nazionale: parchi naturali e parchi storici nelle regioni d'Europa e del Nord America, in *Memoria e Ricerca*, 1(1998), 34; Piccioni, *Il volto amato*, cit., 265-268 and 271-275.

[9] G. Bertarelli, Il Parco Nazionale dello Stelvio. Lettera aperta al professor Renzo Videsott, in *Lo Scarpone*, November 16, 1947; Pedrotti, *Parco Nazionale dello Stelvio,* cit., 49-52.

[10] A. Leonardi, Il proporsi e il consolidarsi di una coscienza ambientale: l'esperienza quarantennale dei parchi naturali del Trentino, in *Storia e Futuro*, 18(October 2008), www.storiaefuturo.com; see also *Bollettino degli Usi Civici*, various issues, 1930-1943 and *Amministrazioni Forestali di Trento, Ispettorato ripartimentale delle foreste di Trento*, bb. 1-636, Archivio Provinciale di Trento.

Many regional parks have been set up since the end of the 1960s in the Italian Alps (e.g. the Adamello-Brenta), but it was necessary to wait 1990 before a third national park was set up in the Dolomites near Belluno, a belated realization of the park of the Venetian Alps proposed in 1919 as a refuge for an endangered colony of wild grouse.

As has been shown above both scientific research (the Swiss model) and recreation (the American model), besides the ever present defence of national identity, had a peculiar role in the planning and management of Italian parks. In particular, it may be said that, at least after 1934, propaganda and tourism superseded preservation as the main aims of Alpine parks in Fascist Italy. The combination of these factors, combined with increasing economic problems and indifference towards preservation, had foreseeable negative effects on the parks' flora and fauna in their early history.

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Nature-SDI*plus*: Nature Conservation Data through User's Eyes

Sabine Hennig, Karin Hörmanseder, Gudrun Wallentin

Abstract

When it comes to nature conservation activities, landscape planning, and protected area management (spatial) data, metadata, and according tools are almost indispensable today. In order to use, share, and reuse nature conservation data, metadata, and tools, these three components must comply with many requirements defined by the users. The interdependent elements (data, metadata, tools, and users) are described by the term *Spatial Information Infrastructure*. In Europe a nature conservation SDI is implemented by the EU-project Nature-SDI*plus* following the INSPIRE Directive. Its realisation is based upon the understanding of European users of nature conservation data, gained by a specific online questionnaire. Due to their special conditions (e.g. management authorities and infrastructure, management objective *research*) large protected areas are ideally suited to exemplify best practice for Nature-SDI*plus* considering in particular the requirements of data users.

Keywords

SDI, data, metadata, tools, user, nature conservation

1. SDI for Nature Conservation

Today, nature conservation is as an integrative part of human activities. For almost all relevant tasks like planning, management, monitoring, evaluating, and reporting spatial data is essential. Besides, being existent, available, and accessible, data must be interoperable, harmonised, standardised, and *cross-border*[11] etc. In Europe data use is currently hindered by e.g. incomplete and inconsistent data availability, difficult, or missing data access, data fragmentation, different geographical scales of data, and duplication of data collection (URL 1). To comply with these deficits, at national and at EU level awareness is growing on the need for a European Spatial Information Infrastructure (SDI). Thereby, SDI is defined as a framework of spatial data, metadata, users, and tools (= applications & services) for e.g. geoprocessing, viewing, connecting and downloading of maps and data (see Fig. 1).

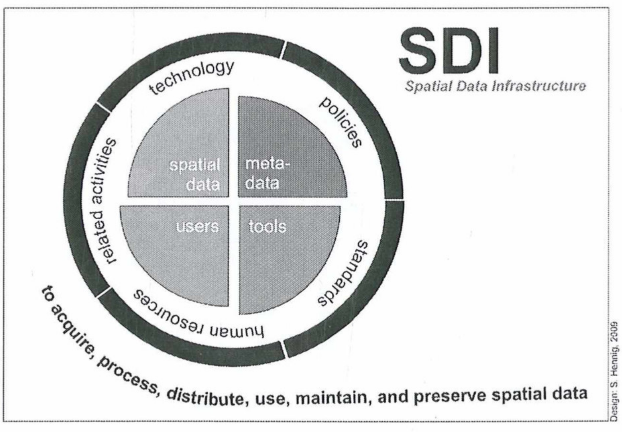

Figure 1: Definition of SDI Spatial Data Infrastructure

For the creation of a European SDI the INSPIRE[12] Directive is the relevant initiative. It embraces 34 different themes. Nature conservation related themes are protected sites, biogeographical regions, habitats and biotopes, and species distribution (URL 1). For nature conservation the eContent+ project Nature-SDI*plus* (see Tab. 1) supports the implementation of the INSPIRE Directive.

[11] Borders exist not only between different countries, they can be found e.g. at local, regional and national level as well as between protected areas and their surroundings. Further, borders exist, when a significant change in one or many land attributes occur.

[12] Infrastructure for Spatial Information in Europe

Table 1: Information on the EU-project Nature-SDI*plus*

Project Management	GISIG, Italy
Term	10/2008 to 03/2011
Partners	30 partners in 17 EU countries
Budget	2,7 Mio €
Internet source	http://www.nature-sdi.eu
Context	INSPIRE Directive (http://inspire.jrc.ec.europa.eu)

Large protected areas are of special significance in the realisation of Nature-SDI*plus*: *Protected sites* are not only explicitly listed in the INSPIRE Directive (see URL 2), and are one main focus of Nature-SDI*plus*, but they are also an important instrument of nature conservation – particularly considering *Natura 2000* in Europe. Due to the existence of management authorities, management tasks, and management infrastructure (e.g. availability and use of data, metadata, GIS) as well as the management objective *research* (including research on management questions) large protected areas show ideal conditions for prototyping and best practice examples for implementing SDI components (data, metadata, services). Thus, they are currently in the process of opening their huge collections of (spatial) data from in-house desktop-GIS solutions to SDIs. In doing so the actual situation and the manifold requirements of the different data users have to be considered to meet the above mentioned deficits concerning the provision of accessible and harmonised spatial data according to the INSPIRE Directive (URL 3). Here the crucial question is how the situation of users and use of European nature conservation data is? Within this paper a rough overview on some selected aspects will be presented which is based on an online survey realised within the Nature-SDI*plus* project. For large protected areas this gives an insight what a SDI on nature conservation should comprise before tackling the technical realisation.

2. Getting information on data users

Planning the implementation of a SDI with its components data, metadata, and tools builds upon the field of software engineering13. Focusing on the demand of user-centeredness, usability is crucial (see Fig. 2). In consequence, usability engineering as part of software engineering must be applied (NIELSON 1993; RICHTER & FLÜCKIGER 2007). Information on usability aspects is gained through a *survey* on data users and their requirements. The survey is developed as an online questionnaire with 67 questions by the online survey tool *Survey Monkey* (URL 4). The questionnaire builds on (see Fig. 2):

the state of the art of empirical social research (see NEUMANN 2006),

the characterisation of the SDI components, and

the understanding of nature conservation and its tasks.

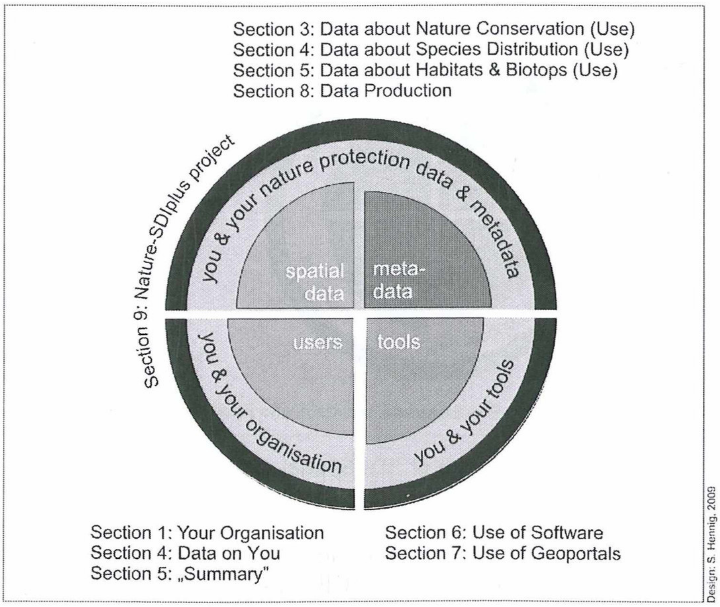

Figure 2: Nature-SDIplus user questionnaire: content & structure

[13] By definition software engineering is the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software, and the study of these approaches (ROSSI et al. 1008)

The interviewees were selected to mirror the broad variety of target users working in different nature conservation application domains and operating at different scales from the local to the EU-wide level. A system of target users (see Fig.3) was developed taking into account the experience gained from the project Nature-GIS (KANELLOPOULOS 2005). To further support monitoring and networking initiatives of Nature-SDI*plus* the questionnaire is still open at http://www.surveymonkey.com/NatureSDI_UserSurvey .

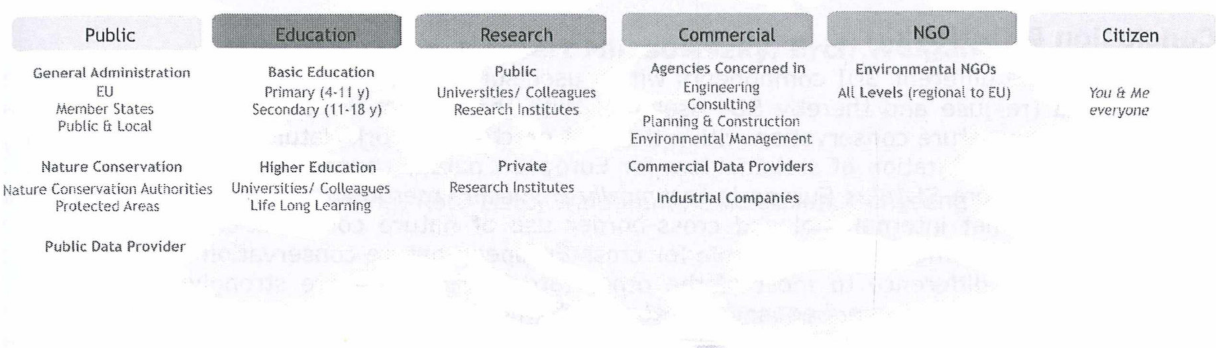

Figure 3: Nature-SDI*plus* Target User Groups

3. Selected *Aspects* on Nature Conservation SDI

Based upon the information gained through the user survey (n~400), use cases were elaborated (see Fig. 4). They are presented by UML diagrams, a standardised general-purpose modelling language (GRÄSSLE, BAUMANN & BAUMANN 2007).

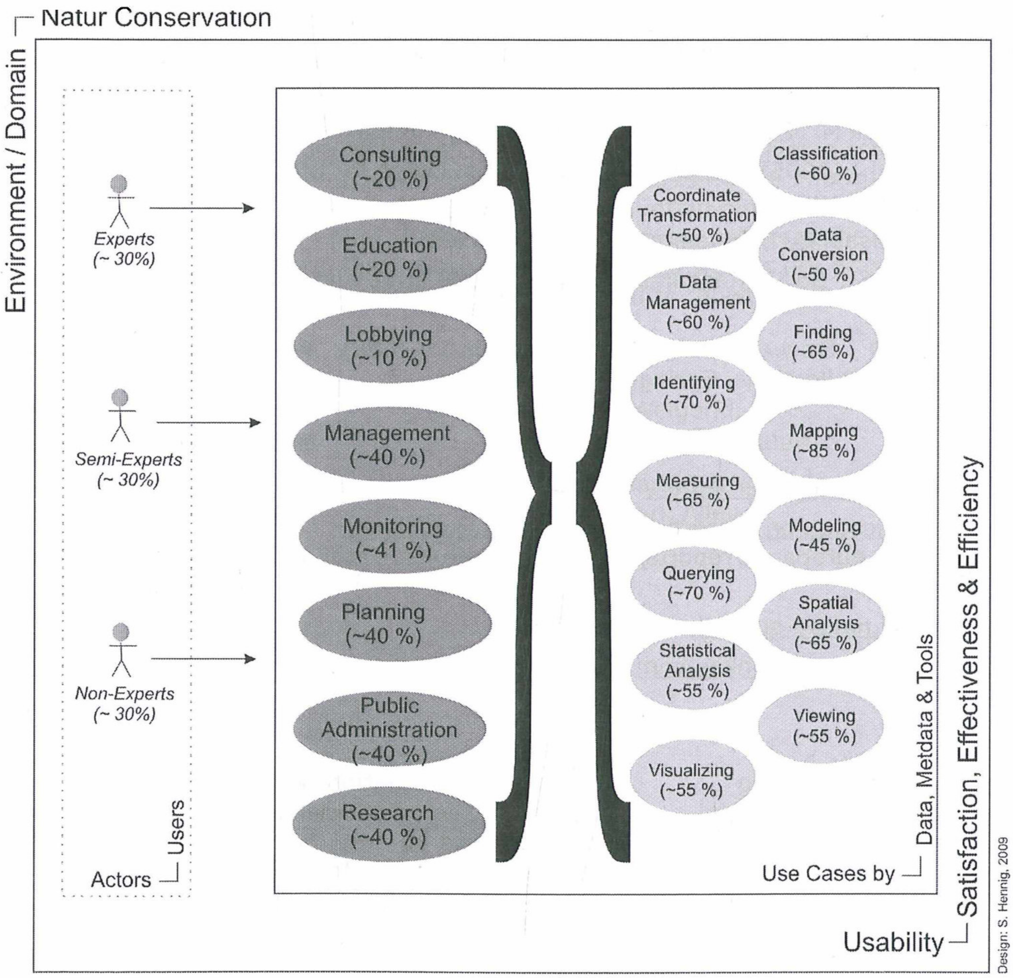

Figure 4: Simplified, generalised & schematised use case diagram concerning tasks by nature conservation data (n~400)

Concerning the spatial data content more than 70 % of the interviewees often or at least sometimes use information on *protected sites boundaries* (~90 %), *actual land use* (~80 %), *administrative units* (~ 80 %), *altitude/ topography* (~75 %), *actual vegetation* (~75 %), and *protected habitats/ biotopes* (~75 %). With reference to the geographical extent data on the local (~85 %), the regional (~95 %) and the national (~70 %) situation are used often/ sometimes. Data on neighbouring countries is rarely or never used by about 50 % of the users. Data with EU-wide, European, or global coverage is never used by ca. 60 %, 75 % respectively 80 % of the interviewees. The minor use of this *international* data is probably the reason, that users do not see difficulties (e.g. language, multicultural issues) in using foreign data.

Conclusion & Outlook

The focus on the different SDI components within user survey and use cases is crucial to ensure efficient data (re-)use and thereby SDI usability. With the bottom-up approach in developing a European SDI for nature conservation within the best practice network Nature-SDI*plus* networking, participation and integration of stakeholders for European nature conservation work is advanced. Thus, through Nature-SDI*plus* Europe is *technically & socially* merging. Considering especially the low importance that international and cross-border use of nature conservation data has, large protected areas can/ must play a key role for cross European nature conservation due to different reasons. First, in difference to most of the other target users they are strongly internationally anchored: Protected area are frequently located in borderline situations, are part of institutional networks like *IUCN, Europarc, Alpine Network of Protected Areas*, and focus on activities related to habitat networks and corridors etc.. Second, modern management per se demands for multidisciplinarity and regional as well as cross border context (BRÜGGEMANN 2004). For prototyping SDI solutions, elaborating best practice examples, and gaining experience on usability for European nature conservation SDIs are best suited to be set up in large protected areas. SDIs can be an important tool to significantly enforce international nature conservation work.

