Table of Contents, part I / 2

Conference Volume | 5th Symposium for Research in Protected Areas | 10 to 12 June 2013, Mittersill | pages 1 - 6

Ecosystem and Ecocity Planning in the Southeastern Anatolia Region in Turkey

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Abstract

In the recent years, there have been many opportunities flourishing through the development of Turkey. One of these is unvalued rich agricultural and hydro-sources in the Southeastern Anatolia Region. The Southeastern Anatolia Project (GAP), one of the most important projects to develop the remarkable natural resources of the world, is considered as a chance to make use of rich water and agricultural resources of the Southeastern Anatolia Region.

In the recent years, the concept of promoting sustainable human settlements and eco-city planning approach have been included into the GAP Project. And by applying these concepts in real projects caused remarkable results through development of the region.

The aim of this study is analyze the concepts of promoting sustainable human settlements and eco-city planning approach in the GAP Project that has been still processed.

In the first section, the region of Southeastern Anatolia and the GAP Project will be introduced briefly. In the second section, the stages of GAP Project and the project existing will be analyzed. In the third section, the projects and sub-projects used for promoting sustainable human settlements will be introduced.

In the last and fourth section, a series of policies and strategies for providing the process of settlements which is optimal and harmonizes with eco-system will be given.

Keywords

Promoting Sustainable Human Settlements and Eco-City Planning Approach, Land Use, Southeastern Anatolia Region and Southeastern Anatolia Project(GAP), Regional Development and Human Resources.

JEL Codes

O13, O18, Q15, Q24, R14, R52, N55,

Brief of southeastern Anatolia region and GAP project

The Southeastern Anatolia Project (GAP) is a multi-sector and integrated regional development effort approached in the context of sustainable development. Its basic objectives include the improvement of living standards and income levels of people so as to eliminate regional development disparities and contributing to such national goals as social stability and economic growth by enhancing productivity and employment opportunities in the rural sector. The project area covers in the basins of the Euphrates and Tigris and in Upper Mesopotamia.

The GAP had originally been planned in the 70s consisting of projects for irrigation and hydraulic energy production on the Euphrates and Tigris, but transformed into a multi-sector social and economic development program for the region in the 80s. The development program encompasses such sectors as irrigation, hydraulic energy, agriculture, rural and urban infrastructure, forestry, education and health. The water resources development component of the program envisages the construction of 22 dams and 19 hydraulic power plants and irrigation of 1.8 million hectares of land. The total cost of the project is estimated as 32 billion US $. The total installed capacity of power plants is 7476 MW and projected annual energy production reaches 27 billion kWh (GAP ADMINISTRATION 1993b).

The project rests upon the philosophy sustainable human development, which aims to create an environment in which future generations can benefit and develop. The basic strategies of the project include fairness in development, participation, environmental protection, employment generation, spatial planning and infrastructure development.

The agricultural development objectives of the GAP include the following: Raising levels of income in the rural sector; providing inputs for industrial enterprises in the region; creating employment opportunities so as to minimize out-migration and encouraging export oriented production in the region (ACMA 2001).

Stages of the GAP Project

The GAP had originally started as an energy production and irrigation project seeking to utilize the rich land and water resources of the region. It was later converted into an integrated regional development project upon the completion of the GAP Master Plan in 1989. The Master Plan is an overall guide for the course that regional development will follow and for plans, programs and projects to be developed on more specific terms. The basic development scenario adopted by the Master Plan is to transform the region as a agriculture based industrial center (GAP ADMINISTRATION 2002).

At present, the GAP is a human centered and integrated regional development project carried out along with the principles of sustainable human development. The development envisaged under the GAP has the goal of creating opportunities for the people of the region fully materialize their preferences and economic potentials. Other than dams, hydroelectric plants and irrigation schemes over the rivers of Euphrates and Tigris, the concept of "Southeastern Anatolia Project" is conceived as a regional development drive aiming the multi-faceted and sustainable socio-economic development of the Region on the basis of a multi-sectoral and integrated approach which covers such diverse areas as urban, rural and agricultural infrastructure, transportation, industry, education, health, housing, tourism and investments in many other fields (GAP ADMINISTRATION 1999).

The State Hydraulic Works (DSI) is engaged in the program for developing land and water resources in the region. The program consists of two parts each of them covering projects related to the basins of either the Euphrates or the Tigris. The program envisages the construction of 22 dams, 19 hydraulic power plants and an irrigation system that will bring 1.8 million hectares of land under irrigation. Upon the completion of the project, 29 % of the total water potential of Turkey will be managed through the facilities on the Euphrates and the Tigris, which together flow more than 52.9 billion cubic meters of water a year. The planned irrigation area corresponds to 20 % of total irrigable land in Turkey and annual energy production to 22 % of total electric energy potential in Turkey.

The GAP region extends over an area of 75,000 km2 and a wide range of crops each requiring different climatic conditions are raised in this area including olive, pistachio, hazelnut and persimmon. The region has 3.2 million hectares of land fit for crop culture. Forested areas make up 1.3 million hectares while 2.3 million hectares of land consists of pastures and ranges.

The GAP focuses on efficient utilization of these natural resources. For the first time in Turkey the management, operation and maintenance of new irrigation systems have been directly transferred to Irrigation Districts, which are organizations formed by local farmers. In 1998, the region accounted for 41.6 % of the total cotton output of Turkey. Favorable climatic conditions in the region make it possible to reap two crops a year. The region is also quite fit for animal husbandry. In this context, research projects led by the GAP Administration focus on genetic improvement and development of advanced breeding techniques.

According to studies made, upon the completion of irrigation projects in GAP, the area brought under irrigation will be equal in size to the total area so far brought under irrigation by the State. This will naturally bring along significant changes in agricultural output and crop design. Such irrigation-led crops like soybean, groundnut, corn, sunflower and fodder crops will be the basis of flourishing agro-industries (GAP ADMINISTRATION & UNDP 1997).

Gradual implementation of the GAP Project, which envisages irrigation on 1.8 million hectares of land and creation of new water reservoirs, will significantly alter the land use and water regime in the region. Also in this process, population movements, rapid urbanization and industrialization will bring along new transformations in both rural and urban areas. Other than advantages to be reaped after irrigation, there are some other points and problems to be considered: Problems emerging as a result of excessive and uninformed practices of irrigation; effects of climate change on crop farming and plant cover in the region; corresponding changes in the flora and fauna; erosion and adverse effects of uncontrolled growth on natural, historical and cultural properties. All these make it necessary to reconsider the project with a view to the dimensions of culture and the environment (ACMA 2000).

In terms of natural resources, Southeastern Anatolia is one of the most unique areas in Turkey. It is the border gate through which species peculiar to steppe and semi-desert areas enter Turkey and the region rooms in two different living environments, which is not found in other regions of the country. These are:

- Banks of the Euphrates and the Tigris, their flood plains and major tributaries of these two rivers,
- Steppe and semi-desert areas especially in the southern parts of the region (GAP ADMINISTRATION 1996).

Changes of the Socio-economic Structure in the Region by the GAP Project

The Region is also named as the "Fertile Crescent" or "Upper Mesopotamia", and known to be the cradle of civilization in human history. Throughout history, the Region has served as a bridge ensuring passage from Anatolia to Mesopotamia. The Tigris and the Euphrates, two important rivers of Turkey flow through the Region. Both originating from the Eastern Anatolia, these two rivers reach sea in the Persian Gulf. Southeastern Anatolia receives less precipitation compared to the other regions of the country. Hence the idea was to utilize the rich water potential of these two rivers for irrigation and energy production purposes, and to regulate the otherwise irregular flow of both rivers.

The integrated project covers not only multi-purpose dam and irrigation schemes but also investments in such development related areas as agriculture, energy, transportation, telecommunication, health, education and urban and rural infrastructure building. The basic development scenario of the GAP Master Plan is to transform the region into a "base" for agro-industrial products. In more concrete terms, the GAP envisages the following:

- irrigation of 1.800.000 hectares of land,
- production of 27 billions kWh energy,
- 106 percent increase in per capita income, and
- generation of employment for 3,8 million people (GAP ADMINISTRATION 2002*)*

Promoting sustainable human settlements by projects

The projects and sub-projects used for promoting sustainable human settlements within the GAP Project are follows;

1. Eco-City Planning Approach for Adiyaman and Local Agenda 21
2. Structuring Sustainable Spatial Organization by Land Use Planning and Management
3. Grass-Roots/Urban Integration Programmes in Halfeti-Sanliurfa
4. Sustainable Urban Living and Social Development Programmes in Batman
5. Participatory Urban Rehabilitation Project in Mardin (GAP ADMINISTRATION 2009).

Ongoing projects

<u>Project title: GAP biodiverstiy reseach project</u>

To conduct an assessment in relation to biological diversity in the GAP region, identify priority areas in this respect and analyze the impact of the project on these areas; to make proposals for sustainable utilization of natural resources.