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URL 1: http://inspire.jrc.ec.europa.eu/

URL 2: Data Specification on Protected Sites - Draft Guidelines
http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/INSPIRE_DataSpecification_PS_v2.0.pdf

URL 3: http://www.nature-sdi.eu/

URL 4: http://www.surveymonkey.com

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The epigeic spider fauna of one subalpine Swiss mountain pine-European larch-Norway spruce stand, and two burnt sites in the Nationalpark Kalkalpen (Austria)

Martin Hepner, Norbert Milasowszky, Erch Weigand

Key words

Spinnen, ökologische Bewertung, Rote Liste, Waldbrand, Sukzession, Sengsengebirge

Abstract

The epigeic spider fauna of one subalpine Swiss mountain pine-European larch-Norway spruce stand, and two burnt sites - two years and 55 years old - at approximately 1470 to 1500 m above sea level was examined using continuous pitfall trapping from 17 June 2005 to 18 Juli 2006. Ten pitfall traps were set out in a linear arrangement in each study site. In total, 81 spider species with 1125 adult individuals belonging to 16 families were caught. Fourteen of the 81 species found were recorded for the first time in Upper Austria. According to the Red List of spiders of Bavaria (BLICK & SCHEIDLER 2004), nineteen species are categorised as critically endangered, endangered, vulnerable or extremely rare. Twelve spider species including the endemic Troglohyphantes noricus (THALER & POLENEC, 1974) are restricted to the alpine region. The highest number and dominance of forest dependent species occurred in the mountain pine stand, the highest number and dominance of dry grassland dependent species in the old burnt site. Hierarchichal cluster analysis based on the Jaccard similarity index showed that the spider assemblages of the mountain pine stand and the adjacent young burnt site were more similar to each other than to the old burnt site. Based on data from the literature, the comparison of the spider assemblages from the three study sites with those from different habitats in the alps (Swiss mountain-pine stands, Norway spruce forests, Scotch pine forests, pastures and meadows, dry grasslands, alpine grasslands and alpine screes) revealed that the three study sites were most similar with each other emphasising the importance of the local species pool. Furthermore, the spider assemblage of the mountain pine-larch-spruce stand is most similar to those of other mountain-pine stands and spruce forests, whereas the old burnt site shows similarities with unburnt and burnt Scotch pine forests as well as dry grasslands. Only the spider assemblage of the young burnt site can not be related to those of other alpine habitats.

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Management of natural parks in Carinthia Discover the regions' protected areas

Robert Heuberger

The companies of the Natural Parks of Carinthia have been integrated into Carinthia regional management. This permits the creation of synergy in regional development, the ideal use of subsidies, and high-quality natural park management.

With the foundation of the Regionalmanagement Kärnten Dienstleistungs GmbH (RMK) Company that assumed responsibility for Carinthia's natural parks in 2007, natural park management was also inserted among the many other regional development structures.

The integration of natural park affairs into the Regional management Kärnten Dienstleistungs GmbH Company has been deemed extremely positive. This structure facilitates synergy with other instruments and regional development programs, such as LEADER or INTERREG, while also improving the coordination of such activities at national level.

If, in other regions there is only one director for the natural parks, one regional, and a Leader manager for the various organizations, these roles have all been combined in RMK and enriched with other departments for related affairs, such as consultancy for funding, renewable power supplies, and tourism.

Together with collaboration with other regional reference authorities, cooperation with the municipalities and the directors of the region's other natural parks can be a key factor in a natural park's success.

This organizational structure also permits the development of new natural parks. The regional office serves as the first reference authority in the region and applies regional networks to the achievement of its objectives, whereas natural park management utilizes specific knowledge and experience for their development. Funding experts are responsible for taking the measures necessary.

Natural park management is entrusted with the following tasks:

1. Coordination point
2. Implementation of local projects
3. Development of tourism offers with particular attention to environmental protection, agriculture,
4. and training
5. Development of natural park projects and strategies
6. Coordination of projects between different natural parks
7. Exploitation of synergy between natural parks and other protected areas
8. Natural park mapping

Further strategic development of the idea of natural parks in Carinthia

<u>Dobratsch Natural Park</u>

Dimensions: 7,248 hectares

Natural park's region: 8,833 hectares

Protected areas: "Villacher Alpe" natural area and "Schütt-Ost" and "Schütt-West" protected areas and parts of the "Natura 2000 Schütt-Graschelitzen" area

Municipalities: Villach, Arnoldstein, Nötsch im Gailtal, Bad Bleiberg

Organizational structure: Arge Interkommunale Plattform Naturpark Dobratsch (Dobratsch Natural Park inter-city work team)

The leading natural park in Carinthia since September, 2002

Important projects:

Development of an alternative winter vacation plan for families without ski lifts

Theme trails: geography educational trail, wildlife educational trail, mountain tunnel trail

Arnoldstein Natural Park Training School

Visitor orientation and reforesting measures for Mt. Dobratsch

www.naturparkdobratsch.info

Weissensee Natural Park

Dimensions: 7,640 hectares

Natural park's region: 563 hectares

Protected areas: Weißensee protected area

Municipalities: Weißensee, Stockenboi

Organizational structure: Weißensee Natural Park Work team.

Natural park since May, 2006

Important projects:

A Natural Living Room

Equipping Gosariawiese Meadow

In Harmony with the Lake

The Book Trail (long-range trail)

List of Weißensee Wildlife Species (under development)

www.weissensee-naturpark.at

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Remote Sensing in Protected Areas: Practical Experiences in Charting Natura 2000-Habitats, Detecting Changes in Landscape and Monitoring

Two case studies in the Gesäuse National Park

Hannes Hoffert, Daniel Kreiner, Julia Auer

Summary

Remote sensing, especially aerial interpretation is a main research tool for the monitoring and conservation management of Protected Areas, and in particular for National Parks. Vegetation modeling via HABITALP aerial interpretation (LOTZ 2006) was carried out with two main inputs: A "Forest site investigation" and the query of site conditions from a Digital Elevation Model (DEM).

Practical experience often reveals both the limits and potential of remote sensing. In many cases remote sensing never displaces terrestrial investigations; when it comes to area-wide tasks the full range of possibilities that remote sensing provides has not yet been employed.

Keywords

Remote sensing, habitat types, woodland communities, forest stand types, DEM, geology, GIS, modelling, monitoring, morphology, dynamics in landscape

Starting Position

Managers of protected areas are often confronted with a limited financial budget and work force for the monitoring of their resources. Thus, inexpensive repeatable monitoring protocols of extreme importance. Remote sensing is rapidly becoming the preferred methodology to fulfill this need. There is no doubt that additional field investigations and monitoring of habitats and their biotic communities are the key element to successful management of protected areas.

Sufficient quality and cost-effectiveness are especially important for the management of large Natura 2000 regions. We draw on our experiences in the Gesäuse National Park, Ötztaler Alpen Natura 2000 area, Hohe Tauern National Park and Puez-Geisler among others to discuss the limits and scopes of remote sensing in such protected areas.

Investigation and Methods

The investigation area is the Gesäuse National Park in the Northern Calcareous Alps in the Styrian province of Austria. The vertical-extension reaches from 600 up to 2370 m a. s. l. The area is characterized by a high frequence of dynamic natural processes such as avalanches, floods and windthrows. Approximately 50 % of the area is covered by woodland, nearly 15% by shrubs, 5% mountainous-subalpine pastures and alpine grassland and around 30% by rocks and their associated vegetation.

The results of a "forest site investigation" (150 relevés with 87 soil profiles and chemical analyses of 21 different soil profiles), the HABITALP interpretation and the DEM were combined to create queries in the GIS (ESRI, ArcGIS Map, Spatial Analyst).

The morphological investigations are implemented by remote sensing, interpretation of laser-scans and the comparison of two generations of areal photos (1954 and 2004) combined with field work.

Objectives

Forest Site Investigations and Vegetation Modelling

Especially the forests and mountainous pastures ("Almen") have not yet been managed according to our conservation goals. Unmanaged pastures would become reforested and thus loose their open landscape character along with its associated faunal and floral diversity. Therefore these habitats are in the management zone of the national park. To optimize grazing for conservation purposes management plans are worked out for each "Alm". The basis for the inventory of different habitats on these pastures was an area-wide aerial image interpretation (HOFFERT & ANFANG 2006). This interpretation following methods of an INTERREG Alpine Space project called HABITALP and served as well as a main base for different follow-up projects, like simulation of bark beetle risk zones (SCHOPF et al. 2008) and especially the modeling of the current dispersion of different woodland communities in the National Park Gesäuse (EGGER & HASSLER 2007). The results of this project guided us to attempt the combination of two different methods, the "Forest site investigation" (CARLI 2008) and the modeling of woodland vegetation depending on site conditions like geology (soil), exposition, declination and sea level (ZIMMERMANN 2008).

Morphology and Dynamics in Landscape

Through these efforts, both high standards and a considerable amount of information concerning the habitats and biotope-types in protected areas has been gathered. Nonetheless, studies on landforms or morphometric parameters are lacking, even though this information can be very advantageous:

- Habitat modelling needs parameters like slope-gradient, exposition, landforms, surface structure, and surface lithology to compliment investigations of the vegetation layer.
- When we talk about protected areas and national parks, land use, landforms and the face of the landscape are basic layers of a macrochore database
- Charting morphology offers the possibility of charting landscape dynamics. Developments resulting from natural hazards or changes in the vegetation cover and forest-based-sector can not only be documented but also observed and analysed.

Therefore the Gesäuse National Park GmbH and REVITAL GmbH are devising a mapping method, where morphometric parameters as well as landscape monitoring aspects are included. At the moment a test area was charted with following parameters:

- declination
- exposition
- morphological landform
- morphological process which actually is responsible for the morphological dynamic
- substrate (generalized)
- Landscape dynamics - causation
- Landscape dynamics - dimension (qualitative)

The challenge is, as usual, executing a low-cost area-wide investigation.

Results

Forest Site Investigations and Vegetation Modelling

Data from 335 woodland relevés were statistically evaluated. This analysis showed up with average values (sea level, exposition, declination and geology) for the different stand types. For each natural forest association we now had corresponding ecological factors and a typical tree species composition. From now on it was possible to have a classification of the forest stand types and to create queries on the HABITALP interpretation (% of tree species coverage), the DEM (Digital Elevation Model), and the geological map of the Gesäuse. Some of the forest associations had to be merged while others had to be mapped in the field. Nevertheless the result was a map of the current vegetation (scale 1:25.000) of a large territory without carrying out area-wide field work.

Morphology and Dynamics in Landscape

The test area (Langgriesgraben, 1.024 ha) was divided into 1917 polygons. One of most valuable results of this effort was that it will be possible to accurately chart the entire Gesäuse National Park with reasonable project costs. Conclusions like "which part of the National Park has got the most dynamic landscape or is affected by natural hazards", "where are seldom landforms", "where do we have a high variety of landscape", "where do we have a highly dynamic landscape in combination with National Park infrastructure", can be answered. Additionally it is possible to model any kind of habitat more accurately – provided that a laser-scan model is available.

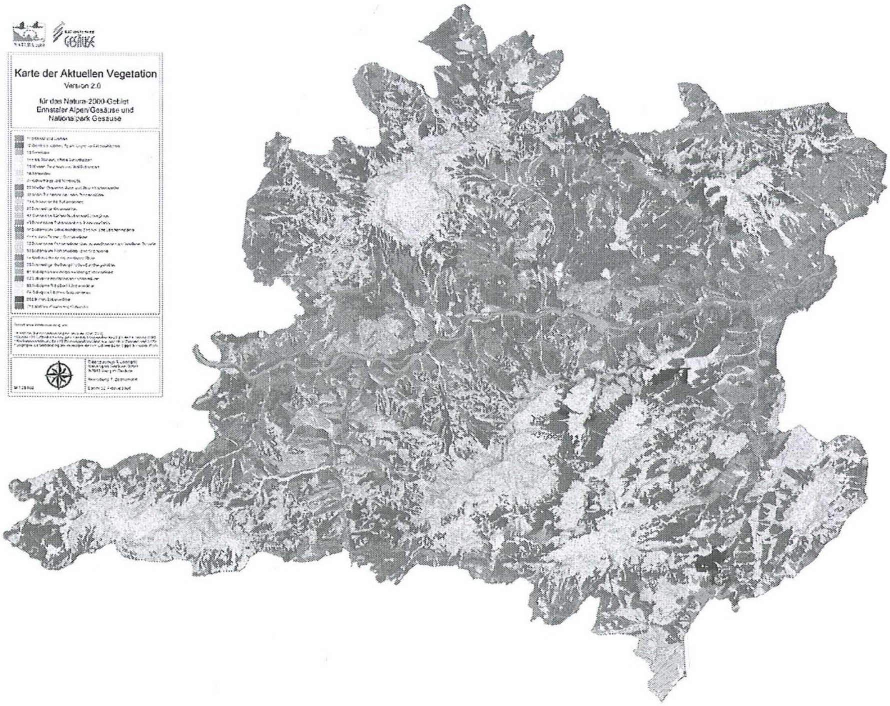

Figure 1: Map of the current vegetation in Gesäuse National Park
(Source: Nationalpark Gesäuse, 2008)

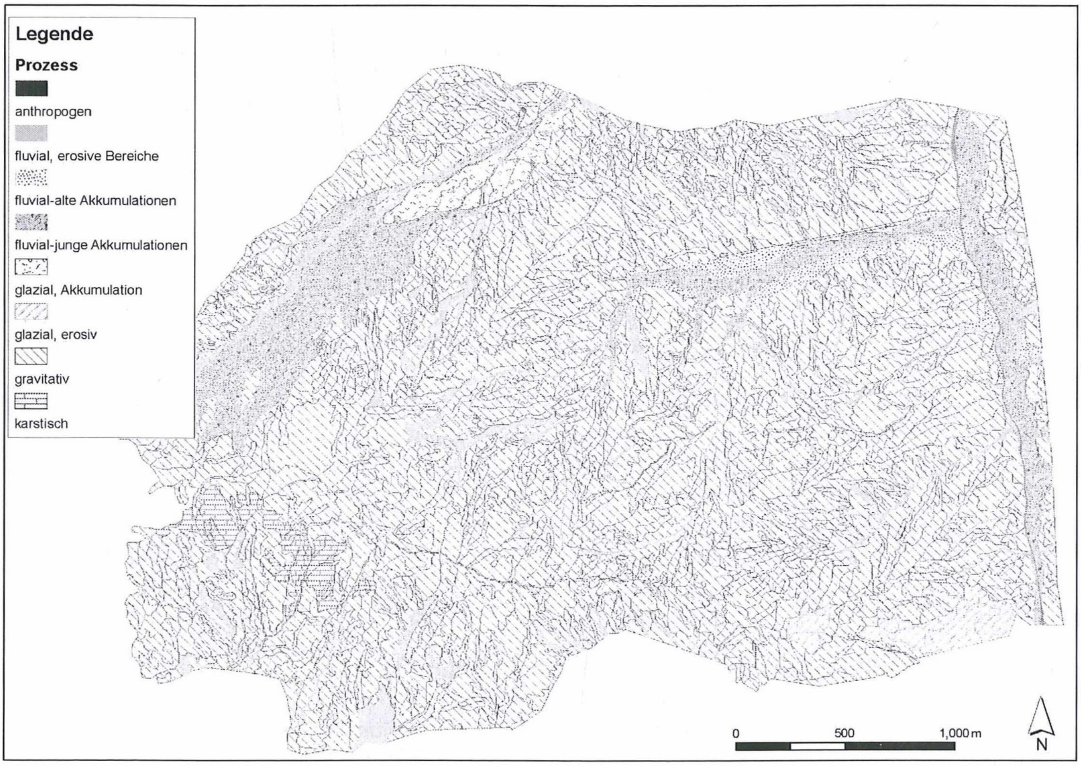

Figure 2: Predominant morphological processes in the test area (Langgriesgraben)
in the Gesäuse National Park (draft). Source: Hoffert, 2009 (in prep.)

Outlook

The different ecological factors provide for a great variety of stand types in the National Park. From riverine forests (Salicetum albae) along the river Enns to larch-stone pine woodland (Rhodothamno-Laricetum and Rhododendro hirsuti-Pinetum cembrae). In history the main type, (spruce-fir-) beech forest on limestone (Helleboro nigri-Fagetum, Adenostylo glabrae-Fagetum, Saxifrago rotundifoliae-Fagetum) had in many cases changed to spruce forest. Currently we work on maps of the FFH habitat types and the "Potential Natural Vegetation" in the National Park

Gesäuse to see where we have the most need for forest management in the near future (ZIMMERMANN & KREINER, in prep.).

Concerning morphological surveys the next step will be to elaborate guidelines for delimitation and interpretation. In combination with other datasets (HABITALP, Geology) another target is to look forward, what kind of queries are possible and which analysis can be done.