The region of Southeastern Anatolia has its uniqueness in terms of its natural endowments. It is the border zone through which species peculiar to steppe and semi-desert regions enter Turkey and thus it has two living environments where species not found in other parts of the country exist. These environments are:

- The courses of the rivers Euphrates and Tigris, their flooding plains and main tributaries.
- Steppe and semi-desert areas in the southern part of the region.

<u>Project title: Studies on the present and prospective climatic features of the GAP region</u>

To analyze changes in climate and hydrology, on the basis of regional climate models, caused by the projects on the development of water resources; to develop models on the present and future climatic conditions in the region; and to assess the possible effects of climate change on water resources.

<u>Project title: Eco-city planning approach for Adiyaman</u>

To identify environmental effects in the province of Adiyaman; to integrate the protection of ecological balances, creation of an environment where coming generations can fulfill their needs and the urban planning principles of Agenda 21 to the planning system.

The project covers the city of Adiyaman and its surroundings, particularly the Ataturk Dam Lake that is affected by urban development taking place in Adiyaman. Specific points of emphasis in the project include carrying capacity, protection-utilization balance and the concepts of Agenda 21.

<u>Project title: Wild life project for the GAP region</u>

To protect biological diversity in the region by creating new living environments for settled and migratory species, including those under the threat of extinction, which live particularly along the course of the Euphrates and around other rivers and dam lakes in the GAP region.

<u>Project title: Environmental education project (Midyat & Nusaybin)</u>

The project aims to increase the environmental health awareness and environmental sensitivity of children at the primary school level (age group 10-11) by implementing environmental education programs in Mardin-Midyat and Nusaybin.

Resettlement, employment and economic investments of people affected by Birecik Dam a project for planning and implementation

The total number of people affected by this process was 30,003 (according to the 1997 Census) and 6,500 people from 850 households were subject to resettlement.

The principles of sustainability and participation were observed closely in the process of supporting socio-economic adaptation and resettlement. Furthermore, the people concerned and other relevant parties were kept informed about the process at all stages of the project and their participation to decision-making was sought. There was an information and consulting office functioning in Halfeti for this purpose.

To attain previously set objectives, activities were carried out under three separate but closely interlinked components:

- Social component relating to social life, organization and management,
- Economic component relating to employment and investments,
- Spatial component relating to resettlement (GAP ADMINISTRATION 1993c).

Social component and related activities:

These activities can be summarized in three categories:

1. Research and surveys to assess the socio-economic structure of the region and attitudes and expectations of the people concerned: There was a questionnaire applied to the inhabitants of 13 settlement units directly affected by dam construction and impoundment. Information was gathered through face-to-face interviews with 1,307 households and in-depth interviews were conducted with various groups.
2. There were community meetings in individual settlements in order to inform people about the construction and expropriation processes, their rights deriving from these processes, alternatives for settlement and other activities; and to solicit their opinion on social, economic and spatial planning. All draft plans were presented to the discussion of people and their final shape was given under the light of these opinions and suggestions.
3. There were various training and support programs to facilitate the social and cultural adaptation of people to their new environments after resettlement. A Multi-Purpose Community Center (CATOM) had been established in Halfeti at a very early stage to draw inputs to the planning and implementation of the project. The following are some training courses-activities carried out for this purpose:
   - Driving
   - Beekeeping
   - Food processing
   - Photography
   - Chess
   - Saz (a musical instrument) playing
   - Painting
   - Demonstrative mushroom culture
   - Tiling
   - English
   - Cutting-sewing
   - Hair dressing

The CATOM that used to be at the center of Halfeti moved to a new place after resettlement and is presently continuing its activities in its new place (GAP ADMINISTRATION 1993b).

Spatial component and related activities:

In this component, the first principle was to identify new settlement areas in the same region in line with the preferences of the people. Then, with the participation of people, new places of settlement were determined. Following this, the basic maps of these identified places were taken in cooperation with the Directorate General of Agricultural Reform (TRGM) and Directorate General of Rural Services (KHGM), which was followed by parcel and development plans. Actual settlement in these places took place, depending upon the preferences of the people concerned, through technical and/or credit support to those constructing their houses or settlement by the means of the State.

A sub-regional development plan of scale 1: 25,000 was developed by considering all relevant natural, social, environmental and spatial data and infrastructure in the area and this plan was approved on 31 May 1999. The plan covers all settlement units affected by Birecik Dam and reflects decisions relating to urban and rural land use patterns for a term extending to 2017. A note added to the plan includes a list showing corresponding organizations in charge and investments needed for each decision. Prior to the official approval of the plan, the document was presented to representatives from all related organizations and agencies and their opinions and criticisms were taken to give the plan its final shape (GAP ADMINISTRATION 1993a).

Halfeti district center:

The maximum water code of the dam is 385 meters. After impoundment, Basbostan neighborhood of the district center of Halfeti completely remained under water while Cekem neighborhood was largely affected. The neighborhoods of Simaliye and Rustiye were affected partly by the waters of the dam. The project considered alternative settlements for those parts of Halfeti center affected by the dam. Finally Karaotlak location at a distance o 8 km to the district center was preferred for having 2,790 decares of available land.

With the technical and logistics support of GAP-RDA, the TRGM took the basic map of the new area as the basis of the development plan. This development plan was completed and approved by the relevant authority (Council of Ministers) on 29 September 1998 and then transferred to the Mass Housing Administration (TOKI) for the construction of houses. Upon the intervention of the Governorate of Sanliurfa to take over construction, developments took another course and finally 220 dwellings (each 100 m2, 3 rooms and a saloon), 1 basic education school, a three-story hospital building and 30 shops of varying sizes were constructed and delivered to their residents and users as of the year 2001.

Pollution control in the Dam Lake and Tributary Streams:

The Birecik dam had originally been planned only for irrigation and power generation purposes. But later, it was considered that drinking and use water needs of the centers of Gaziantep and Nizip could be provided by this reservoir. This radical change had serious implications on the activities of the GAP Administration in designing alternative places of settlement and the resettlement process thus fell also within the scope of the Regulations on the Control of Water issued pursuant to the Law No. 2872 on the Environment.

To ensure smooth progress in project activities, there was need to conciliate the provisions of the Regulations stated above and original data from the project area. Consequently a joint observation-survey work was carried out in the area from 20 to 24 April 1998 with the participation of specialists from relevant parties. Data obtained in field survey-observation was evaluated in a series of meetings held with the Directorate General of Environmental Protection and taken as a base in the scale 1: 25,000 sub-regional development plan.

Institutional framework and coordination:

The GAP Administration had to perform rather heavy coordination functions in relation to the project mainly for the diversity of parties involved in it. Considering this, it was decided to create a "Higher Commission for Resettlement in Birecik Dam" upon the approval of the Prime Ministry. Secretarial works of this commission were undertaken by the GAP Administration. The higher commission met 8 times to discuss issues relating to the project and its progress and took relevant decisions to solve emerging problems.

Apart from this higher commission, there was also a Project Monitoring Committee in the region and this regional committee made meetings to discuss various problems and suggestions. The committee also held wider meetings attended by the local representatives of governmental agencies including the Governorate of Sanliurfa, District Governors in the area, mayors, NGOs, village headmen and people affected by the dam lake. There is some projects;

1. Participatory urban rehabilitation project in Mardin
2. Survey of archaeological settlements in Southeastern Anatolia
3. Environmental plan for Acirli (Midyat - Mardin) historical site
4. Project for support to the re-settlement, employment and socio-economic development of population affected by Ilisu dam (GAP ADMINISTRATION 1996).

Policies and strategies for optimal human settlement and ecocity approaches

In the Southeastern Anatolia Region for providing optimal settlements and harmonizing them with eco-systems the following policies and strategies can be proposed;

Ecocity development has four stages:

1. Concept initiation and comprehensive planning,
2. Ecoscape planning and legislation,
3. Eco-engineering design and development,
4. Ecosystem monitoring and management (DI CASTRI 2000)

Ecocity development needs five motivations:

1. Administrative authorizing,
2. Scientific supervision,
3. Industrial sponsoring,
4. Citizens' participation and
5. Medium motivation (GRIMM 2000)

Strategies for eco-cities

a) Planned and safe city
    1. Protection of heritage sites, monuments, etc
    2. Pedestrianization of commercial areas
    3. Restriction of certain hazardous industries/ processes/ activities
    4. Environmental management plans (incorporation of environment considerations in master plans, sectoral plans)
    5. Proper traffic and transport systems
    6. Training and capacity building in planning and development authority (ROSELAND 2000).
b) Pollution free city
    1. Polluter pays (fines)
    2. Clean fuel for vehicles
    3. Battery operated and low emission vehicles in certain zones
    4. Bicycle ways
    5. Green rating of industries (MIGUEL 1999).
c) Clean cities
    1. Green belt scheme
    2. Protection areas national parks, zoological / botanical gardens
    3. Open spaces
    4. Water body/ river front open spaces landscaping (ROSELAND 2000).
d) Energy efficient city
    1. Alternate energy sources (wind mills solar energy)
    2. Piped gas supplies to the house holds
    3. Preparation of environmental actions
    4. Planned and safe city
    5. Pollution free city
    6. Clean city
    7. Green city
    8. Energy efficient city (ICLEI 2000).

Inter sectoral and institutional mechanism

1. Central and state government
2. Central and state pollution boards
3. Environmental authorities
4. Urban development authorities
5. Transport authorities
6. Health authorities
7. Town and country planning boards
8. Forest department
9. District administration (HAUGHTON 1997).

Priority actions

1. Identification of responsibilities
2. Involvement of all stake holders, central state government, district administration, planning development authorities municipal corporation, industries, overseeing and coordination chief secretary
3. Resource conservation
4. Adoption of eco-friendly technologies
5. Budgetary requirements
6. Monitoring and surveillance mechanism (JARI 1999).

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Meadows and Pastures – Islands of Biodiversity in the National Park Kalkalpen (Upper Austria)

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Figure 1: Species-rich hay meadow in the Kalkalpen National Park (Spannriegl hay meadows)

Keywords

Pastures and Meadows, Biodiversity, Land Use

Introduction

Kalkalpen National Park in Upper Austria comprises the two ranges Sensengebirge and Reichramiger Hintergebirge. Its total area encompasses 208 km². Forests cover 81 % of this area whereas 8 % are covered with dwarf pines. Rocks and boulder cover 5 % of the area and only 6 % are covered with grasslands. Therefore Kalkalpen National Park is characterized by dense forests hosting many small meadows, pastures and alps. These areas are often hidden in the National Park and located far away from anthropogenic impacts. Areas not covered by forests are e.g. landslide tracks. From this wide range of open lands 65 meadows and pastures were chosen and investigated in detail. These open patches of grassland are indeed a relevant factor of landscape diversity and an enrichment for the biodiversity of the Park. The importance of these meadows, pastures and alps is related to biodiversity; this study demonstrates the close relationship existing between biodiversity and land use.

Methods

From the wide range of open landscapes in the Kalkalpen National Park 65 meadows, abandoned grasslands, alps and pastures were chosen. These areas were investigated within detailed field studies. The studies were based on existing information (e.g. biotope maps), aerial photographs containing the edges of the study sites and a data sheet allowing a systematic description of these areas.

The parameters of investigation were the following:

- accessibility
- typical vegetation type/FFH habitats
- biotope types
- hydrological balance
- nutrient balance
- list of plant species
- structures
- disturbances
- current land use
- forage yield
- forage quality
- measures

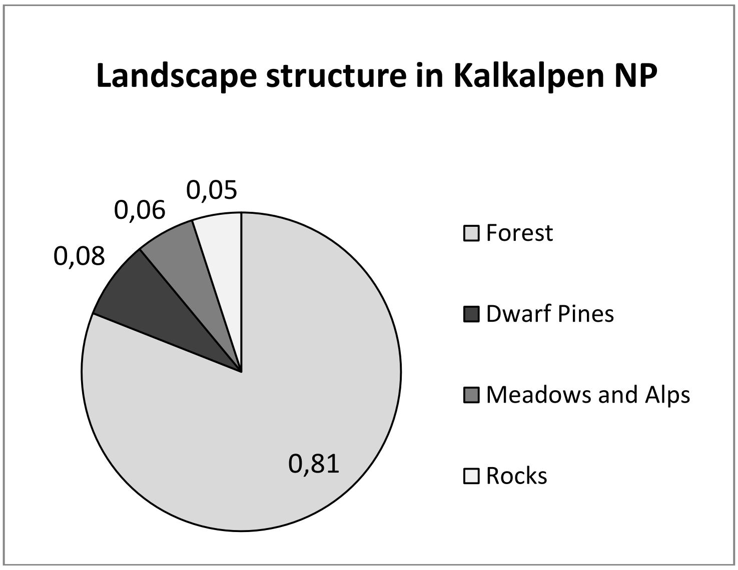

Figure 2: Main biotope types in Kalkalpen National Park (percentage).

In addition to these investigations existing valuable data and studies could be used for the project: EGGER (2007), GREIML (1994), GREIML (1991), HÖLZL (1991a + b), PILS (1994), Riedl (1992), SCHERMAIER (1995), STUMMER (1990), STUMMER (1991); LENGLACHNER & SCHANDA (2002).

The collected data were entered into a data base (developed by the Kalkalpen National Park). This data base was the most essential mean of investigation. It is connected with ArcGis and serves as a tool for planning, administrating and monitoring the grassland areas in Kalkalpen National Park.

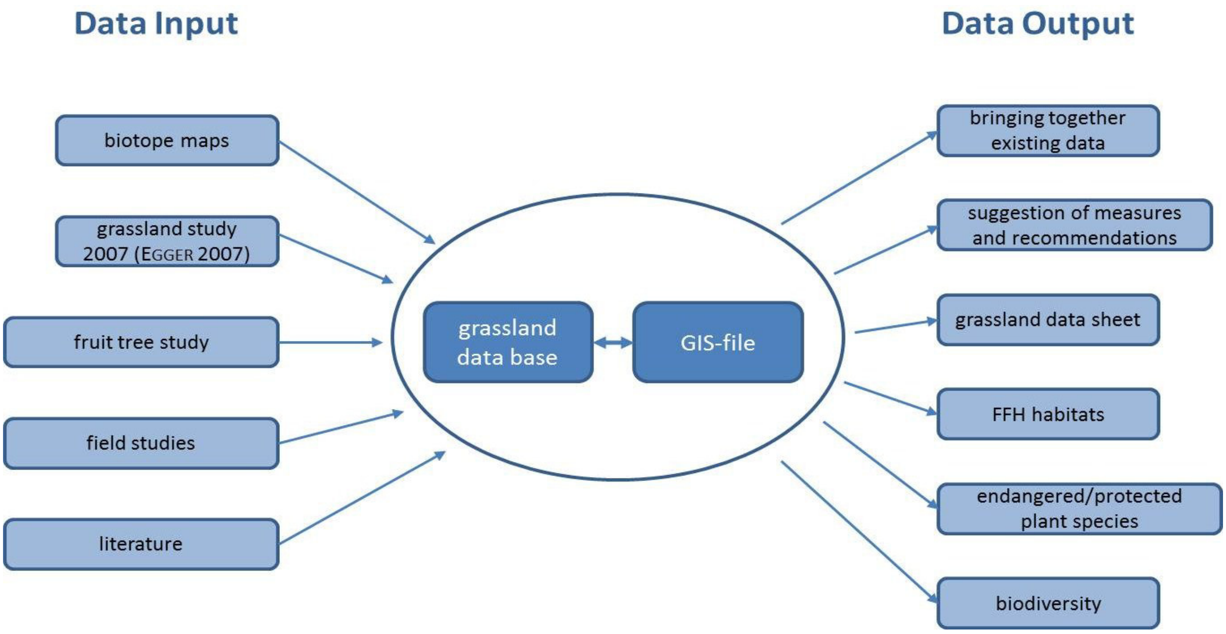

Figure 3: Scheme of data flow in the Kalkalpen National Park's data base

Results

Kalkalpen National Park is focused on nature conservation, interventions, even those aimed at maintenance of biodiversity, must be kept as low as possible. However, in order to maintain species richness in the grasslands, some management measures such mowing or pasturing, must be periodically performed. In Austria extensively used grassland is endangered due to agricultural intensification on the one hand and on the other hand due to abandonment of land use.

In total the Kalkalpen National Park's grasslands were allocated to 26 different biotope types. According to the Red List of endangered Biotopes in Austria (ESSL & EGGER 2010), 17 of these biotope types are endangered. Mostly of the endangered biotope types occur in meadows, on alps and pastures. Within the abandoned grassland, the majority of biotope types is not endangered (see following figure).