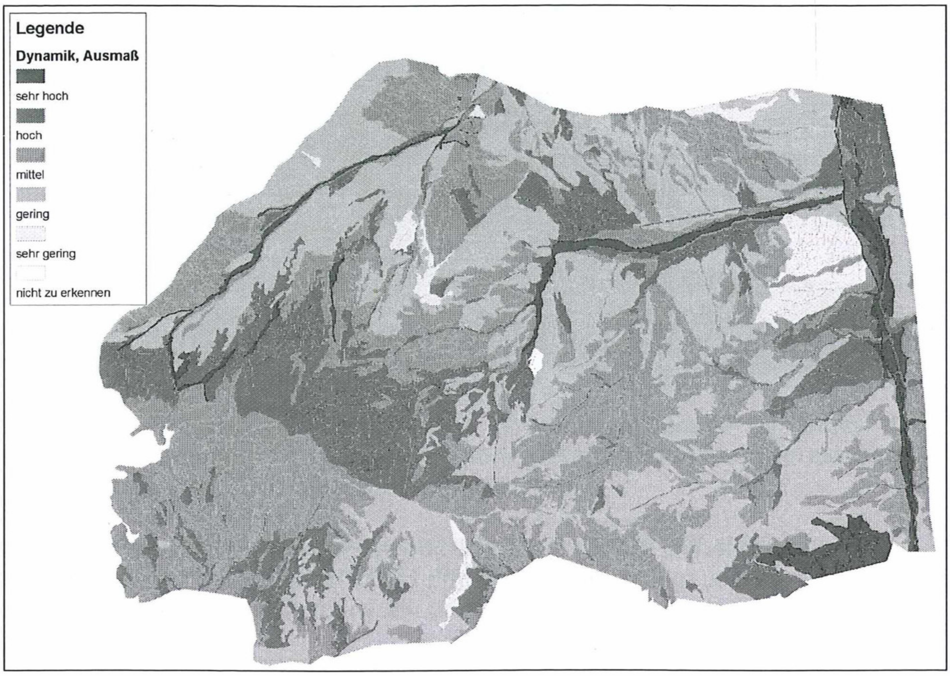

Figure 3: Landscape dynamics - dimension in the test area (Langgriesgraben) in the Gesäuse National Park (draft). The charting of dynamics is a result of the comparison of aerial photos from 1954 and 2004 and interpretation of morphological structure in consideration of the vegetation cover and forestry activities. Source: Hoffert, 2009 (in prep.).

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Biodiversity of butterflies and moths in the National Park Hohe Tauern

Peter Huemer

Summary

The author gives an overview about research activities on butterflies and moths of the National Park Hohe Tauern (Austria) which already began in the late 18th century and culminated in a popular book in 2008. The faunal composition of all representative ecosystems was recorded during the last 20 years. Species richness proved extremely high with about 1300 taxa. The discovery of local endemics is of particular interest for the park management. Several species of Lepidoptera are potential bioindicators, particularly with respect to climatic change and intensification or abandonment in agriculture.

Keywords

butterflies, moths, species diversity, endemics, bioindication

Aims and duration of project

Starting in 1988, a major intention was a survey of the entire faunal composition of butterflies and moths in the National Park Hohe Tauern covering all ecosystems through an intensified inventory of these groups. Under the auspices of the Tiroler Landesmuseum Ferdinandeum in Innsbruck, the first intensive field programme was organized in East Tyrol, lasting 10 years. Simultaneously further local inventory programmes were undertaken in Salzburg and Carinthia. However, despite the extensive sample data sets which partially date back to the late 18th century no complete survey had been published. Therefore sponsored by the National Park Hohe Tauern, a co-operative research programme between the museums in Klagenfurt, Innsbruck and Salzburg was initiated, with the publication of a popular book on the fauna of butterflies and moths being defined as a major goal. This supplementary inventory lasted from 2003 to 2007.

Area of Study

The National Park Hohe Tauern (Austria) is the largest protected area in Central Europe, covering altogether about 1.800 sq. km and ranging from about 1000 to 3798 m s.l. Therefore an area-wide inventory was not aspired and would have gone far beyond available resources considering the size of area as well as the vast number of species to be expected. Alternatively the field research exemplarily covered all types of terrestrial biotopes of the major ecosystems in the PA: wetland habitats, mountain pastures and alpine grassland, forests, dwarf-shrub zones, rocky habitats and alpine scree. Furthermore the sites were scattered over the entire protected area, mainly in East Tyrol from 1988 to 1998 and with a special focus on insufficiently explored areas of Salzburg and Carinthia during the last years.

Methods

The collecting methods were selected to enable a registration of a maximum amount of species within a limited number of excursions.

Due to the night activity of about 85% of central European Lepidoptera mainly light-trapping methods were chosen but also traditional sampling methods during day-time:

illuminated white sheet (light source 125W UV)
light tower (light source 15W-20W UV)
automatic light traps (light source 8W-15W UV)
usage of a dip net
visual registration of day-active species

- visual registration of larvae and leaf-miners
- usage of bait (sugar-wine mixture)
- usage of phermones

In general several of these methods were used simultaneously.

Results and Discussion

The conservation of autochthonous species diversity is one of the major tasks in this and other nature reserves. However, exactly this diversity was grossly unknown or at most insufficiently known for many organisms including Lepidoptera.

First attempts of faunistic studies date back into the late 18th century. Sigismund von Hohenwarth, the later third Bishop of Linz, collected insects and plants in the Hohe Tauern and described striking new species which are still valid today, e.g. *Zygaena exulans* and *Caloplusia hochenwarthi*. Later on famous scientists such as Josef Mann, Otto Staudinger and Josef Klimesch visited the area, particularly the surroundings of Großglockner. Beside a large number of interesting records, several new taxa have been described by these earlier generations of scientists. Their studies combined with the recent inventory resulted in an alpha diversity of 1296 species of butterflies and moths (HUEMER & WIESER, 2008). A statistical analysis of Beta diversity, e.g species which are unique to each of the ecosystems, has not been conducted yet and will be subject to a further publication.

The actual fauna is almost completely based on postglacial reconolisation, with the exception of maybe a few taxa which could have survived on nunataks. Arctic and Alpine, Continental and Mediterranean species can be separated. Furthermore migrating species are widespread in the National Park. Of particular interest for conservational aspects are a number of local or regional endemics including the recently described *Aspilapterix spectabilis, Ancylis habeleri, Sphaleroptera dentana* or very latest *Sciadia tenebraria taurusica*. In consideration of molecular data, further fascinating taxonomical results may still be expected in future.

The majority of taxa is rather stenotopic than eurytopic and hence usually restricted to few biotopes within one of the major ecosystems. Due to their sensitivity to climatic change and/or anthropogenic influence such as fertilization or abandonment of alpine grassland several species are potential candidates for a prospective bioindication study.

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Participation Processes in Biosphere Reserves – Development of an Intervention

Theory, Analysis of Strategies and Procedural Ethics by example of BRs Nockberge, Vienna Forest and Großes Walsertal (Austria)

Michael Jungmeier, Ina Paul-Horn, Daniel Zollner, Falk Borsdorf, Karin Grasenick, Sigrun Lange, Birgit Reutz-Hornsteiner

with contributions from:
Ch. Diry, I. Drozdowski, R. Moser, D. Rossmann, A. Duller

Summary

The establishment as well as the management of a Biosphere Reserve (BR) can be understood as a permanent intervention to promote regional change management towards sustainability.

These long-term processes need a proper theoretical base, concise tools and a consistent accumulation and reflection of experiences. By example of three Austrian BRs (Vienna Forest, Walsertal, and – in planning: Nockberge) very different processes will be documented, analysed and reflected along 7 guiding hypothesis. Five aspects are taken into account in particular:

Intervention science and intervention ethics

Participation processes

Change management

Diversity management

Good regional / local governance

The workflow is structured as a sequence of scientific analysis and regional involvement. Empirical data is collected in document analysis, sophisticated workshop settings, a virtual platform and in-depth interviews. The interpretation is performed with methods of the different disciplines involved. The different perspectives within the interdisciplinary research-team and the focus on transdisciplinary synthesis will lead to new concepts of participation. However, this will enhance the capacity to understand and to conduct participation processes in BRs.

Keywords

Biosphere Reserve, participation, change management, governance, intervention, diversity management, protected areas management and planning

Aims and duration

Planning of protected areas in general and of Biosphere Reserves (BR) in particular is one of the largest spatial planning processes in a modern society. It is a large scale intervention with far-ranging and long-term economic, socio-cultural and ecological impacts. The portfolio of individual and common options for actions will change, rules between different players and groups will be newly defined, new institutions and mechanisms will be developed and implemented. The management of a BS may therefore be seen as a continuous process of regional change management.

By example of three Austrian Biosphere Reserves an interdisciplinary research team wants to document and understand the participation processes under the perspectives of:

Intervention theory

Intervention ethics

Diversity management

Change management

Regional governance

The scientific process will lead to (components) of a theory. A step by step process of reflection with and in the BR-regions will lead to an enhanced capacity to understand and conduct participation processes in BR-regions.

The study which lasted 18 months, started in July 2008, and will end in December 2009.

Area of study

Primarily, planning and management processes in the three Austrian BRs are the "source" of the research project.

1. BR Großes Walsertal: The 192 qm² large reserve is situated in an agricultural and cultural homogenous area. Planning and management is (was) done under individual involvement of many stakeholders, which can be done quite well in a site containing 3.500 inhabitants in six municipalities. From an economic-geography point of view it can be seen as a disadvantaged rural area. The park was established through a participative process and was internationally recognised in 2000.

2. BR Vienna Forest: The reserve with an extent of 1.056 qm² borders 61 municipalities with more than 200.000 inhabitants. Economically, the site is situated on a gradient between the rural settlements and (peri-) urban areas. Geographically spoken, the local communities are oriented to different directions. This makes broad participation processes difficult and complex. Therefore the park management tries to orient the communication to specific target groups.

3. (Planned) BR Nockberge: The National Park Nockberge will be transformed into a BR in a large-scale participation process. More than 300 (!) events took place in the region in the last three years. Economically, the region which includes four municipalities, is characterised by tourism, agriculture and forestry.

The case study areas differ in many aspects. This diversity will contribute to broadening the approaches and the results and will therefor lead to more general hypothesis about the interventions made into these landscapes.

Workflow and methods

The workflow combines scientific analysis and regional involvement. The Scientific Advisory Board will meet three times during the process. It is tasked with controling the scientific qualities (methods and results). The thematic analysis and workshops will lead to sectoral results, whereas the interdisciplinary analysis and workshop combine the different aspects and will lead to the integrating general results and findings. Regional workshops are instruments to collect, reflect and distribute information.

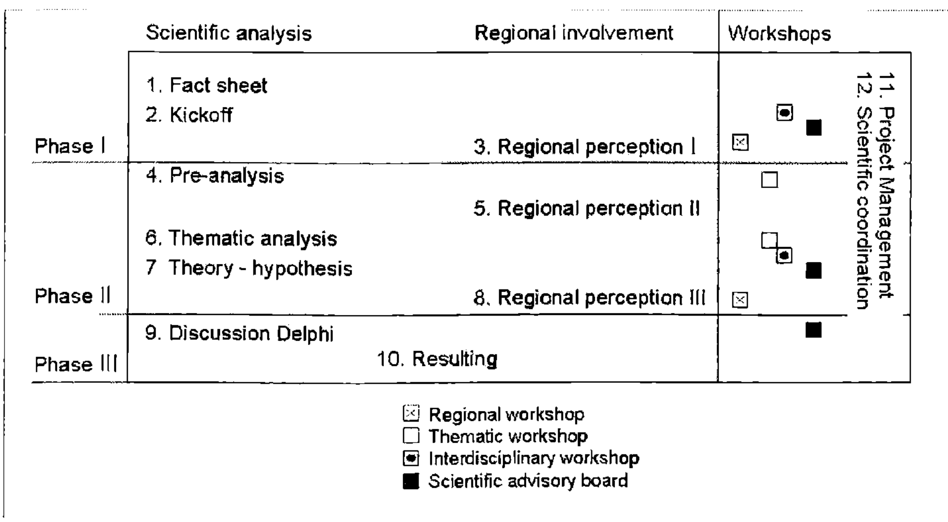

Figure 4: Overview of workflow.

The applied methods within the different thematical focuses are performed with methods of the different disciplines involved.

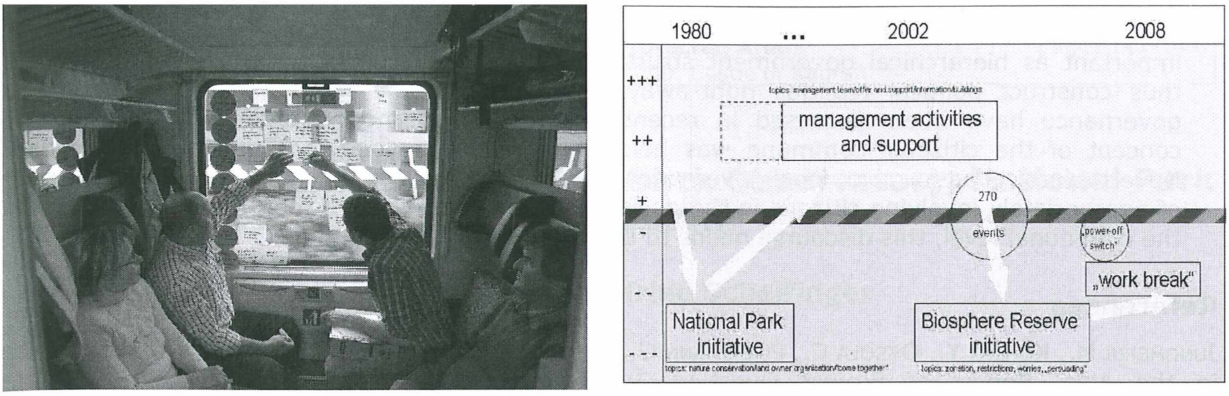

Figure 5: Perception analysis in the train.

By raising evidences of good and bad practices during the protected area development experienced by the participants of the "train workshop", a "memory map" will be made visible along a timeline telling predominantly amicable periods from controversial periods. By analysing the single statements (shown in the left-hand picture), phases can be observed and interpreted (see right hand picture): While there was a good cognition in the late seventies, the initiative to establish a national park was seen as a major negative impact. By and by, the continuous activities of the national park management team turned the perception of the participants towards the positive realm. In the early new millennium, the initiative to commute the national park into a biosphere reserve was again seen as a strong impact. Though accompanied by more than 270 regional events and meetings, a positive impression could not be created. This prompted the responsible political representative to press the "power-off button" for the Biosphere Reserve initiative. Currently, the development is still "frozen", and all actors are evenly unsatisfied with the situation.

Results

As the project is still ongoing, the final and approved results will only be available in December 2009. Basically, the main result however will be the verification and/or further development of the following seven guiding hypothesis:

Intervention impact: A BR is per se a permanent intervention by influencing different subsystems on several levels of impact. The essential components of the system are part of the triangle of sustainability. Thereby, social, ecological and economic subsystems follow different rules and show different impacts. The perspective of cultural sustainability may help as orientation how to make decisions sustainable. Aspects that are discussed intensively and emotionally are often not the factors that make the difference.

Intervention strategies: The establishment and management of BRs happen simultaneously with basically different concepts: Bottom-up vs. top-down, normative vs. process-oriented, sovereign vs. participatory, push vs. pull. The specific mix of components is an essential success factor.

Ethic of intervention: Due to the fact that simple cause-and-effect models fail, planning, establishment and management of BRs need a specific ethic of intervention. Moreover, increased knowledge of participants does not automatically lead to improved capacity to act. Therefore, all persons involved in the process have to develop new competences. A permanent process of (self-) reflection is a crucial element in this (new) ethic of intervention.

Regional change management: The set of tools and theories in organisational development in general and change management in specific can be used for understanding, analyzing and optimizing planning and management of BRs. Thereby, a few aspects have to be adapted and seen in a new context.

Diversity management: Activating and involvement (empowerment) of diverse groups and players is an essential success factor in a BR. The applied approaches, communication- and participation strategies only get through to a part of the target groups. The involvement of regional players depends on a variety of parameters (level of organisation, access to information, etc) and as a consequence specific groups of the population may be disadvantaged, or excluded.

'Subject-subject-relationship': For the planning, but also for the implementation of research projects in this field cooperative exchange between persons and interest involved ("stakeholders") is a key factor (Subject-subject-relationship). A polarisation in "researchers" and "objects of research" or "planners" and "planned" (Subject-object-relationship) is counterproductive and should be avoided.

Local governance and participation: Participation on the communal level has become more important as hierarchical government structures increasingly lacked the ability to thrive and thus construct political realities right-away. Many "ideals" of a "just" form of good local governance have been discussed in recent years. Perhaps most prominently, though, the concept of the citizens' commune was held to represent a good instrument in this realm. Nevertheless, good forms of local governance need to consider the fundamental future necessity of appropriately involving citizens in the decision-making processes of their local authorities. On the communal level, this discourse needs to be performed in new settings.

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Tends of air pollutants at the Sonnblick Observatory, National Park „Hohe Tauern"

August Kaiser, Helfried Scheifinger

Keywords

Air pollutant transport, air pollutant trends

Summary

The Sonnblick Observatory, situated in the centre of the "National Park Hohe Tauern", contributes to the Global Atmosphere Watch Programme (GAW) of the World Meteorological Organization (WMO) since 1996. The aim of GAW is to study the large scale chemical composition of the atmosphere and to serve as an early warning system to detect air pollution trends. Air pollutants may have strong impacts on sensitive eco systems. Changes in the chemical composition of the atmosphere are therefore of special importance to protect both, the biological balance and the climate of national parks.