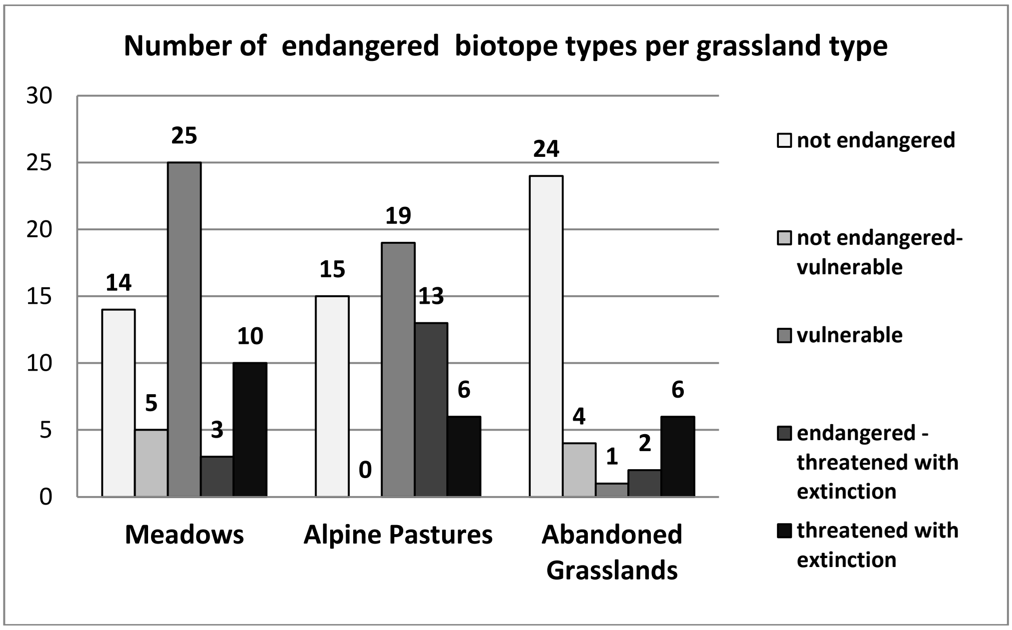

Figure 4: Number of endangered biotope types
(according to Red List of endangered Biotopes in Austria) per single grassland type

Within the framework of the investigations a total number of 812 different plant species was counted on grasslands (meadows, alps, pastures and abandoned grasslands). Among those, 117 species are fully protected according to the Upper Austrian Nature Protection Law; 126 plant species are endangered according to the Red List of endangered species for Upper Austria. In addition many plant species regionally endangered were found Amt der Oö. Landesregierung (1997 – 2010), Land Oberösterreich (2001), Lenglachner & Schanda, (2002), Niklfeld (1999).

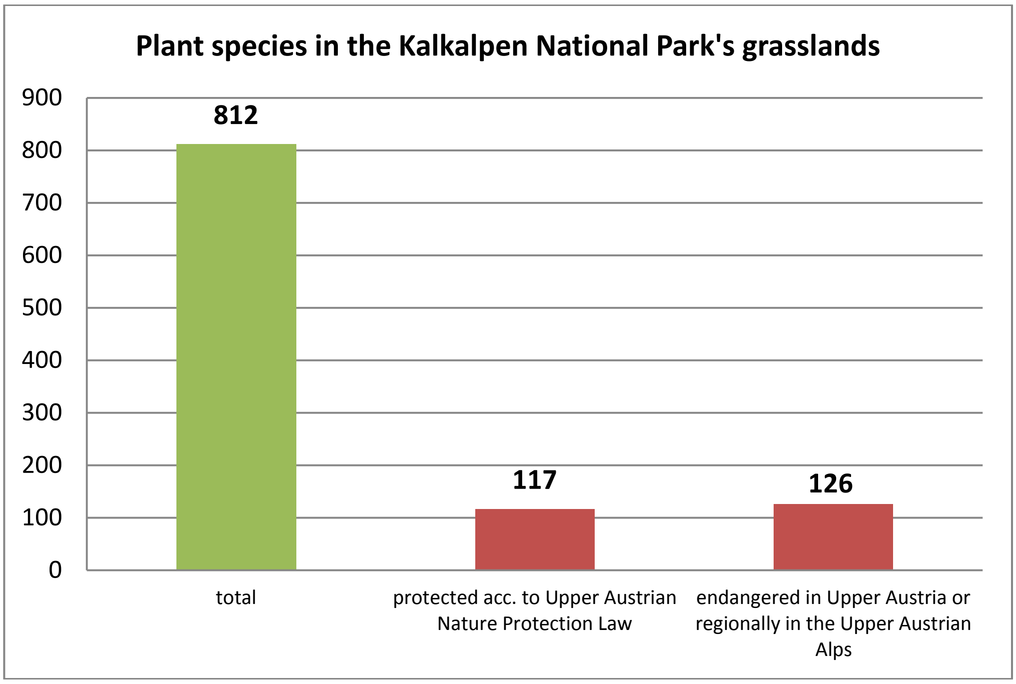

Figure 5: Overview of the numbers of detected plant species and their status of endangerment

Meadows

Most of the meadows in the National Park are mowed once a year. Date and frequency of mowing are adapted to local conditions and have a great impact on species diversity of the grasslands. The majority of the grasslands is mowed only due to nature protection objectives. Most meadows are located in the territories “Bodinggraben” and “Holzgraben”. Altogether, more than 450 plant species were found on the meadows; among these, 51 are plant species protected in Upper Austria and 70 plant species that are, according to the Red List of vascular plants for Upper Austria (Hohla et al. 2009), endangered.

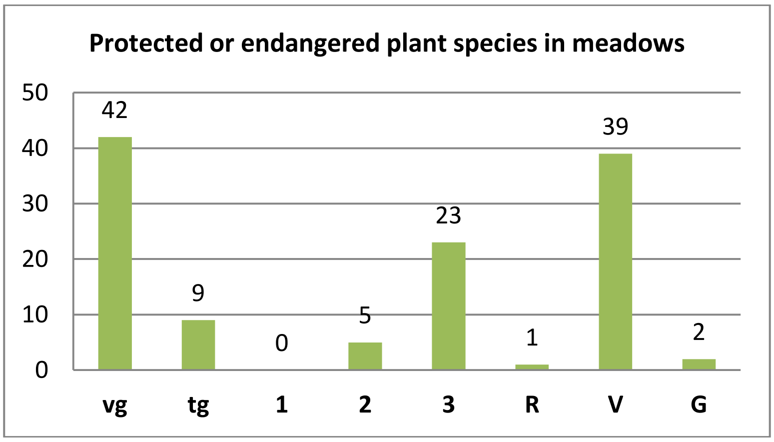

Figure 6: Number of protected or endangered plant species on meadows (multiple mentioning is possible if a species is protected and endangered) (vg = fully protected, tg = partly protected - according to Upper Austrian Nature Protection Law) , (0= exterminated, extinct or missing, 1 = threatened with extinction, 2 = endangered, 3 = vulnerable, R = very rare, but not endangered (potentially endangered), V = near threatened, G = data deficient, but endangerment assumed according to Red List for Upper Austria)

Alps and Pastures

Since centuries alps and meadows are used during the summer season to feed livestock. In the Kalkalpen National the grazing livestock is mostly cattle and in some cases horses. Rarely, sheep or goats are sent to the alpine pastures. The natural timber line shifted down, partly due to active clearings and partly due to livestock grazing. Especially within the extensively used areas, the alps represent a very high species diversity. In addition the high diversity of structures and a small-scale landscape mosaic contribute to a high diversity of habitats. Altogether more than 650 plant species were found on the investigated alps, some single alps contain more than 200 plant species. Many of these species have a high value from an environmental protection point of view. In this sense 90 species are fully protected in Upper Austria whereas 20 species are partly protected. Altogether 111 plant species are endangered according to the Red List of vascular plants for Upper Austria.

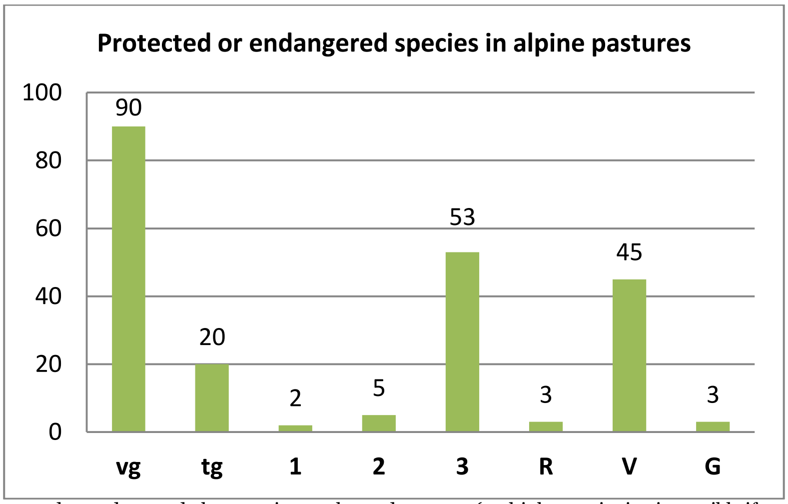

Figure 7: Number of protected or endangered plant species on alps and pastures (multiple mentioning is possible if a species is protected and endangered) (vg = fully protected, tg = partly protected - according to Upper Austrian Nature Protection Law) , (0= exterminated, extinct or missing, 1 = threatened with extinction, 2 = endangered, 3 = vulnerable, R = very rare, but not endangered (potentially endangered), V = near threatened, G = data deficient, but endangerment assumed according to Red List for Upper Austria)

Abandoned Grasslands

Abandoned grasslands are open landscapes which evolved due to human land use; in the past they were mowed or grazed by livestock but then land use has stopped. Some of these abandoned grasslands have not been used only for some years, others have been abandoned for many years or decades. Species diversity of single abandoned grassland sites decreased considerably after abandonment. Yet some abandoned sites host an high species diversity, here more than 500 plant species were found. According to the Red List of vascular plants for Upper Austria 96 of them are protected and 61endangered. If the abandonment will continue, in the following decades forest will reclaim these sites and the species range will change seriously. Restarting the land use is hence proposed only for the most valuable abandonment sites.

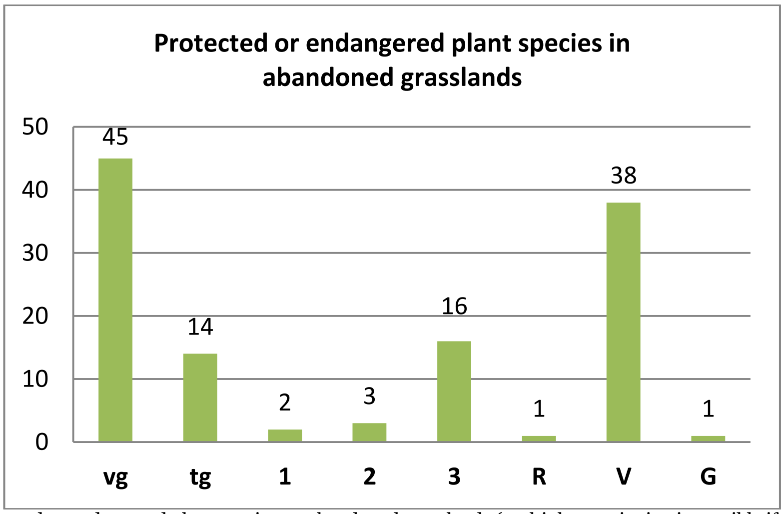

Figure 8: Number of protected or endangered plant species on abandoned grasslands (multiple mentioning is possible if a species is protected and endangered) (vg = fully protected, tg = partly protected - according to Upper Austrian Nature Protection Law) , (0= exterminated, extinct or missing, 1 = threatened with extinction, 2 = endangered, 3 = vulnerable, R = very rare, but not endangered (potentially endangered), V = near threatened, G = data deficient, but endangerment assumed according to Red List for Upper Austria)

Discussion/Conclusion

The project had the objective of analyzing and assessing the species diversity, the biocoenosis and the structures of the grasslands in the Kalkalpen National Park. The assessment was based on a field survey aimed in capturing the ecological status of the meadows, pastures and abandoned sites. The surveyed data encompassed among other things the occurrence of plant species, presence of FFH habitats, plant sociology, hydrological and nutrient balance variables as well as negatively affecting factors. The total number of sampled sites was 65, more or less equally distributed in number among the categories meadows, pastures and abandoned sites. The data thus collected were then organized in a relational database for ease of consultation, storage and maintenance. The data analysis performed with the aid of the database revealed that 812 plants species are currently present in these areas, 117 of them are classified by the Upper Austrian Law as protected species while 126 are included in the Upper Austrian's Red List. The sites with the highest plant diversity are the alps and the pastures followed by the abandoned sites.

Grassland diversity in the Kalkalpen National Park is enormous. The focus of the Kalkalpen National Park is targeted toward nature conservation. Interventions, even those aimed at maintenance of biodiversity, must be kept as low as possible. Pros and cons of such interventions have to be weighed carefully every time. Is there a need for keeping a site open through grazing or mowing or should its further development be left to natural succession? These relations were shown in this study and hence a crucial aid in decision making for future strategies was developed.

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National Park Certificate for Alpine Pastures

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Keywords

National Park Certificate, Alpine Pasture, Natura 2000, Measures, Implementation

Introduction

Alpine pastures (alps) with National Park Certificate are an exemplary synergy between nature protection and alpine land-use. Large areas of the Hohe Tauern National Park are used as mountain pastures. Here there is a great need for protection of a high biodiversity, especially in relation to climate change and the associated effects: shift of vegetation zones and downward changes in plant species composition.

The establishment of the National Park Certificate allows the achievement of multiple objectives within a single project. At the National Park Hohe Tauern (Tyrol) such objectives were represented by:

1. the preservation and improvement of FFH habitats through measures set by the alpine farmers on a voluntary basis
2. classification of the conservation status of the FFH habitats found in the participating pastures, documentation and improvement of their conservation status during sites inspections
3. alpine pasture management adaptation to local conditions and ecologically compatible with the National Park
4. measures to steer tourist along pre-defined trails and paths
5. recognition of the National Park as the main authority in charge of solving alpine pasture farmers issues (i.e. pasture management or building measures)

Methods

The National Park Certificate of pastures is based on a joint visit of the alp by staff of the Hohe Tauern National Park and the eb&p Environmental Agency Ltd. together with the alpine pasture farmer. During this joint visit, the pasture will be thoroughly screened. All concerns of farmers are documented and current pasture management is screened. Existing basic data such as bog mapping in Hohe Tauern National Park (WITTMANN et al. 2007) and the mapping of the FFH habitats (HOFFERT et al. 2006) are a valuable basis for recommendations for pasture management and necessary measures. As part of the site inspection, all necessary measures are documented. In accordance with the Conservation Plan on the Alpine Pasture (AIGNER et al. 2007, AIGNER 2004, AIGNER et al. 2003, AIGNER et al. 2005 and EGGER et al. 2006), the measures are defined in detail and calculated.

Picture 1: All measures are agreed in cooperation with the alpine farmers.

The implementation of the agreed measures is carried out by the alpine pasture farmers or by the *"Maschinenring"*. In the implementation phase, the alpine pasture farmers are intensively supervised by staff of the Hohe Tauern Tyrol National Park and the eb&p Environment Agency Ltd.. Once a year, the implemented measures are evaluated and accounted.

Results

Currently, 26 alps, corresponding to approximately one third of the whole alps present in the Park, are taking part in the program.

In total the FFH habitats conservation status was improved or initiated in approximately 100 hectares. Many other measures with have been set the goal of increasing biodiversity in the National Park (e.g. habitat protection or establishment of stone-walls, revitalization of mountain meadows). Further advantage of the implemented standardized certification methodology is the possibility of evaluating the future development of the FFH habitats at any time.

In the first five-year project period around € 600,000 were granted by the federal land and the European Union.

Picture 2: The recovery of valuable grazing land is performed with care and the goal of enhancing the landscape complexity.

Picture 3: Stone walls have been restored with a total length of 1,340 m .

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 15 - 18

Resource competition between chamois, alpine ibex and red deer in the Swiss National Park?

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Abstract

Protected areas provide unique opportunities to investigate species interactions under natural conditions. In the absence of large predators, ungulates have reached relatively high densities in the Swiss National Park, and in some valleys, chamois, alpine ibex and red deer co-occur in close proximity. We explored the potential for resource competition between the three species by integrating information on local diet composition and fine-scale spatial distribution with respect to environmental parameters in the valley with the highest ungulate density in the Park. We then tested for correlations in a) their respective population sizes from census data collected over the last 21 years, and b) correlations between census sizes and body condition of chamois and ibex, measured as yearling horn growth.

Based on a correspondence analysis, no difference was detected in diet composition between the three species during spring and summer. Chamois and ibex showed significantly different diets only in autumn, and red deer in winter, although diet composition varied seasonally for all three species. The discrimination success between chamois and ibex based on environmental parameters was also poor, but both species could be differentiated well from red deer. An intermediate negative correlation was detected between the census sizes of red deer in year n and that of ibex in year n+1, while population sizes within the same year were not correlated. Horn growth of young chamois was negatively correlated with the number of red deer in the Park during summer. It is thus likely that local resource competition with red deer has a negative influence on ibex population size with a lag effect of one year (possibly linked to body condition over winter), and on chamois body condition.

Keywords

niche differentiation, alpine ungulate, habitat use, diet, horn growth

Introduction

In the absence of natural predators, ungulate populations in some protected areas in Europe have reached high densities, potentially leading to increases in intra- and interspecific competition. The latter is often difficult to demonstrate in mobile wild populations without removal experiments, which is not possible within protected areas. An integrated approach comparing measures of niche differentiation with evidence for inverse population trends or changes in body condition in sympatry is therefore necessary. Here we investigated both niche differentiation (diet and habitat use) and evidence for competition (population trends and body condition based on yearling horn growth in bovids) between chamois, ibex and red deer in a valley with high densities of all three species within the Swiss National Park.

Methods

Niche differentiation:

- **Diet**: based on dung samples collected in February, May, August and November in 2008. Plants found in samples were grouped into Cyperaceae, Poaceae, herbs, Ericaceae and conifer fragments. A correspondence analysis was then conducted on the frequency of each group per sample, followed by Anova.
- **Habitat use**: based on regular mapping of the spatial distribution of ungulates during one morning in January, May, August and November 1997 to 2012. The analysis was based on the following environmental parameters: altitude, slope, aspect, topographic roughness, percentage of area covered by meadow and rock, respectively, within a 50m radius of each animal. The data were analysed using Generalised Additive Mixed Models (GAMMs) with a binomial distribution for each species pair.