The Austrian contribution to GAW consists of measurements performed by the Federal Environmental Agency (ozone, carbon monoxide and -dioxide, nitrogen oxides), the Technical University Vienna (aerosols), the University of Natural Resources and Applied Life Sciences, Vienna (UV-B and ozone column) and the meteorological measurements.

The sampling periods of the ozone and the carbon dioxide concentrations are sufficient to calculate trends. Fig. 1 gives an overview about the annual means of the ozone and the CO2 concentrations at Sonnblick since the beginning of the measurements up to Dec. 2007. The linear trends, based on deseasonalised monthly averages and their significancy are listed in Tab. 1. The significancy is calculated with the Mann-Kendall and the t-test (Rapp, 2000). Due to frequently missed CO2 data before 2001, the CO2 trend is only calculated for the period from May 2001 to Dec. 2007.

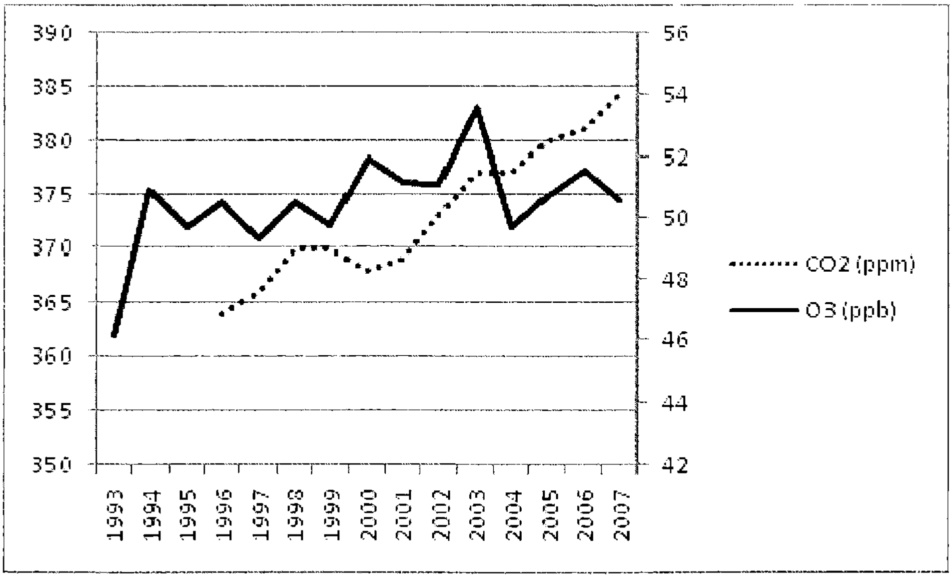

Figure 1: Annual ozone (continuous) and CO2 (dotted) concentrations at Sonnblick

Both, ozone and CO2 show a significant increasing trend (Tab. 1). Whereas the CO2 trend is more or less continuous (Fig. 1) and a consequence of the increasing emissions (Umweltbundesamt, 2008), there are two outstanding years with low ozone concentration in 1993 and high values in 2003 (Fig. 1).

Table 1: Trends in the deseasonalised monthly mean ozone and CO2 concentrations at Sonnblick (ppb/month). Investigation period ozone: Jan 1993 - Dec 2007, CO2: May 2001 - Dec 2007.

	Trend (ppb/month)	Mann-Kendall	t-test
Ozone	0.01564159	99.9840469	99.9961395
CO2	0.18202534	100	100

There are different processes that may rule changes in the ozone concentration: Changing emissions of the ozone precursors, photochemical ozone production or changes in the air flow regimes, causing transport of air masses with different ozone content to the measurement sites. GILGE et al. (2009, in preparation) show that there are no significant trends in the concentrations of the ozone precursors. Fig. 2 shows annual means of the ozone concentration and the sunshine duration measured at Sonnblick. The similarities of both curves are impressive, suggesting that the increasing ozone concentration is ruled by the increasing photochemical production to a high degree. But there are two outstanding years (1993 and 1997) with relatively low ozone concentration but with average (1993) or above average sunshine duration (1997). To understand the reasons of air pollution trends the knowledge of the origin of the polluted air masses is essential. KAISER et al. (2007) studied the origin of NOx, ozone and CO for the GAW-DACH sites. The ozone concentrations at the high Alpine GAW sites are influenced by the boundary layer during summer, but, during winter, air masses that sink down from high elevation contribute to the high ozone concentrations at these sites. AUER et al. (2006) found that the increasing sunshine duration is connected with a large scale increase of air pressure over the Alps during the last years and they assume an increase of the anticyclonic weather conditions. Anticyclones are connected with sinking air masses. Therefore the increasing frequency of the anticyclones may result in an increase of sinking air masses and may be an additional factor causing an increase of the ozone concentrations at elevated Alpine sites at least during the cold season (winter, perhaps also sometimes during autumn and spring).

Thus the increase of the background ozone concentration at high elevated Alpine sites seems partially to be due to the increasing sunshine duration; additional, a higher frequency of sinking air masses from high elevation may favour the elevated ozone concentrations during the cold season. For more details please see KAISER et al., 2009 (in preparation).

However, analyzing the reasons of air pollution trends is challenging. Analyses of the influence of changes in the air flow regimes on the air pollution trends at the high Alpine GAW-DACH sites will be the objective of further studies.

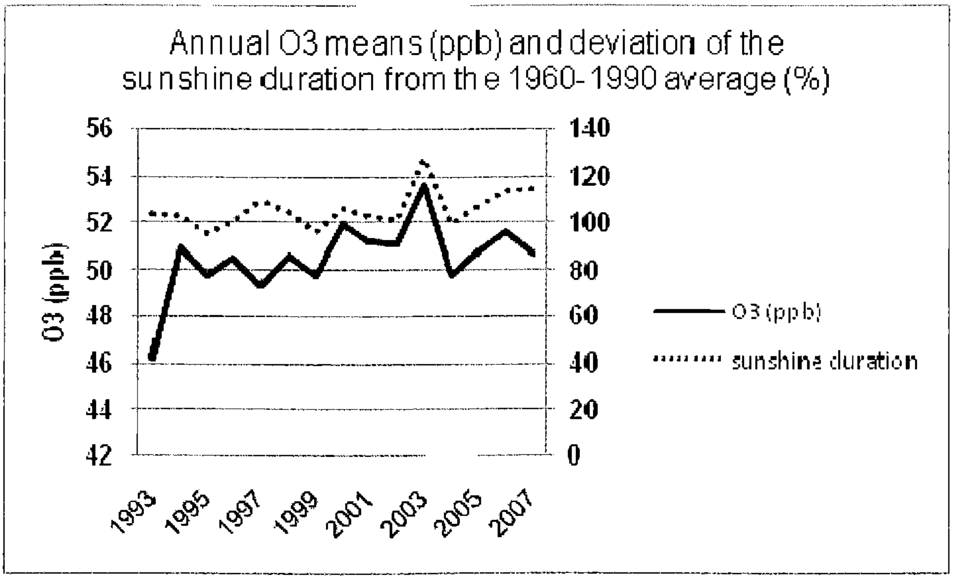

Figure 2: Annual mean ozone concentrations (continuous) and annual anomalies of the sunshine duration (dotted) from the 1960-1990 average at Sonnblick.

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Satellite-based measurement of the surface displacement of the largest glacier in Austria

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Summary

Surface displacement at Pasterze Glacier (47°05'N, 12°44'E, 17.5 km²), the largest glacier in Austria, has been measured by means of differential SAR interferometry (DINSAR). SAR imagery recorded during the summer periods between 1995 and 2001 was available for this analysis. One out of three analysed image pairs of the ERS (European Remote Sensing Satellite) Tandem Mission (20.8.1995-21.8.1995) showed sufficient coherence at the partly debris-covered glacier tongue for deriving a significant displacement image (interferogram). Maximum surface displacement rates of 30-40 mm per day in the SAR line-of-sight have been calculated for this image pair. Based on these results and additional reasonable assumptions a maximum annual surface displacement rate of 20-30 m valid for 1995 can be estimated. The calculated annual displacement values are comparable to the values measured directly in the field tachymetrically. This underlines the high potential of ERS-Tandem-Mission images with a time interval of one day for glacier monitoring at mid latitudes during the summer period for such large areas as for instance the Hohe Tauern National Park with its 1800 km².

Keywords

Pasterze Glacier, DINSAR, ERS Tandem Mission, Hohe Tauern National Park.

Introduction and objective

Detecting changes in surface elevation and velocity of glaciers is relevant for a number of glaciological research questions such as mass balance studies or 3D modelling (Oerlemans 2001, Kääb 2005). To observe such changes area-wide over entire valley glaciers, remote sensing techniques such as photogrammetry (Kääb 2005) or radar imagery techniques – in particular the interferometric SAR (=Synthetic Aperture Radar) method (Kenyi & Kaufmann 2003)– are required.

This study discusses the detection and satellite-based measurement of the surface displacement of Pasterze Glacier (47°05'N, 12°44'E, 17.5 km²), the largest glacier of the Eastern Alps, by means of differential SAR interferometry (DINSAR).

Study area

The Pasterze Glacier (47°05'N, 12°44'E) is the largest glacier of the Austrian Alps with a surface area of about 17.5 km² in 2002 ranging in elevation between 2065 and 3500 m a.s.l. The glacier is a compound valley glacier fed by a number of tributaries located in the heart of the Hohe Tauern National Park at the foot of Mt. Großglockner (3798 m a.s.l.), the highest mountain of Austria. The ablation area is primarily formed by a glacier tongue covering about 3.6 km². The glacier tongue is connected to the main accumulation area by a distinct icefall named "Hufeisenbruch". In particular the right part of the *c.*5km long glacier tongue is covered by a pronounced debris mantle with an extent of *c.*1.2 km² in 2002 (Fig. 1) affecting ice ablation (Kellerer-Pirklbauer 2008, Kellerer-Pirklbauer et al. 2008).

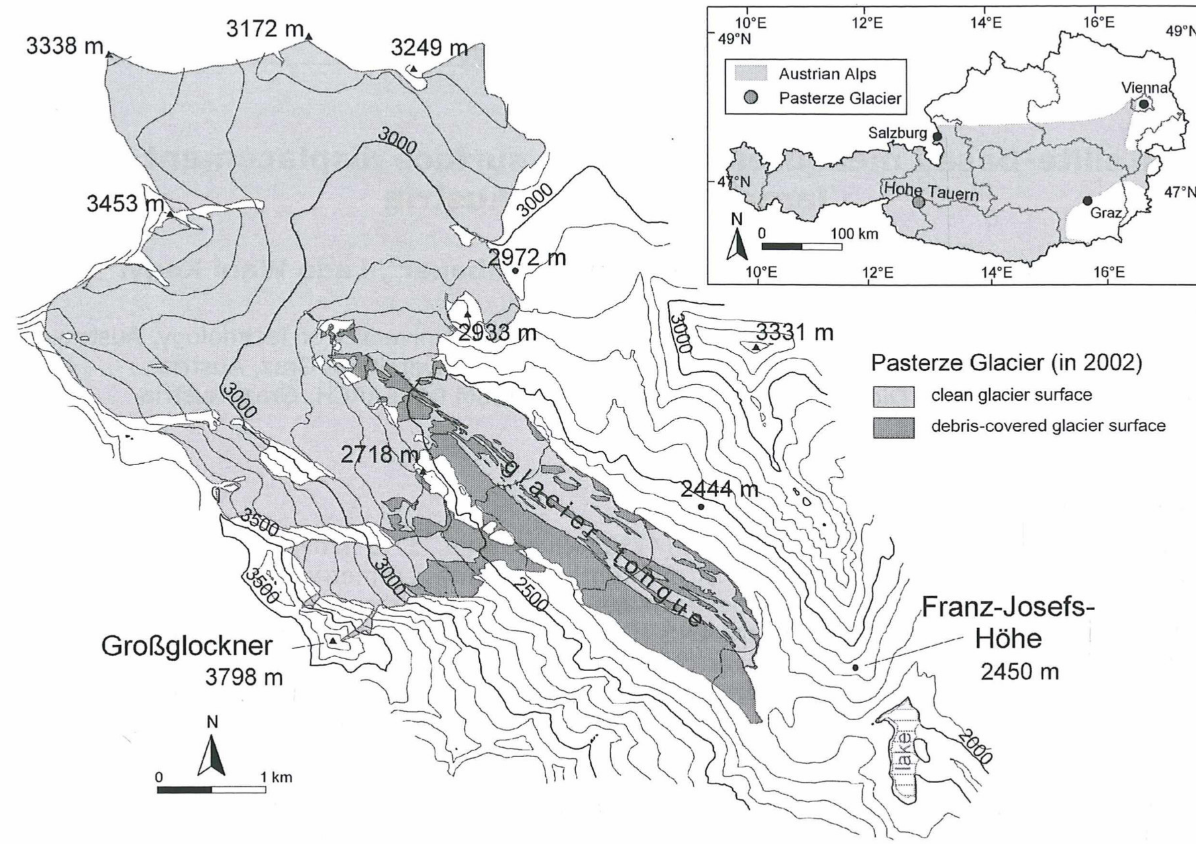

Figure 1: The Pasterze Glacier and its supraglacial debris cover in 2002 (based on the map Alpenvereinskarte Glocknergruppe, 9th Edition, published by the German Alpine Association in 2006, scale 1:25 000).

Method and data base

Both the amplitude and the phase of the backscattered echoes are normally recorded in a SAR system. However, the phase of a single SAR image is of no use and therefore, conventionally the amplitude or intensity image is usually provided to the end users. In contrast, the phase difference of two backscattered SAR echoes of the same area on the ground taken at slightly different view angles can be utilized to generate digital elevation model (DEM) of the imaged terrain (Prati et al. 1992, Zebker et al. 1994, Kenyi & Raggam 1996). This technique is known as SAR interferometry (INSAR) and can be extended to differential SAR interferometry (DINSAR) to detect small surface changes in the order of few centimeters (Gabriel et al. 1989).

For this present study, fifteen SAR-images recorded during the summer period were available for the period 1995 to 2001. Five SAR-image pairs with a low normal baseline (between +153 and -89 m) were analysed. One out of the five analysed image pairs (20.-21.8.1995) of the European Remote Sensing Satellite/ERS Tandem Mission showed sufficient coherence at the tongue of Pasterze Glacier for deriving a significant displacement image or interferogram (Table 1). The computation of the interferogram was possible despite the fact that only SAR-imagery of descending orbit (geometrically less favourable for displacement measurements) was available.

Table 1: ERS-1/2 SAR image pairs used for interferometric analyses. Only the second image pair from 20.8.1995 and 21.8.1995 (ERS Tandem Mission) showed sufficient coherence for deriving a significant interferogram for the glacier tongue below the icefall.

Orbit-image pair	parallel baseline (m)	normal baseline (m)	temporal baseline (days)
(1) 1.8.1995-2.8.1995	-18	-52	1
(2) 20.8.1995-21.8.1995	40	-89	1
(3) 6.7.1999- 7.7.1999	45	85	1
(4) 15.10.1997-26.8.1998	49	153	315
(5) 30.8.2000-15.8.2001	-77	-20	350

Results and Discussion

Figure 2 illustrates the geocoded ERS SAR amplitude image of the orbit image pair 20.8.1995-21.8.1995. SAR-echoes in overlay areas are stretched out in the SAR viewing direction (or SAR line-of-sight) and therefore do not deliver useful information. Figure 3 depicts the geocoded differential SAR interferogram of the orbit image pair 20.8.1995-21.8.1995. Most parts of the glacier tongue below the ice fall show sufficient coherence.

The measured difference in the phase depicted in Figure 3 was corrected from its phase ambiguity by applying an unwrapping process (Brunch-cut method). As a next step, a displacement image with displacement rates given in mm was calculated by using large areas of stable bedrock outcrops near the mountain Fuscherkarkopf. The results show that during the one-day observation period 20.-21.8.1995 maximum surface displacement rates of 30-45 mm/day in the SAR line-of-sight have been calculated (Fig. 4).

Our one-day displacement results and additional simplifying assumptions allow the estimation of a maximum annual surface displacement rate for the year 1995. The simplifying assumptions are primarily glacier flow parallel to the surface, ablation or ice melt of 2 cm for the one day observation period and steady glacier displacement all year round.

The estimated ablation value of 2 cm for the one day observation period in August 1995 is based on averaging field measurements (LIEB 1995, G.K. Lieb pers. comm.). However, the high coherence of the image pair 20.8.1995-21.8.1995 indicates rather stable surface conditions suggesting even a lower ablation value. In this regard it is important to consider that - mathematically - a daily ablation value of 1 cm changes the surface displacement rate for the year 1995 by 10.3 m. Regarding the last assumption one has to point out that glacier velocity is certainly not steady depending on temperature and presence of water and hence stresses within the glacier and at its basis (*cf.* BENN & EVANS 1998: 166-169).

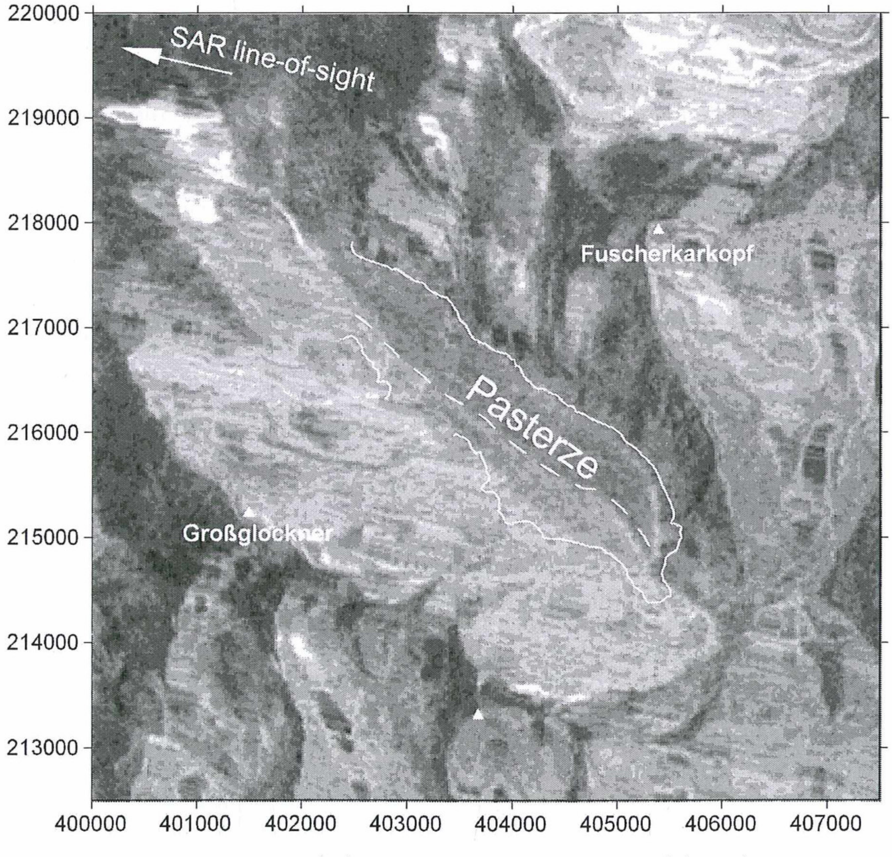

Figure 2: Geocoded ERS SAR-amplitude image of the orbit image pair 20.8.1995-21.8.1995. The outline of the glacier tongue (full line) and the boundary between the debris-covered and the clean ice part (dashed line) are indicated.

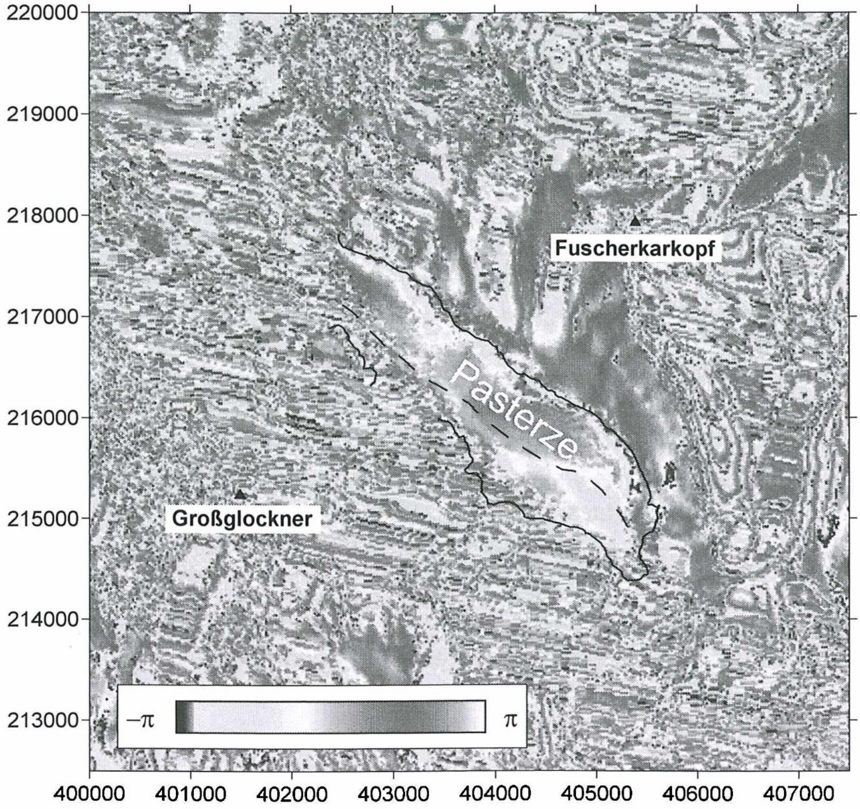

Figure 3: Geocoded differential SAR interferogram of the orbit image pair 20.8.1995-21.8.1995 depicting the difference in the phase (modulo 2π). Most parts of the glacier tongue below the ice fall show sufficient coherence. The measured difference in the phase indicates the terrain displacement in the SAR viewing direction. The outline of the glacier tongue (full line) and the boundary between the debris-covered and the clean ice part (dashed line) are indicated.

Based on our results and the previously mentioned assumptions a maximum annual surface displacement rate of 20-30 m valid for 1995 can be estimated. These displacement rates are comparable with the glacier velocities measured tachymetrically directly in the field at the three cross profiles (*cf.* Fig. 4) Freiwandlinie (close to the glacier terminus), Seelandlinie (central part of the glacier tongue) and Burgstalllinie (below the icefall) (LIEB 1995).

Refer to KAUFMANN et al. (in press) for a detailed methological description, analysis and discussion on the DINSAR example at Pasterze Glacier presented here. However, note that this publication is written in German.

Conclusion

This example of a DINSAR application clearly shows the potential of the technique for alpine glacier monitoring in mid latitude environments with high relief. It also demonstrates the high importance of sufficient coherence which is strongly reduced by high rates of ice ablation typical at low and mid latitudes. To conclude, only ERS-1/2 Tandem Mission images with a time interval of one day can be applied at mid latitude glaciers for surface displacement analyses during the summer period. This underlines the high potential of this method for glacier monitoring for such large areas as the Hohe Tauern National Park with its 1800 km^2.

Acknowledgments

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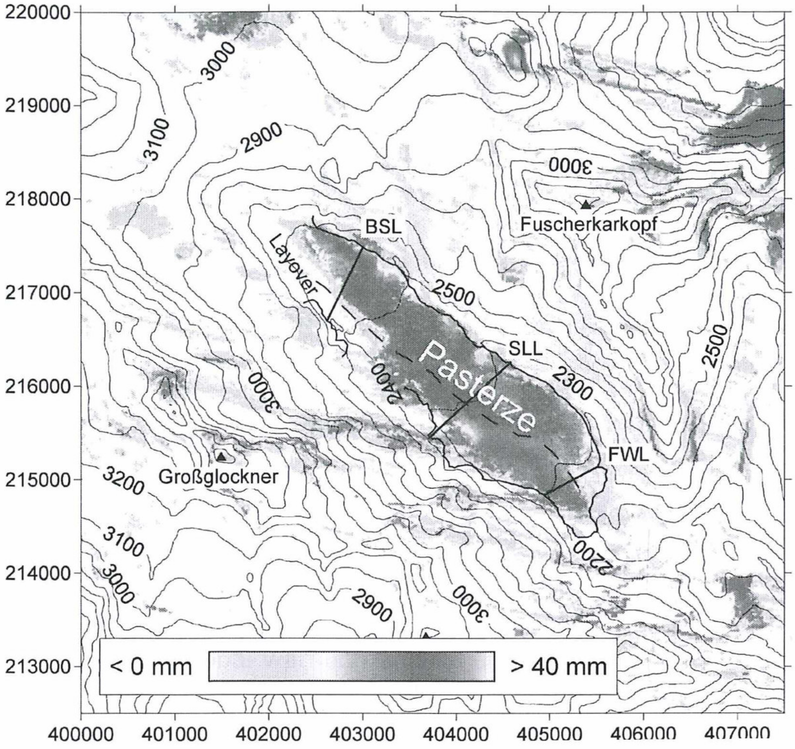

Figure 4: Geocoded differential SAR interferogram of the orbit image pair 20.8.1995-21.8.1995 depicting the calculated displacement in mm. The outline of the glacier tongue (full line), the boundary between the debris-covered and the clean ice part (dashed line) as well as the location of the three cross profiles with annual surface velocity measurements carried out by the Institute of Geography and Regional Science, University of Graz (measured tachymetrically: FWL=Freiwandlinie, SLL=Seelandlinie and BSL=Burgstalllinie) are indicated.

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Glacier fluctuation and vegetation history during the Holocene at the largest glacier of the Eastern Alps (Pasterze Glacier, Austria): New insight based on recent peat findings

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Summary

The spatial extent of Pasterze Glacier (47°05'N, 12°44'E, 17.5 km²), the largest glacier of the Eastern Alps located in the National Park Hohe Tauern, oscillated substantially during the Holocene. Precise knowledge of periods of smaller and larger glacier extent compared to present is still far from being complete. Ongoing global warming and its effects on the cryosphere reveal previously glaciated terrain and its underlying minerogenic and biogenic sediments. In this study four larger compressed peat pieces from the proglacial area of Pasterze Glacier found in June 2007 have been radiocarbon dated and palynologically analysed. The peat analyses indicate that Pasterze Glacier was substantially smaller compared to today at least at 3370–2200 cal BC and 1940–1430 cal BC. Remarkable is the fact that the largest peat piece covers a time span of about 900 years. The pollen flora is dominated by spruce (*Picea*) and corresponds with the well known composition during the Middle and Late Holocene at this elevation. The pollen content of one peat piece reflects the human impact on the vegetation of the higher altitudes during the Bronze Age. Our results allow a deeper insight into the vegetation history, climate and glacier history and the bog ecology during the Late Holocene in central Austria. Some of the results have been also used for educational purpose at the Hohe Tauern National Park visitor centre in Mittersill, Austria, for the "time wheel Pasterze" (Zeitrad Pasterze).

Keywords

Pasterze Glacier, Holocene, Palynology, 14C-dating, glacier changes, Hohe Tauern National Park.

Introduction and study site

Knowledge regarding the regional climate and its effects on vegetation and glaciation in Central Austria during the Holocene is still far from being complete. In general, a retreating glacier allows the colonisation of the deglaciated proglacial area by vegetation during a long-lasting warmer and drier period. In contrasts, an advancing glacier during a cooler and wetter period buries and hence potentially preserves the organic material such as peat pieces or wood fragments. Ongoing global warming and its effects on the cryosphere reveal previously glaciated terrain and its underlying minerogenic and biogenic sediments allowing deciphering past glacier and vegetation and hence climatic history.

A number of fragments of prehistoric biogenic material (pieces of *Pinus cembra, Larix decidua* and compressed peat) were found in particular during the 1990s at the proglacial sandur of Pasterze Glacier (47°05'N, 12°44'E, 17.5 km²), the largest glacier in the Eastern Alps (Fig. 1). The material was subsequently studied by colleagues in Salzburg (Slupetzky 1993, Slupetzky et al. 1998) and Innsbruck (Nicolussi & Patzelt 2000a, 2000b). These earlier publications focused on radiocarbon and dendrochronological analyses and less on palynological investigations (*cf.* Fig. 3).

After a remarkable break in peat findings for several years at this glacier, relatively large peat pieces were found in autumn 2006 and in particular during summer 2007. The temporal break in findings for several years might suggest that the new findings belong to a different sediment stratum as the ones found previously. Results and interpretations are presented here.

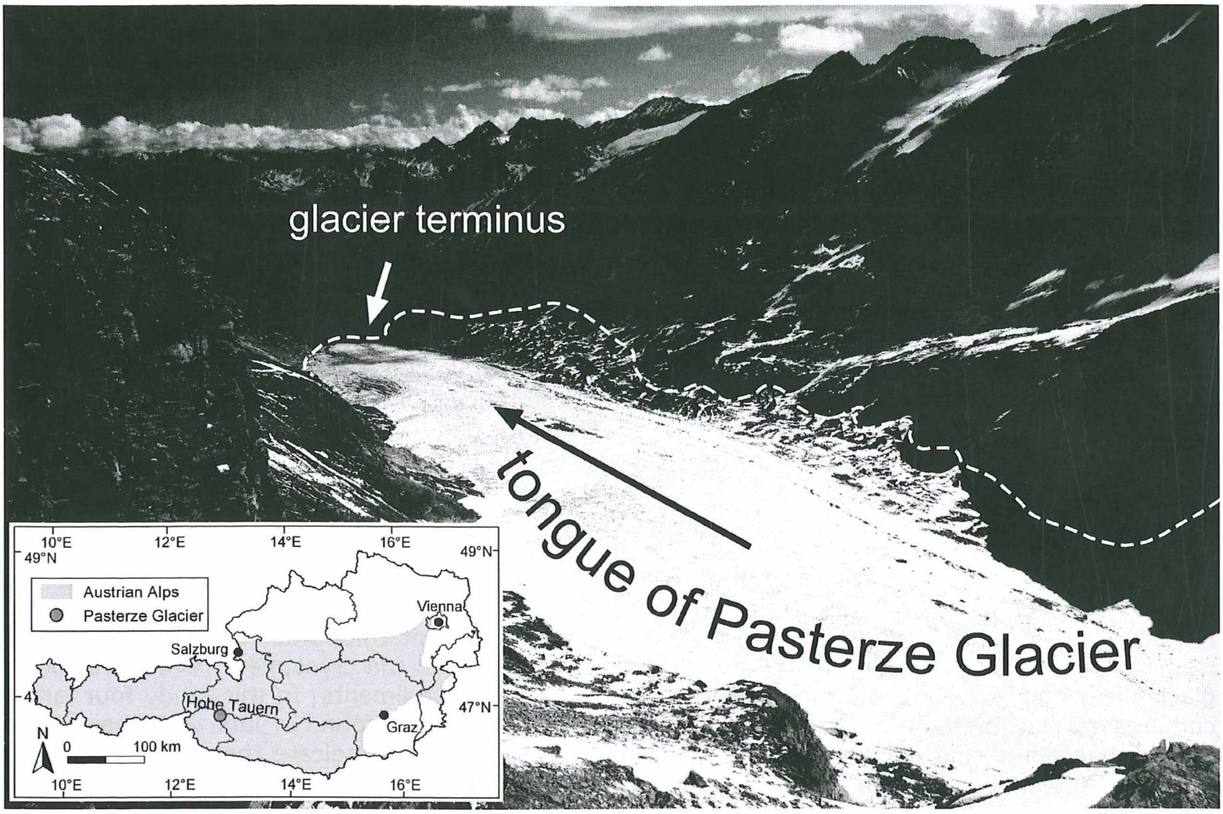

Figure 1: Location of Pasterze Glacier in within the Austrian Alps and a terrestrial view of its tongue and terminus in 2007. The four peat pieces discussed here have been found in the proglacial sandur close to the glacier terminus. The dashed line indicates the glacier margin at the debris-covered glacier part (Photograph kindly provided by P. Hadler).

Studied material and applied methods

Four large peat pieces were collected in summer 2007 in the proglacial sandur very close to the terminus of Pasterze Glacier (Figs. 1 and 2). The area itself was during that time a debris-covered dead ice body with numerous small depressions. The dead ice was presumably still connected to the main glacier but without any horizontal surface movement. The four peat pieces weighted between 1 and 12 kg. More importantly for the analysis was the thickness or c-axis of the compressed peat pieces which ranged between 5 and 13 cm (Table 1).