Evidence for competition:

- **Population trends:** based on yearly ungulate censuses 1990 - 2011. Spearman correlations were conducted between the logarithm of population changes for each species pair.

- **Body condition:** based on horn growth of male yearling ibex and male and female chamois kids and yearlings born in 1990 or later. Spearman correlations were conducted between the horn growth and census sizes of all three species in corresponding years.

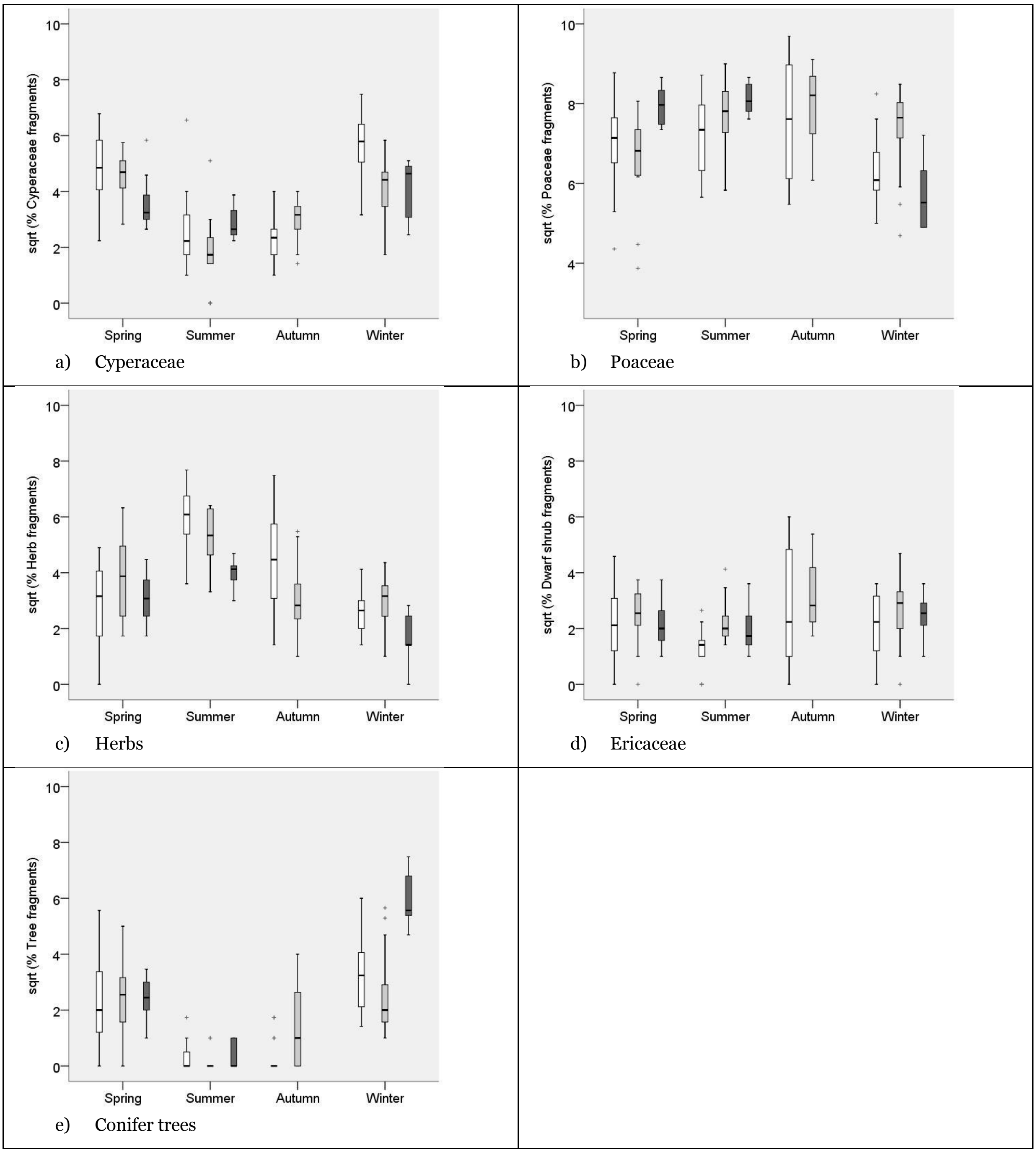

Figure 1: Boxplots for relative abundance (square-root transformed) of the five most frequently represented plant groups found in fecal pellets of chamois (white bars; n=20 for each season), alpine ibex (light grey bars; n=20 for each season) and red deer (dark grey bars; n=12 for spring and winter, n=9 for summer, no data for autumn) in the study area (Val Trupchun). Horizontal bars represent the median, box heights the interquartile range, and whiskers span 1.5 x interquartile range. Outliers (>1.5 x interquartile range) are denoted by +.

Results

Niche differentiation:

Diet: Overall, the variation in the proportion of different plant groups in the diet of chamois, ibex and red deer was higher for the same species between seasons than between species within the same season (Figure 1). There was no difference in diet composition between the three species during either spring or summer, only between chamois and ibex during autumn, and between red deer and the two bovids in winter.

Habitat use: Habitat segregation was weak between chamois and ibex during all seasons. However, the habitat use of red deer differed from the other two species during summer (distributional data for red deer were not available for the other seasons, since the species only occurs within the National Park during summer).

Competition:

Population trends: An intermediate negative correlation was detected between the change in census size of red deer from year t to t+1 vs. the census size of alpine ibex from year t+1 to t+2 (Spearman's rho = -0.58, p = 0.007). However, no negative relationship was found between the changes in counts of red deer from year t to t+1 to that of chamois the following year, nor between chamois vs. ibex or ibex vs. chamois (Spearman's rho < |0.3|, p > 0.2; Figure 2).

Body condition: Horn growth of male chamois during their kid and yearling years combined showed a significant intermediate positive correlation with the average overall number of ibex over the same time period (Spearman's rho = 0.66, p = 0.001), but a negative correlation with the average total number of red deer (Spearman's rho = -0.601, p = 0.004). The horn growth of female chamois during their kid and yearling years combined was significantly negatively correlated only with the average number of male red deer (Spearman's rho = -0.643, p < 0.001). On the other hand, horn growth in yearling male ibex was not correlated with the census sizes of any of the three species during the same year (0.020 ≤ |r| ≤ 0.157; p ≥ 0.376).

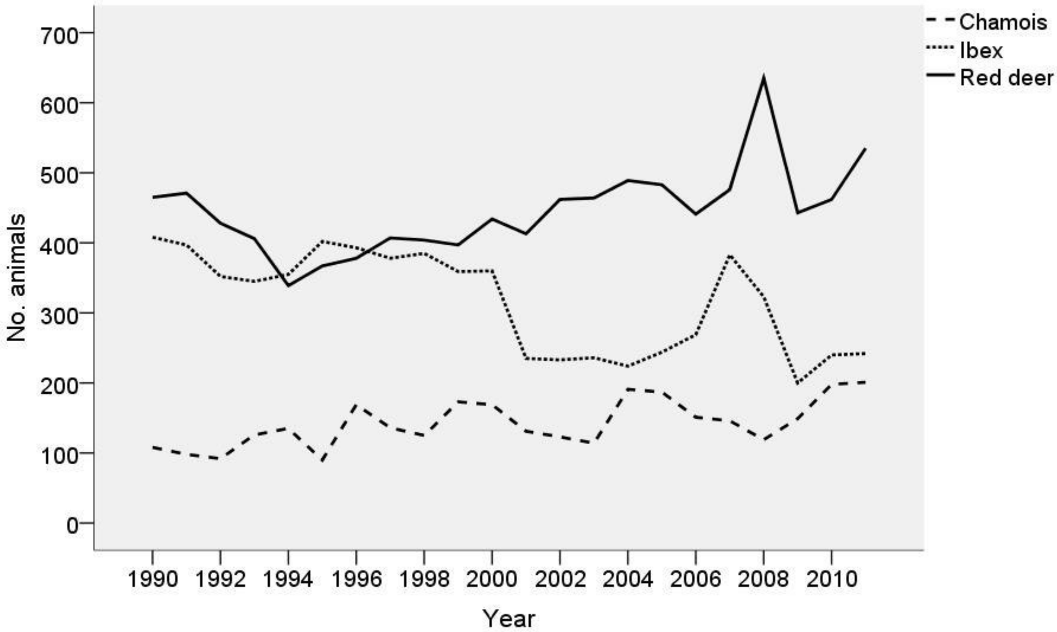

Figure 2: Annual census counts for red deer, chamois and alpine ibex in the study area (Val Trupchun) 1990-2011.

Discussion

The high niche overlap between chamois and ibex with respect to both diet and habitat use could be interpreted as high potential for competition (e.g. BELOVSKI 1986; JENKINS & WRIGHT 1988). However, we found no evidence for competition between chamois and ibex either with respect to reverse trends in population sizes between 1990 and 2011, or the density of one species negatively influencing body condition (i.e. horn growth) of the other. By contrast, there was a significant positive relationship between the horn growth of young male chamois and the total population size of ibex, suggesting that body condition, survival and fecundity of the two species are determined more by common environmental factors than by competitive interactions, at least at their current population densities.