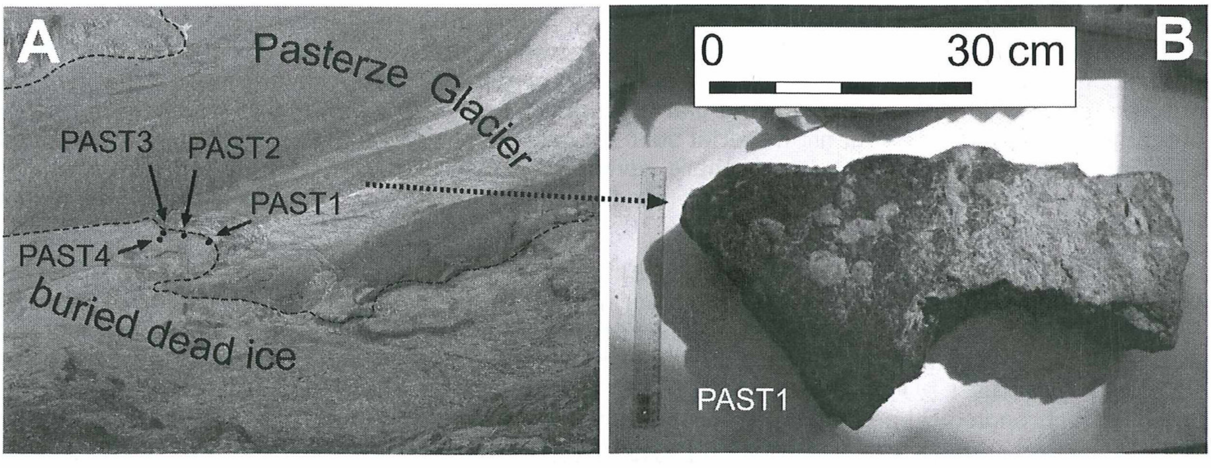

Figure 2: The four peat findings near the terminus of Pasterze Glacier on the 25th of June 2007: (A) locations of the peat findings PAST1 to PAST4. (B) The largest of the four studied peat pieces (PAST1) with a dimension of 56x29x13 cm and a weight of 12 kg (Photographs by A. Kellerer-Pirklbauer).

Table 1: Characteristics of the four studied peat pieces. For location of each finding refer to Fig. 2.

Peat piece	Weight (kg)	Size (cm) Length (*a*-axis)	Width (*b*-axis)	Thickness (c-axis)
PAST1	12	56	29	13
PAST2	12	44	43	11.5
PAST3	2	24	22	7
PAST4	1	18	12	5

All four peat samples were radiocarbon dated and palynologically analysed. Radiocarbon dating was carried out for six ^{14}C-samples by applying the AMS-method (VERA, Vienna). Both the upper and lower side of the two large pieces PAST1 and PAST2 were radiocarbon dated. Only one side (upper/lower?) of the two smaller pieces PAST3 and PAST4 were dated.

Palynological analyses were carried out by R. Drescher-Schneider applying conventional palynological routines. At three of the four peat findings (PAST1, 2 and 4) four samples of 0.5 cm^3 of organic material were studied. The four samples were equally spaced over each thickness profile/*c*-axis (e.g. for PAST1: 0, 5, 10 and 13 cm. PAST3 had low pollen content.

Results

The six radiocarbon ages vary between 1630-1430 cal BC and 3090-3370 cal BC (Table 2), thus all peat findings belong to the Late Holocene, i.e. the Subboreal Chronozone (3780-800 cal. BC; Haas et al. 1998). The thickness profile/*c*-axis of the two larger peat findings cover time spans of 430 to 900 (PAST1: 3100-2200 cal BC) and, respectively, 100 to 510 (PAST2: 1940-1430 cal BC) years. The pollen conservation was sufficient in most samples for correct pollen designation. The pollen density varied substantially between samples but was sufficient (apart form PAST3) for pollen analysis. Pollen analytical results for PAST1, PAST2 and PAST4 (pollen diagram not shown) indicates for instance the dominance of spruce in all samples and the human impact on the vegetation in sample PAST2 during the Bronze Age.

Table 2: Radiocarbon datings of the four peat findings and description of the six dated samples (*cf.* Table 1).

Code-VERA	Lab-Nr.	14C-age ±1σ-error	Calibrated age	Sample origin (profile depth)	Position	Material
Pasterze 1	VERA-4439	4375±35 BP	3100-2900 cal BC (95.4%)	PAST1 13.0-13.5 cm	lower surface of peat finding	moss, 2 needle-heads, 2 *Carex* nutlets
Pasterze 2	VERA-4440	3855±35 BP	2470-2200 cal BC (95.4%)	PAST1 0.0-1.0 cm	upper surface of peat finding	moss, Cyperaceae-remains
Pasterze 3	VERA-4441	3260±40 BP	1630-1430 cal BC (95.4%)	PAST2 0.0-0.5 cm	upper surface of peat finding	moss, Cyperaceae-remains, small limb
Pasterze 4	VERA-4442	3515±35 BP	1940-1740 cal BC (95.4%)	PAST2 8.5-9.0 cm	lower surface of peat finding	different vege-tative remains.
Pasterze 5	VERA-4443	3310±40 BP	1690-1490 cal BC (95.4%)	PAST3 0.0-0.5 cm	tentatively upper surface of peat finding	moss, Cyperaceae-remains
Pasterze 6	VERA-4444	4530±35 BP	3370-3260 cal BC (34.0%) 3250-3090 cal BC (61.4%)	PAST4 0.0-0.5 cm	tentatively upper surface of peat finding	moss

Discussion and Interpretation

Our results show that PAST1 belongs predominantly to the warmer period between the Rotmoos II (Piora II) and the Löbben (=Tiefengletscher) oscillations (Fig. 3). PAST2 is related to the Löbben oscillation. PAST3 is related to a warmer period within the Löbben oscillation and PAST4 is connected to the Rotmoos II oscillation. The pollen flora of all analysed peat findings (PAST1, PAST2 and PAST4) conforms to the known flora composition of the Middle to Late Holocene dominated by spruce. The results further indicate that Pasterze Glacier was smaller compared to today during the periods ~3370-2200 cal BC and ~1940-1430 cal BC. If one presumes that the development of a peat bog as well as a significant vegetation cover needs some decades to develop, we can conclude that a 2000 year long glacier unfavourable period existed between ~3370 and ~1430 cal BC in central Austria.

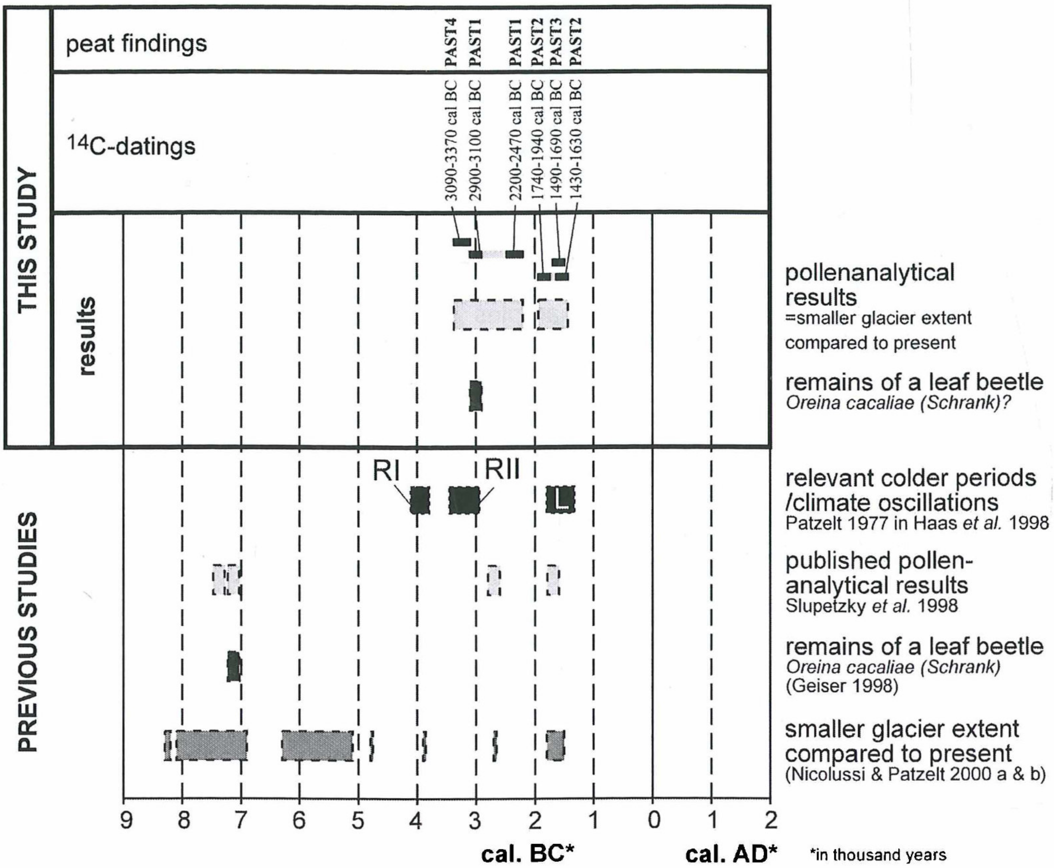

Figure 3: Results of this study and previous studies regarding the vegetation and glacier history at Pasterze Glacier. Parts of a newly found fossil leaf beetle are very similar to the ones studied earlier dated to 7280-7035 cal BC (*cf.* Fig. 4). Time spans of relevant colder periods during the Middle and Late Holocene are: Rotmoos I (=Piora I) ca. 4100-3780 cal BC., Rotmoos II (=Piora II) ca. 3450-2960 cal BC und Löbben (=Tiefengletscher) ca. 1800-1320 cal BC (after Haas *et al.* 1998, Fig. 4).

Findings related to animals which are commonly found in littorale areas of lakes and bogs indicate very humid ecological conditions during peat growth. The remains of a fossil leaf beetle, similar to a fossil beetle found earlier, belong presumably to the leaf beetle species *Oreina cacaliae* (Schrank) (Fig. 4). Therefore, our palynological and radiocarbondating results are relevant for three different aspects: (a) vegetation history, (b) climate and glacier history and (c) indications regarding the bog ecology.

Conclusion and Outlook

The results of this study allow a deeper insight into the vegetation history, climate and glacier history and the bog ecology during the Late Holocene in central Austria. It is for instance shown that Pasterze Glacier was substantially smaller compared to today at least at 3370–2200 cal BC and 1940–1430 cal BC, hence during a roughly two thousand year long period. Besides its scientific value the results presented here have been partly used for educational purpose at the Hohe Tauern National Park visitor centre in Mittersill, Austria, for the "time wheel Pasterze" (Zeitrad Pasterze).

Concluding analyses of the four peat findings presented here are currently in progress. These analyses are – amongst others – the analysis of tree parts embedded within the peat pieces (conclusions regarding the tree limit), two further radiocarbon datings (conclusions regarding the lower and upper surface of PAST3 and PAST4), analysis of macro remains and the analysis of animal remains (for more precise conclusions regarding the bog ecology).

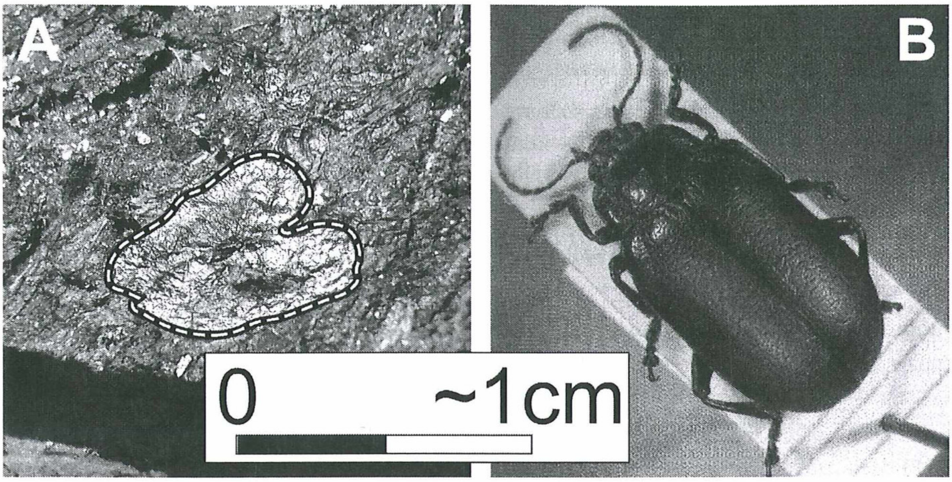

Figure 4: (A) Parts of a fossil leaf beetle (possibly of the species *Oreina cacaliae (Schrank)*(*cf.* Geiser 1998) found in PAST1 with an age of 3100-2900 cal BC. (B) Image of a recent specimen of an *Oreina cacaliae (Schrank)* taken from Geiser (1998).

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The project "ALPCHANGE – Climate Change and Impacts in Southern Austrian Alpine Regions" with research results from the study area Schober Mountains, Hohe Tauern Range

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Summary

ALPCHANGE is a project on climate change and its impacts on the alpine environment in southern Austria with an – originally – three years running period from June 2006 to May 2009 (extended to November 2009). The project is mainly carried out by two universities in Graz (University of Graz and Graz University of Technology) and is funded by the Austrian Science Fund (FWF). The main objective of ALPCHANGE is to quantify landscape dynamics in alpine regions caused by climate change in past and present by combining two basic approaches: (1) investigation of the interaction of present climatic conditions and high mountain processes by use of a monitoring network established during the project period, and (2) analysis of signals from various dynamic landscape parameters – permafrost, geomorphodynamics, glaciers, and snow – for the ongoing climate change by a series of methods. Field research within ALPCHANGE is carried out at seven study sites in the Hohe and Niedere Tauern Ranges; three thereof within the boundaries of the Hohe Tauern National Park. In this paper we summarise research results from the study area in the central part of the Schober Mountains, focussing on the Gößnitzkees Glacier, the Weissen Cirque (housing a rock glacier) the Kögele Cirque (housing a debris-covered glacier remnant) and the Hinteres Langtal Cirque (housing a rock glacier).

Keywords

ALPCHANGE, climate change and impacts, permafrost, glacier, snow, geomorphodynamics, Hohe Tauern National Park

The project ALPCHANGE and its objectives

The project "ALPCHANGE – Climate Change and Impacts in Southern Austrian Alpine Regions" is a project studying climate change and its impacts on the alpine environment in southern Austria with an originally three years running period from June 2006 to June 2009 (now extended to November 2009). The project is mainly carried out by the University of Graz and Graz University of Technology and is funded by the Austrian Science Fund (FWF). The authors form the core team of ALPCHANGE. Furthermore, G.K. Lieb and V. Kaufmann are involved since more than a decade in research activities in the Schober Mountains (e.g. LIEB 1996).

The main objective of ALPCHANGE is to quantify landscape dynamics in alpine regions caused by climate change in past and present. ALPCHANGE combines two basic approaches: (1) investigation of the interaction of present climatic conditions and high mountain processes by use of an upgraded monitoring network established for the very first time in southern Austria, and (2) analysis of signals from various dynamic landscape parameters – permafrost, geomorphodynamics, glaciers, and snow – for the ongoing climate change by a series of different methods.

The four landscape parameters react in differing time scales to climate change and therefore provide different information: snow cover instantly, glaciers within years to decades (depending on size), geomorphic features within years to decades and permafrost within decades to centuries. The interdisciplinarity of the project required usage of different methods and made the co-operation of a number of researchers with different backgrounds necessary.

Field research within ALPCHANGE was carried out at seven study sites in the Hohe and Niedere Tauern Ranges, four thereof (CSM, DOV, PAG and SON) within the boundaries of the Hohe Tauern

National Park (Fig. 1). For further information on the project please visit www.alpchange.at. In objective of this paper is to summarise research results from the study area in the central Schober Mountains (CSM).

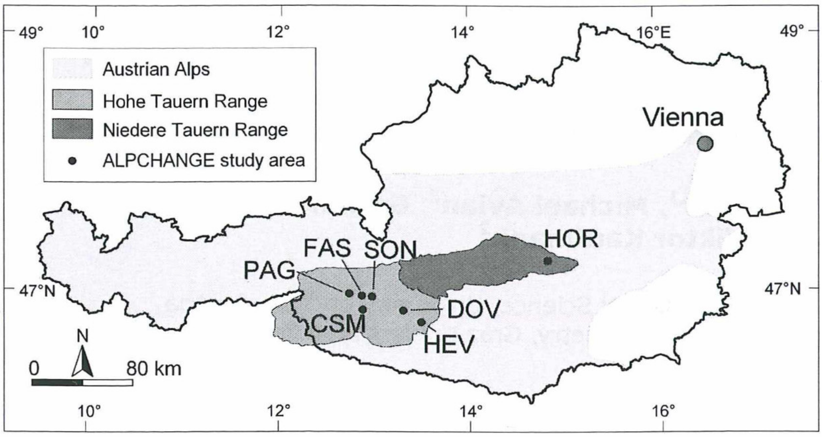

Figure 1: Locations of the seven ALPCHANGE study areas within the Hohe and Niedere Tauern Ranges. Abbreviations of study areas:

CSM=Central Schober Mountains*
DOV=Dösen Valley*
FAS=Fallbichl-Schareck
HEV=Hintereggen Valley
HOR=Hochreichart area
PAG=Pasterze Glacier*
SON=Sonnblick*

*located within the Hohe Tauern National Park

The study area Central Schober Mountains and the studied landforms

The Schober Mountains are characterized by crystalline rocks and a continental climate (1500 mm at 2000 m a.s.l., 0°C mean annual air temperature at 2300 m a.s.l.) causing minor glaciation and large areas affected by permafrost. The permafrost favourable conditions are indicated by the high number of rock glaciers (n=126), underlining the fact that the Schober Mountains provide suitable topoclimatic and geological conditions for rock glacier formation (Lieb 1996). Within the CSM our research activities at a local scale focus primarily on the following four landforms: the Gößnitzkees Glacier, the Weissen Cirque (housing an active rock glacier) the Kögele Cirque (housing a debris-covered glacier remnant) and the Hinteres Langtal Cirque (housing a highly active rock glacier) (Fig. 2).

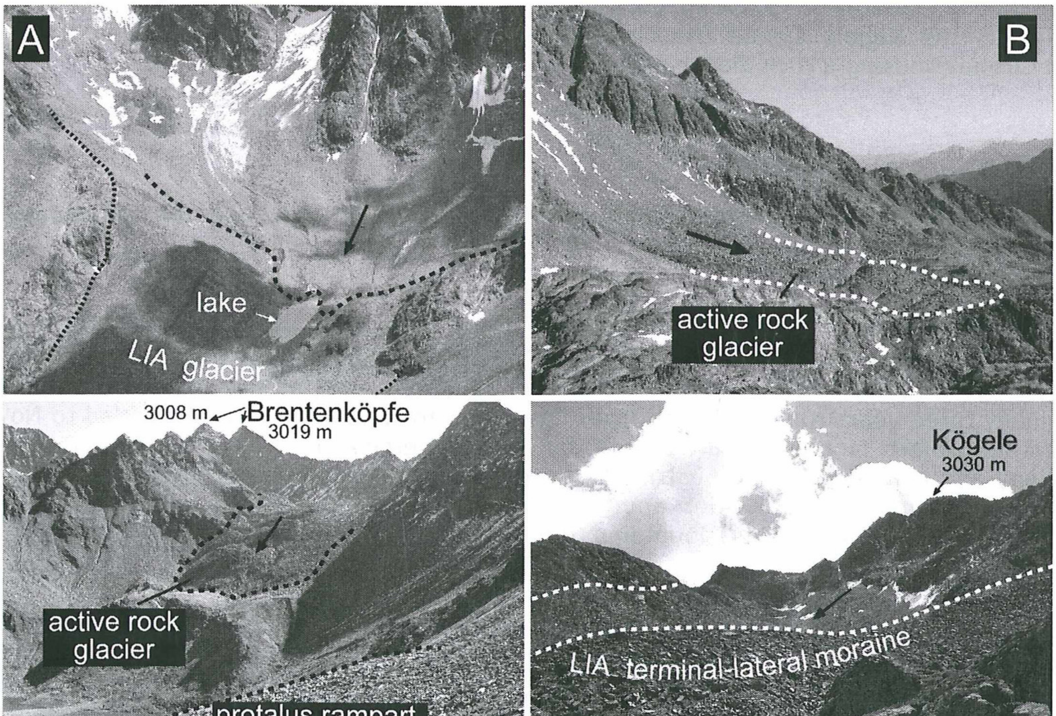

Figure 2: Terrestrial photographs of the four relevant landforms in the study area Central Schober Mountains (CSM): (A) Gößnitzkees Glacier, (B) Weissen Cirque and (C) Hinteres Langtal Cirque - both housing a rock glacier, (D) Kögele Cirque - housing a debris-covered degrading glacier remnant; LIA=Little Ice Age (ca. 1850 AD); black arrow indicates flow line of glacier/rock glacier; photographs by M. Avian and A. Kellerer-Pirklbauer.

Applied methods

Table 1 summarises the applied methods at each of the four studied landforms in the study area CSM that are briefly introduced and depicted in Chapter 2.

Table 1: Applied methods at the four studied landforms Gößnitzkees Glacier, Weissen Cirque, Hinteres Langtal Cirque and Kögele Cirque. Abbreviations: LiDAR=Light detection and ranging or Laserscanning (airborne and/or terrestrial); GS=geodetic survey; PG=photogrammetry (aerial and/or terrestrial); MTD=ground surface temperature and near ground surface temperature measurements (e.g. shallow boreholes) by use of miniature temperature dataloggers; AGE=age dating of rock glacier surfaces; MET=meteorological station; GEOM=geomorphic mapping and observations; RDC=monitoring of cirque processes with automatic remote digital cameras.

Studied landform	LiDAR	GS	PG	MTD	AGE	MET	GEOM	RDC
Gößnitzkees Glacier	X	X	X				X	
Weissen Cirque	X	X	X	X	X		X	
Hinteres Langtal Cirque	X	X	X	X		X	X	X
Kögele Cirque	X		X	X			X	

Research Results

Gössnitzkees Glacier

Gößnitzkees Glacier is located in the central part of the Schober Mountains at the valley head of the Gößnitz valley. "Kees" is the regional term for glacier. The unfavourable climatic (see above) and topographic (steep rock faces, narrow crests, lack of flat surfaces at high elevations above the regional equilibrium line altitude/ELA) conditions of the Schober Mountains for glaciation are the reasons that Gößnitzkees Glacier with its 0.59 km² in 2006 (Kaufmann & Ladstädter 2008c) is the largest glacier in this area. A distinct accumulation area is missing and avalanches from couloirs of the headwalls nourish the glacier with snow, ice and rocks. Therefore, more than 60% of the glacier is covered by a continuous supraglacial debris mantle with variable thickness (Kellerer-Pirklbauer et al. 2005). The glacier flow velocity is low and ranges between 20 and 50 cm a^{-1} as derived from ten velocity markers. Assuming a similar glacier retreat pattern as during the last decades, this glacier will be gone by ca. 2030 (Kaufmann & Ladstädter 2008c).

ALPCHANGE research at this landform (Table 1) is carried out by using LiDAR (initiated in 2000 on an annual to biannual basis; Kellerer-Pirklbauer et al. 2005), by geodetic survey (annually since 1996; Kienast & Kaufmann 2004), by aerial and terrestrial photogrammetry (aerial since 1954, terrestrial since 1988; e.g. Kaufmann & Lieb 2002, Kaufmann & Ladstädter 2004, 2008c and 2008b) and geomorphic mapping and observations. Published research results supported by ALPCHANGE are found in Kaufmann & Ladstädter (2008b).

Weissen Cirque

The Weissen Cirque is located less than a kilometre south of Gössnitzkees Glacier facing to the west. The cirque is dominated by the tongue-shaped Weissenkar Rock Glacier which is fed by active scree slopes. The rock glacier consists of an active upper lobe overriding an inactive lower lobe. The landform is characterized by well developed furrows and ridges at its lower half, a lower limit at 2615 m a.s.l., a length of 500 m and a surface area of 0.11 km².

ALPCHANGE research at this landform (Table 1) is carried out by geodetic survey (initiated in 1997, annually), by aerial photogrammetry (since 1974; Kaufmann et al. 2006), by ground surface temperature and near ground surface temperature measurements using UTL and Geoprecision dataloggers (initiated in 1997, extended in 2007; Kellerer-Pirklbauer et al. 2008c), by rock glacier dating (Kellerer-Pirklbauer 2008a) and by geomorphic mapping and observations. Published research results supported by ALPCHANGE are found in Delaloye et al. (2008), Kellerer-Pirklbauer (2008a) and Kellerer-Pirklbauer et al. (2008c).

Research at the Hinteres Langtal Cirque

The Hinteres Langtal Cirque as well as the neighbouring Kögele Cirque (see below) are both orientated towards W-NW each with comparable high crests and mountain summits slightly exceeding 3000 m a.s.l. to the S and E. The first mentioned cirque is dominated by the Hinteres Langtalkar Rock Glacier indicating at its front the local lower limit of discontinuous permafrost at 2450m a.s.l. The rock glacier is approx. 850 m long and 200 to 350 m wide. Its frontal part is heavily influenced by disintegration through active sliding processes since 1994 (e.g. Avian et al. 2005 and 2008a, Roer et al. 2008).

ALPCHANGE research activities at the Hinteres Langtal Cirque (Table 1) are the most comprehensive ones of all four landforms studied in the CSM. At this site, we apply LiDAR (initiated in 2000; e.g. AVIAN et al. 2008a), geodetic survey (initiated in 1999, annually), aerial photogrammetry (since 1954; KAUFMANN & LADSTÄDTER 2008a), ground surface temperature and near ground surface temperature monitoring using Geoprecision dataloggers (network installed in 2006; e.g. KELLERER-PIRKLBAUER et al. 2008b), meteorological measurements through a comprehensive climate station (installed in 2006), geomorphic mapping and observations (since 1999; KELLERER-PIRKLBAUER & KAUFMANN 2007, KELLERER-PIRKLBAUER 2008b) and continuous monitoring of cirque processes by using an automatic remote digital camera/RDC (installed in 2006) delivering daily images of geomorphic and snow cover processes (KELLERER-PIRKLBAUER et al. 2008a).

Published research results supported by ALPCHANGE are found in Avian et al. (2008a and "in press"), DELALOYE et al. (2008), KAUFMANN & LADSTÄDTER (2008a), KELLERER-PIRKLBAUER (2008b), KELLERER-PIRKLBAUER & MATSUOKA (2009), KELLERER-PIRKLBAUER & ROUBAL (2009), KELLERER-PIRKLBAUER et al. (2008a, b and d) and ROER et al. (2008). Figure 4 presents for instance results of the long-term monitoring of the morphodynamics of the Hinteres Langtalkar Rock Glacier based on aerial photographs (1954-2006) and geodetic measurements (1999-2007). This graph clearly depicts for instance the extremely high horizontal displacement values in 2003-2004 caused by the exceptional warm summer 2003.

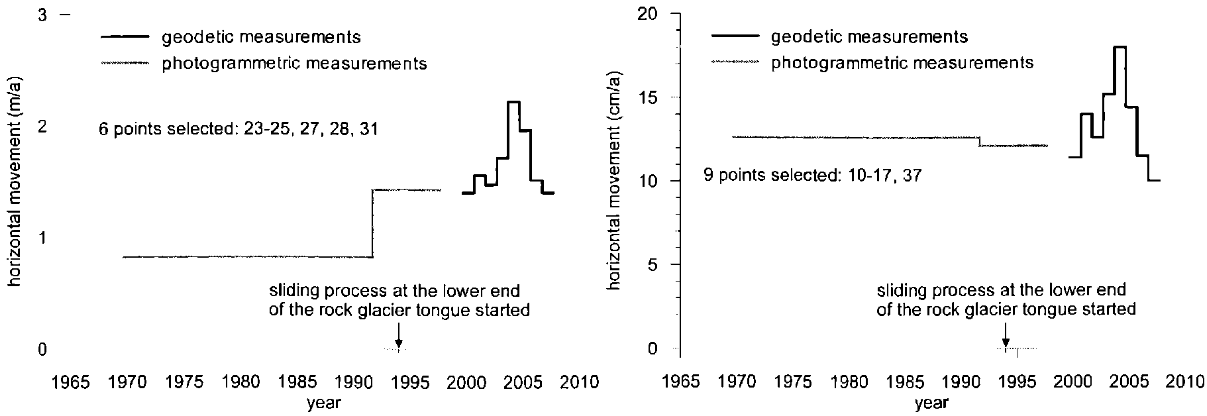

Figure 3: Mean annual horizontal displacement (in m a^{-1}) of the Hinteres Langtalkar Rock Glacier depicted for the faster lower part (left) and the substantially slower upper part (right) of the rock glacier (*cf.* Kaufmann & Ladstädter 2008a).

Kögele Cirque

The Kögele Cirque is located some 50 m higher compared to the neighbouring Hinteres Langtal Cirque. In contrast, this cirque lacks a rock glacier but houses a glacier remnant that is still slowly creeping down-valley thereby deforming its widespread supraglacial debris mantle. This debris layer is dominantly structured as small-scaled tongue-shaped landforms (STLs) that have a bended appearance proving the ongoing down-valley movement (see Fig. 3 in KELLERER-PIRKLBAUER & KAUFMANN 2007)

ALPCHANGE research activities at the Kögele Cirque (Table 1) are carried out by applying aerial photogrammetry (since 1969; KELLERER-PIRKLBAUER & KAUFMANN 2007), ground surface temperature and near ground surface temperature monitoring using Geoprecision dataloggers (network installed in 2006; KELLERER-PIRKLBAUER 2008b) and geomorphic mapping and observations (since 2006; KELLERER-PIRKLBAUER & KAUFMANN 2007, KELLERER-PIRKLBAUER 2008b). Published research results by ALPCHANGE are found in KELLERER-PIRKLBAUER (2008b).

Considering the entire CSM

Finally ALPCHANGE research activities at CSM are also carried on a more regional scale, as for instance climate change analyses (TAUCHER et al. 2008 and 2009) or a comprehensive analysis of glacier changes of the Hohe Tauern Range comprising CSM (AVIAN et al. 2008b).

Final remarks and Outlook

This paper summarises a whole suite of research activities from one of the study areas of ALPCHANGE. Chapters 2, 3 and 4 briefly introduced the study area Central Schober Mountains and the studied landforms the methods and our research activities as well as published results. Most of the mentioned publications are available digitally and therefore please don't hesitate to contact one of the authors of this short paper for more details on a given publication. Furthermore, a series of collected data from our research activities in the CSM are still being processed and are prepared for publication. Finally, please note that most of our research activities initiated during the ALPCHANGE project period will be continued to be carried out as e.g. within the project PermaNET (www.permanet-alpinespace.eu).

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This study was carried out within the project ALPCHANGE (www.alpchange.at) funded by the Austrian Science Fund (FWF) through project no. FWF P18304-N10. We appreciate the help of students of the University of Graz and Graz University of Technology as well as volunteers of the Hohe Tauern National Park during the numerous field campaigns.

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The use of GPS and DGPS for glacier monitoring at the tongue of Pasterze Glacier between 2003 and 2008

Andreas Kellerer-Pirklbauer

Summary

The Global Positioning System (GPS) and the differential Global Positioning System (DGPS) have been applied for this study at the 4.5 km^2 large tongue of Pasterze Glacier, the largest glacier of the Austrian Alps located in the Hohe Tauern National Park. D/GPS research presented here has been carried out during the period 2003 to 2008. The D/GPS measurements were carried out partly to support other monitoring techniques. In total, D/GPS measurements focussed on (a) positioning and tracking of aligned stone locations at three cross profiles at the glacier tongue where elevation change and movement is measured annually by tachymetric surveys, (b) precise displacement measurements of single point locations at the central cross profile for flow direction studies, (c) measurement of the retreat of the glacier terminus, (d) glacier shrinkage at its lateral margin, (e) positioning of control points for terrestrial laser scanning (TLS) at the glacier surface, and (f) tracking of selected large rocks for glacier flow velocity and flow direction studies. The presented und discussed results demonstrate the high potential of the D/GPS for detailed glacier monitoring detecting even small changes.

Keywords

Pasterze Glacier, glacier monitoring, GPS, differential GPS, Hohe Tauern National Park.

Introduction

Detecting and monitoring changes in glacier behaviour is crucial in understanding the effects of the ongoing climate change on alpine environments. Detailed mapping is a difficult task in areas with minor topographic information where the landform scale is too small for the precise location or where the surface is changing rather rapidly as for instance in glaciated areas in the European Alps at present. However, detailed maps regarding the size and shape are required in order to establish climate-glacier relationships. The development of Global Positioning Systems (GPS) is a significant contribution for detailed glaciological surveying and mapping. By applying this method it is possible to map with a high accuracy at much faster rates than before, when this could only be achieved by traditional (and time-consuming) geodetically surveys. Achieving high accuracy is especially true using a differential GPS (DGPS) system that allows mapping continuously points or lines in a low-relief terrain with an error of a few centimetres.

The aim of this contribution is to present different applications of GPS and DPGS for glacier monitoring exemplary demonstrated at the tongue of Pasterze Glacier in Austria. The research presented here was carried out during annual glaciological surveys as well as in the project "ALPCHANGE - Climate change and impacts in southern Austrian alpine regions".