On the other hand, niche differentiation between red deer and both bovid species was high with respect to habitat use (though not with respect to diet) during summer. Combined with the fact that red deer are absent from the Park during winter and only co-occur with chamois and ibex in significant numbers during a time when resources are expected to be abundant, little or no competition would be expected between red deer and chamois, or red deer and ibex. However, a significant negative correlation was found between the changes in census size of red deer and ibex with a time lag of one year, and the horn growth of young male and female chamois was also negatively correlated with the census size of red deer. At the same time, there was no evidence for any effect of intraspecific competition on horn growth. High numbers of red deer thus seem to have a negative influence on both ibex and chamois, although the effect appears to be different for the two species.

Conclusions

In accordance with LISTER (1980) and PIANKA (1980), our results confirm that high niche overlap between species does not necessarily imply the existence of competition, and vice versa, that interspecific competition cannot be ruled out based on a high degree of niche differentiation during a time when resources are abundant.

Natural interruptions of population growth in chamois and ibex by high mortality during harsh winters (e.g. GRØTAN et al. 2008) may keep populations of both species below levels at which resources become limiting and thus enable their coexistence in the same area with little interspecific competition.

It is likely that the foreseeable natural re-colonisation of the Swiss Alps by predators will alter competitive interactions between chamois, ibex and red deer.

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Alpine Pastures Active – New Ways for Biodiversity

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Abstract

In the middle of 2009 the Interreg IV project „Alpine Pastures Active – New Ways for the Biodiversity" started. Initiators are the Nature Conservation Department of Office of the Provincial Government of Salzburg and the Bavarian Academy for Nature and Landscape Conservation.

With resumption of the management of six alpine pastures an optimum form of management for the conservation and development of these alpine ecosystems should be evolved. The focus is on management methods with different forms of grazing, especially on the combination of different animal genera of rare farm animal races.

The test areas are located in Salzburg Federal State / A (Kallbrunnalm) as well as in Upper Bavaria/ D (Landkreis Traunstein), most of them in protected areas.

The project wants to exemplify and promote an economically sound and ecologically commendable management of alpine pastures (best practice). Therefore an interdisciplinary approach is needed which considers biodiversity and resources as well as cultural and socio-economic aspects.

Goat of the endangered farm animal breed "Blobe Ziege" at the Kallbrunnalm/Kühkranz

We use defined test series for activation of under-grazed surfaces especially in view of climate change. The focus of tested management methods is on nature conservation and development. Main target is the optimisation of different surface management methods.

In order to catch the effects on animals and plant species which are specific for alpine pastures vegetation-ecological, zoological and historical monitoring has been implemented.

Classical methods have been applied as for example the analysis of permanent observation plots and transects, detailed vegetation mappings, scoop catch, pitfall traps and oeko-kad-aspirator. Changes in land use and management have been identified by the interpretation of aerial photo series, the evaluation of historical data and interviews with contemporary witnesses and experts. Moreover, erosion forms in over-exploited surfaces with and without grazing impacts are screened. The development of nutritional value and supply of biomass are further parameters to consider in the context of a sensible reestablishment of pasturage.

The applicability of new satellite supported methods for an intelligent pasture management is tested to answer different practice-oriented issues. The telemetric collection and analysis of location and behavioural data of the grazing animals shows the differences in seasonal use of vegetation plots and gives hints on favoured fodder plants and resting places.

To define standard guidelines for surface management and recommendations for best practice, the pooling of the different mentioned systematic approaches is necessary. The overlay of the acquired data creates the basis for the definition of ecologically and locally optimised surface management and identification of the best practices for comparable alpine regions. Furthermore, the acquired data should estimate grazing intensity (number of animals/ha, retention period, plant selection) in combination with soil type data for understanding the future development of erosion (with and without grazing influence).

Beyond the complex analysis and evaluation of the generated data, workshops and meetings with stakeholders are organized. Major task is developing strategies to prevent conflicts and raising the awareness about the economic and cultural value of alpine areas with high potential of nature conservation.

In order to enforce the long-term protection of the nature conservational values, it must be given a special focus to the integration of regional economic aspects. The involvement of decision makers is condition precedent for success in the implementation of best practice. Besides measures recommendations for future nature conservation contracts, the demonstration of possibilities for strengthening the regional economy by alternative management forms is in focus. The promotion of rare farm animals and their owners as key personalities in the context of multifunctional and sustainable agriculture is strongly put forward.

Since this is the first cross border project of this kind between the Salzburg and Bavaria, it supports actively the establishment of counterstrategies for preventing the loss of attractiveness and value of alpine pastures.

More information

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 21 - 26

Urban sprawl and protected areas: How effective are buffer zones in reducing recreation impacts on an urban national park?

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Abstract

New housing developments for tens of thousands of new local residents in the 22nd Viennese district will increase the recreation use pressure on the nearby Donau-Auen National Park and the UNESCO Biosphere Reserve Untere Lobau. These areas are intensively used settings and the high use pressure caused by urban sprawl will further negatively impact the natural resources and the quality of the visitor experience. This study investigated planning and management options regarding their capability to reduce the visitor pressure on these areas. The main challenge was how can the existing large-scale agrarian-dominated areas surrounding the park be transformed into attractive recreational landscapes. Stakeholders from several administration bodies and scientists from various disciplines developed these scenarios, which included a bundle of landscape design, land use, traffic and recreational infrastructure measures. In addition, measures to restore the ecological integrity of the area were included. An agent-based model tested the effectiveness of these buffer zone scenarios. The definition of agents (=virtual visitors) and their decision making algorithms included several approaches such as an image-based conjoint choice survey among area visitors and visitor counts. The agent-based simulations indicated that these buffer zones can only absorb up to 30% of the recreation use pressure.

Keywords

Agent-based modelling; Protected area planning; Recreation; Stated choice; Urban sprawl; Vienna

Introduction

National parks within the borders of larger cities provide many ecosystem services for urban population. They are biodiversity hot spots, produce for example drinking water, regulate hot summer temperatures, and provide wildlife viewing, recreational, spiritual and eco-tourism opportunities and wellbeing for their visitors (Daniel et al. 2012). They are also refuges from hectic city life and the work environment and are settings for social gatherings (Arnberger et al. 2010; Hammitt 2002). At the same time, they are confronted with high recreation use pressures throughout the day, week and year because of their attractiveness. Crowding, recreational conflicts, and degraded environments may occur within urban protected areas and reduce the recreational quality they offer. Serious conflicts between recreation use and nature conservation management can arise because users may displace due to overcrowding to areas of high ecological value and, thereby, potentially reduce undisturbed zones and times for wildlife (Arnberger & Brandenburg 2007).

The Viennese part of the IUCN-category II Donau-Auen National Park, which also includes the UNESCO Biosphere Reserve Untere Lobau, is such an example of a heavily used urban protected area (Figure 1). This area is a traditional, intensively used, recreational setting of high ecological value as documented by more than 600,000 visits annually (Arnberger 2006). New housing developments for tens of thousands of new local residents will further increase the recreation use pressure on the nearby national park. This development will result in drastic transformations of the local environments surrounding the park. About 50,000 new local inhabitants are expected within the next 15 years (Arnberger et al. 2012). The increasing high recreation use pressure will further degrade the park's natural resources and the quality of the recreational experience because of crowding and user conflicts (Arnberger et al. 2010; Eder & Arnberger 2012).

This study, which was co-financed by the Austrian Man & the Biosphere Programme (ÖAW-MAB), investigated planning and management options regarding their capability to reduce the visitor pressure on these areas (Arnberger et al. 2012). Urban sprawl is obviously one of the relevant research priorities affecting this and many other protected areas in the world. The question of arises whether protected areas under pressure can fully achieve their objectives in terms of protection of processes, ecological functions and biodiversity, and recreational quality.

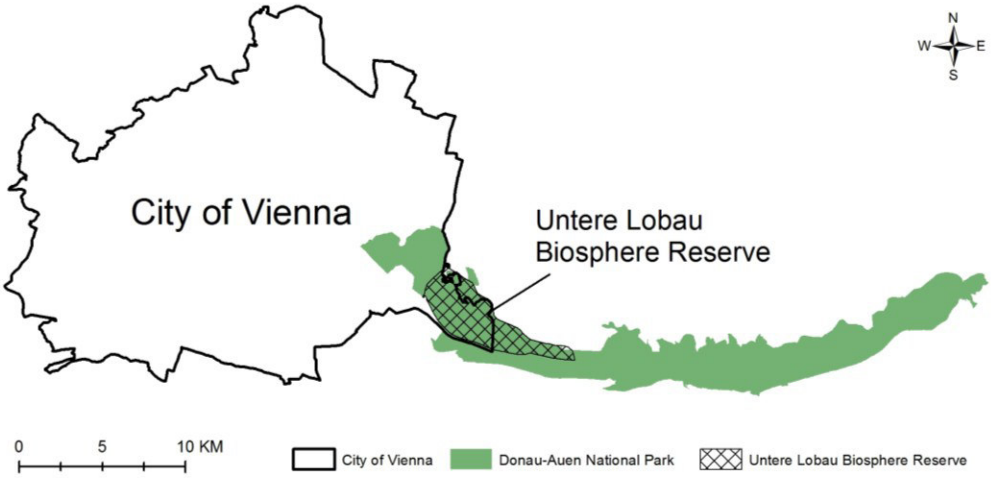

Figure 1: Study area: UNESCO Biosphere Reserve Untere Lobau and Donau-Auen National Park.