Study area

The Pasterze Glacier (47°05'N, 12°44'E) is situated at the foot of the Großglockner mountain (3798 m a.s.l.), the highest summit of Austria, in the Hohe Tauern Range, Austria (Fig. 1). The studied glacier is a compound valley glacier fed by a number of tributaries. Pasterze Glacier reaches a length of 8.4 km, comprises a volume of about 1.8 km^3 (Lieb 2004), ranges from 2065 to ca. 3500 m a.s.l. and covered in 2002 an area of 17.5 km^2. The glacier is the largest ice mass in Austria. According to the most recent Austrian glacier inventory, the glacier extent was 18.4 km^2 in 1998 (A. Lambrecht, pers. com. 2007) indicating substantial recent glacier recession (details in Kellerer-Pirklbauer 2008, Kellerer-Pirklbauer et al. 2008).

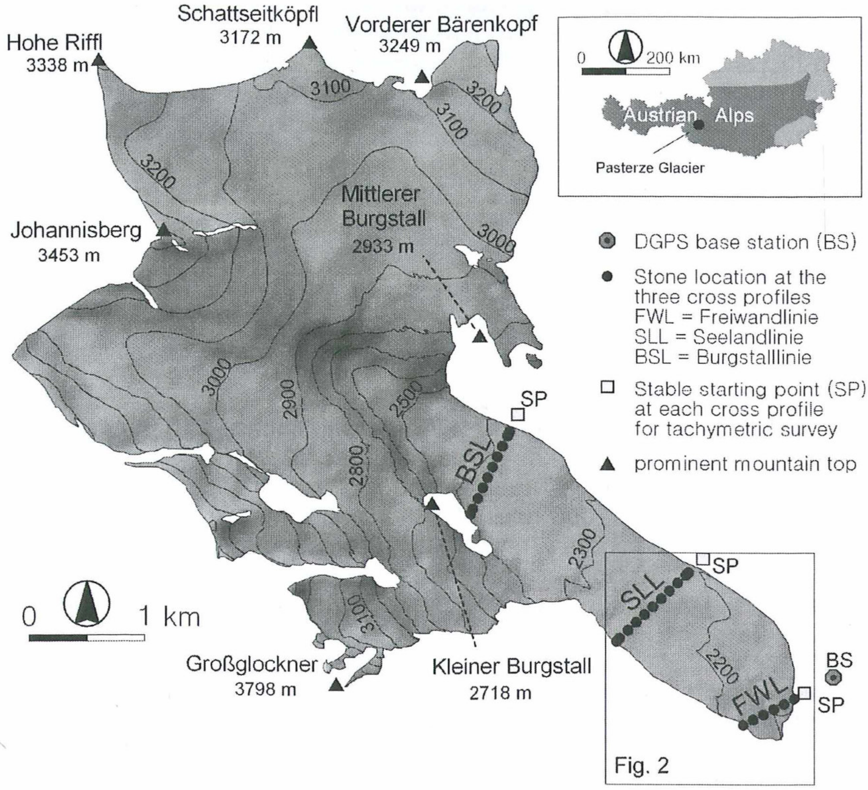

Figure 1: The Pasterze Glacier and its spatial extent in 2000. Stone locations of the three cross profiles at the glacier tongue where elevation change and movement is measured annually by tachymetric surveys, the stable starting points (SP) for these surveys as well as the location of the DGPS base station (BS) are indicated. The background map is based on glacier contour lines from 2000 of the topographical map ÖK1:50000 sheet 153 (Großglockner), Federal Office of Metrology and Surveying.

Method

Originally the GPS was conceived to indicate positions in the Earth surface in any place independently of the meteorological conditions. Even more precise positioning is possible if two GPS receivers are used. One receiver (mobile station) is used in the field for mapping (i.e. glacier margin) and a second receiver is located at a nearby known position (base station). The data of the base station can be used to correct most of the errors that are intrinsic to the system. The correction factors can be either transmitted directly via radio to the mobile station enhancing spatial accuracy, or the corrections factors can be used for later post-processing of the data. This setup is called differential GPS (DGPS; Leick 1990). The accuracy of the GPS-results diminishes with increasing distance between the mobile and base stations. For measurements on the Pasterze Glacier the base station was located at the Franz-Josefs-Höhe hence the base station was located within a distance of 3.5 km from the remotest target point.

For this study the global positioning system (GPS) and in particular the differential GPS (DGPS) has been applied during the period 2003 to 2008 for the following glaciological research objectives: (a) positioning and tracking of aligned stone locations at three cross profiles at the glacier tongue where elevation change and movement is measured annually by tachymetric surveys, (b) precise displacement measurements of single point locations at the central cross profile for flow direction studies, (c) measurement of the retreat of the glacier terminus, (d) glacier shrinkage at its lateral margin, (e) positioning of control points for terrestrial laser scanning (TLS) at the glacier surface, and (f) tracking of large rocks for glacier flow velocity and flow direction studies.

Measurements taken by DGPS are naturally of higher accuracy compared to the ones taken by GPS. The accuracy of the DGPS measurements at Pasterze Glacier has been exemplarily calculated for the measurements at the glacier cross profile "Seelandlinie" (Figs. 1 & 2) in 2004. Results show that at the total number of 224 single DGPS measurements the accuracies are as follows: in *x*-dimension ±20.4cm, in *y*-dimension ±28.9cm and in *z*-dimension ±39.8cm. This indicates that at Pasterze Glacier – with its high-relief topography negatively influencing the GPS-signal quality – the *x* and *y* accuracies are in the order of 20-30cm. The accuracy of the GPS measurements at Pasterze Glacier might be regarded as at least one order of magnitude lower as the ones of the DGPS measurements. Only in 2008 the GPS approach was applied by using the GARMIN GPSMap

60CSx device. GPS-based mapping of the glacier margin was partly tricky because of difficulties in the distinction between slopes free of buried glacier ice and slopes underlain by quasi-relict glacier ice, glacier crevasses, unstable ice margins as well as steep ice cliffs formed by e.g. incising meltwater channels.

Results and brief discussion

Results regarding the positioning and tracking of aligned stone locations at three cross profiles at the glacier tongue where elevation change and movement is measured annually by tachymetric surveys are presented in Fig. 1 for the entire glacier tongue and in Fig. 2 for the lower two cross profiles SLL and FWL. The scientific background, the glaciological relevance of these stone locations as well as the tachymetric survey principle is explained in KELLERER-PIRKLBAUER et al. (2008)

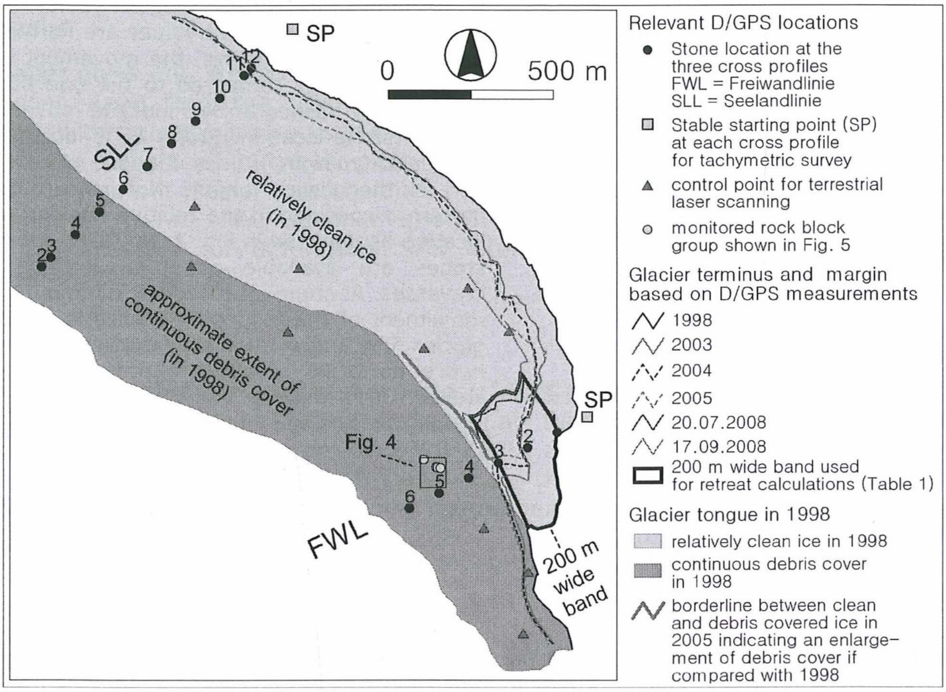

Figure 2: The lower part of the tongue of Pasterze Glacier in 1998, spatial changes during the period 1998-2008, and D/GPS measurement locations. The continuous supraglacial debris cover in 1998 and - to some extent its shift towards the east until 2005 - are indicated. The glacier margins are indicated for 1998 (based on orthophotographs from Sept. 1998), 2003 (16.09.; DGPS), 2004 (20.09.; DGPS), 2005 (21.09.; DGPS) and two times for 2008 (20.07. and 17.09.; twice GPS). The 200 m wide band at the clean ice part of the glacier terminus used for the retreat calculations presented in Table 1 is outlined.

Results regarding precise displacement measurements of single point locations at the central cross profile SLL for flow direction studies are depicted and explained in Fig. 3. These results indicate that the movement along this cross profile behaves in a radial manner meaning that supraglacial stones at the glacier margin move oblique outward whereas supraglacial stones at the valley centre move relatively straight downvalley, parallel to the main flowing direction.

Results regarding the retreat of the glacier terminus as well as glacier shrinkage at its lateral margins are depicted in Fig. 2. Table 2 gives a summary on the analysis of the glacier retreat along a 200 m wide band at the clean ice part (Fig. 2) during the ten year period 1998 to 2008 as well as during the summer of 2008. Within 10 years this glacier lost along a 200 m wide band at the glacier terminus 0.07 km² which is equivalent to about 1/250 of the entire glacier area in 2002. Interesting is the fact that the areal glacier loss during the two months July-September 2008 was larger than during the entire years 2003-2004 and 2004-2005.

Results regarding the positioning of control points (reflective targets) at the glacier surface for TLS are depicted in Fig. 2. The glaciological relevance of the control points for TLS are explained in AVIAN et al. (2007). Results regarding the tracking of large rocks for glacier flow velocity and direction studies are exemplarily depicted and explained in Fig. 4 for a prominent rock block group close to the glacier terminus which moved ca. 58 m during the period 1998 to 2008. Results show that the flow direction at this site differs substantially from the main valley axis. This can be explained by changes in the glacier surface geometry caused by differences in glacier ablation due to the shielding effect of a partly existing continuous debris cover. Ablation close to the glacier terminus at the debris-covered side is reduced by about 50% compared to the clean ice side (KELLERER-PIRKLBAUER et al. 2008). This affects also the subglacial ice flow dynamics as evidenced by the striation pattern of glacially reshaped rock outcrops in the proglacial area (Fig. 5).

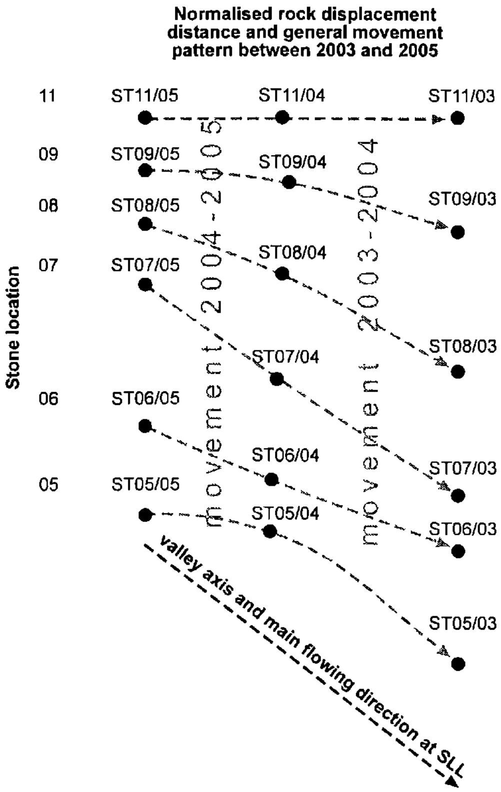

Figure 3: Stone displacement at the glacier surface relative to the valley axis (main flow direction indicated as black dashed arrow) at the cross profile "Seelandlinie" (SLL) during the two glaciological years 2003-2004 and 2004-2005. Displacement values are normalised at each stone location. In general, the movement in the second period was lower compared to the one during the first period. Grey dashed arrows indicate movement direction at each stone location. Stone 11 is located close to the left glacier margin, stones 5 and 6 close at the central part of the glacier tongue. Note the radial movement pattern if considering the relative position of each stone location as depicted in Fig. 2. No DGPS measurements of stones are available at stone location 10 due to crevasses. At stone locations 04, 03 and 02 the observed movement of the respective stones is a mixed signal of glacier flow and surface sliding of stones on ice surface, hence no DGPS results are presented here for these stones. DGPS-data for this graph were collected in 2005. See Fig. 2 for stone locations.

Table 1: Areal losses along a 200 m wide band at the clean ice part of the glacier terminus due to glacier retreat between 1998 and 2008 indicated in Fig. 2. The margin of 1998 is based on orthophotographs from Sept. 1998. The margins for September 2003, 2004 and 2005 as well as for July and September 2008 are based on D/GPS measurements.

Glacier retreat on an annual basis (glaciological year: Sept. to Sept.)		
Period (number of glac. years)	Areal loss (m²)	Average per year (m²)
09.1998-09.2003 (5)	37788	7558
09.2003-09.2004 (1)	3857	3857
09.2004-09.2005 (1)	3704	3704
09.2005-09.2008 (3)	23031	7677
09.1998-09.2008 (10)	68380	6838

Glacier retreat during two months in summer 2008 (July to Sept.)	
Summer 2008	Areal loss (m²)
07.2008-09.2008	4481

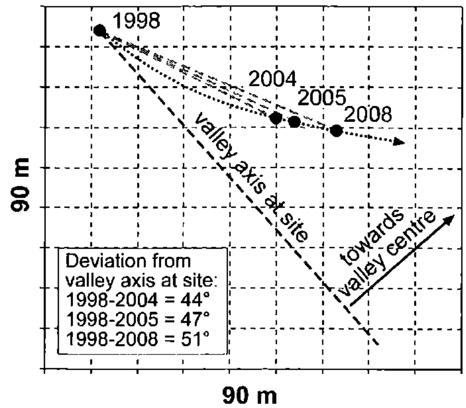

Figure 4: Change in main flow direction of a prominent rock block group due to changes in the ice flow dynamics. At this site the increasing deviation of the flow direction from the valley axis over time can be explained by an increasing glacier flow component from the valley side towards the valley centre. This movement is caused by higher ablation rates at the valley centre due to the absence of a protecting debris cover compared to the site of the rock block group which itself is protected by a debris cover. This difference in ablation caused a change in the surface geometry of the glacier (see Kellerer-Pirklbauer et al. 2008 for details on this process). For location of the site and the distribution of supraglacial debris at the site and areas free of debris (clean ice) to the NW see Fig. 2.

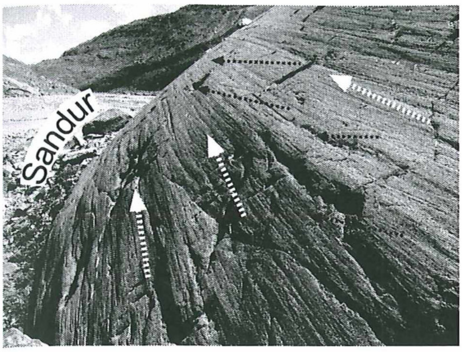

Figure. 5: Glacially reshaped rock outcrop at the proglazial area of Pasterze Glacier showing two different generations of striations related to a former (primary) flowing direction indicated by white arrows and a later (secondary) flowing direction indicated by black arrows. The primary flowing direction was following the valley axis during periods of larger glacier extent. The secondary flowing direction was more orientated from the valley side to the valley centre related to the degrading ice mass and related changes in the ice flow dynamics. The proglacial outwash plain (Sandur) is indicated. Photograph 19.07.2008, view towards SE.

Final remarks

This short paper gives only a brief overview of the use of GPS and DGPS in glaciological studies at Pasterze Glacier. Apart form the different glaciological aspects mentioned here, one should point out that DGPS at this glacier is also used for other purposes such as mapping peat pieces and wood fragments in the proglacial outwash plain (*cf.* KELLERER-PIRKLBAUER & DRESCHER-SCHNEIDER, this volume), for carrying out glacier mass balance measurements (by Central Institute for Meteorology and Geodynamics, Vienna; W. Schöner and B. Hynek) or for precise ice thickness change measurements necessary for differential SAR interferometry/DINSAR (by Joanneum Research, Graz; R. Wack and A. Sharov).

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