The goal of this research was to identify the optimal measures to reduce the visitor pressure on this area. One strategy is to transform the existing large-scale agrarian-dominated areas surrounding the national park into attractive recreational landscapes using a bundle of landscape design, land use, traffic and recreational infrastructure measures. The following research questions guided this study:

- How can the existing large-scale agrarian-dominated areas surrounding the national park be transformed into attractive recreational landscapes?
- What is the best combination of landscape design, land use, traffic and recreational infrastructure measures?
- Which visitor groups should be specifically addressed by these measures?
- What influences have such measures on spatial behaviour of visitor groups?
- How many visitors will visit the new recreational landscapes instead of the national park?
- What parts of the protected area will face decreasing visitor use levels because of these measures?

Methods

<u>Study area</u>

This study area is an alluvial landscape, called the Lobau, and is located in the eastern part of Vienna, the capital city of Austria, with a population of about 1.7 Mio. The 2,400 ha-area is part of the 22nd district of Vienna and managed by the Forest Department of the City of Vienna. It protects one of the largest natural riparian wetlands in Central Europe that are still ecologically intact to a relatively high degree. It was declared a National Park in 1996 and accredited by the IUCN as a Category II protected area in 1997. About 60 % of the Danube Floodplains National Park consists of floodplains; the remaining areas are watercourses, fields and meadows. The protected area is surrounded by large-scale agrarian-dominated areas, Viennese suburbs, the Community of Groß-Enzersdorf in Lower Austria, and the Danube River. Close to 15,000 inhabitants live within 15–20 min walking distance. A dense network of about 120 km of forest roads, trails and several narrow paths run through the area, especially in close proximity to the main residential areas. Area access is free and unlimited. Several trails are open for bicycling and one international cycle route passes through the national park. Several parking lots are provided. The area provides several visitor facilities such as a visitor centre and interpretive trails. A one-year visitor monitoring carried out in the Viennese part between 1998 and 1999 showed that bicycling (47 % of all users) and walking activities (40 %) dominate, followed by dog walking (10 %) and jogging (3 %) (Arnberger 2006).

<u>Methodological approaches</u>

This project relied on several methodological approaches. Stakeholders from several administration bodies and scientists from various disciplines participated in the project. Area visitors' preferences and stated behaviours were included in the modelling approach to analyse the effects of different landscape design and land use, traffic and recreational infrastructure measures on their spatial behaviour. In a first step, planning scenarios for the existing large-scale agrarian-dominated areas as new buffer zone were defined. In a second step, these scenarios were simulated regarding their effectiveness in reducing recreation impacts on the protected area.

Definition of recreational scenarios

The main question was how can the existing large-scale agrarian-dominated areas surrounding the protected area be transformed into attractive recreational landscapes. Four base scenarios were developed in stakeholder workshops (Table 1). Each of these scenarios included a bundle of landscape design, land use, traffic and recreational infrastructure measures. Recreational infrastructure measures, for example, included new bicycling and hiking trails. The relocation of parking lots and closing streets for motorized traffic were examples for traffic measures. In addition, measures to restore the ecological integrity of the area were included in the scenario definition. These measures would lead to higher water dynamics in parts of the protected area. It was decided within the workshops to focus on bicyclists as largest user group and dog walkers because of their problematic behaviour not keeping their dog on a leash.

Table 1: Landscape design, land use, traffic and recreational infrastructure measures per scenario

Measures	**Scenario A1**	**Scenario A2**	**Scenario B1**	**Scenario B2**
Extension of recreational trail network in the new buffer zone	X (smaller trail network)	X (smaller trail network)	X (larger trail network)	X (larger trail network)
River restoration measures		X		X
Traffic measures	X	X	X	X
Landscaping measures			X	X

Assessing trail preferences with an image-based stated choice approach

Modelling visitors' recreation behaviour in the study sites (within the national park as well as in the planned buffer zone) requires a sound knowledge about their landscape, recreational infrastructure and social use preferences. An image-based conjoint-choice survey asked the influence of various landscape types (ranging from natural to built environments), recreational infrastructure facilities and trail use conditions (trail user numbers, visitor activities) on protected area visitors' trail use intentions for specific leisure activities such as bicycling (N = 520; Figure 2).

Such stated choice approaches are rooted in the traditional microeconomic theory of consumer behaviour and preference theory and have been applied to study preferences and choice behaviour for a range of recreation and tourism related issues (Arnberger et al. 2010; Kemperman & Timmermans 2006; Laing et al. 2005; Louviere et al. 2000; Reichhart & Arnberger, 2010). The stated preference approach asks respondents to evaluate alternative configurations of hypothetical, multi-attribute, goods or services (Louviere et al. 2000). Such alternatives – in this case buffer zone scenarios – are defined as combinations of factors, for example physical/resource, social and infrastructural characteristics of the Danube floodplains landscapes. Random utility theory postulates that choices can be modelled as a function of the factors of the alternatives. Selection of one alternative over the other implies that the utility of that alternative is greater than the utility of any other alternative (Hensher et al. 2005). In addition, latent-class choice modelling was applied to account for possible heterogeneity of respondents in their trail choice. Latent class methods can identify visitor segments based on their choices and provide within-segment share predictions (Kemperman & Timmermans 2006). Such analyses assist in explaining the heterogeneity of individuals and allow a more complete explanation of choices. Latent class models have been recently used in different research fields including outdoor recreation (Arnberger et al. 2010; Kemperman & Timmermans 2006; Reichhart & Arnberger 2010; Scarpa & Thiene 2005).

Figure 2: Example of computer-generated visual trail scenarios to assess visitors' trail use intentions.

Agent-based modelling

An agent-based model tested the buffer zone scenarios regarding their capability to reduce visitor use pressure. The definition of agents and their decision making algorithms included several approaches. Besides trail preference data based on the stated choice approach, behavioural and individual data, derived from visitor counts or on-site visitor surveys completed the definition of the agent types. Agents were defined as activity types such as bicyclists or dog walkers. GIS-data of the protected area itself as well as of the surrounding existing and planned buffer areas served as spatial input data and included vegetation structures, land uses, water bodies, access points and recreational infrastructures such as trail types. Agent-based simulations relied on the MASOOR simulation platform (JOCHEM et al. 2008). Setting the input parameters was partly based on a previous agent-based model carried out in the study area (TACZANOWSKA et al. 2008).

Modelling results

The image-based stated choice survey found that visitors' trail use intentions were influenced by all physical and social trail factors. More relevant factors were the trail environment, water bodies and visitor numbers on the trail. However, the role of these trail factors on visitor intentions depended on specific leisure activities: dog walking, for example, required different site factors than bicycling. Agent-based simulations indicated that the planned buffer zones can only absorb about 30% of the recreation use pressure. Within the measures, parking lot relocation and new bicycling trails seems to be rather efficient.

Discussion

This study found that the use pressure on the protected area can be lowered. Nevertheless, recreation use will drastically increase despite of these investments in recreational infrastructure and landscape design. Thus, recreation use intensity will further negatively impacting the natural resources and the quality of the visitor experience. Area management will be further challenged by the increasing use pressure and will face more investments in visitor management efforts and maintenance of recreation infrastructure within the area. The buffer area seems not to be able sufficiently absorbing all recreation use. Therefore, additional green spaces in the urban-sprawl region seem to be required to substantially reduce recreational use pressure on the protected area.

Conclusion

This study tested a rather new method mix to simulate the effectiveness of several recreational scenarios regarding their capability in reducing recreation impacts on the protected area. This study relied on interdisciplinary and transdisciplinary approaches, which required substantial resources. Nevertheless, the simulation of the scenarios assessed their effectiveness and thus can avoid suboptimal and costly planning and management measures. While first evaluations of the simulations indicate that results are reliable, further analyses which specifically compare stated with revealed behaviour of respondents are necessary. The integration of other (recreational) areas surrounding the national park and the new settlements into the simulation programme may provide a more holistic understanding of recreation use patterns in the region. A comprehensive long-term monitoring programme addressing the effects of urban sprawl on the national park and its ecosystem services would be useful. This would also include surveys among visitors and local residents on a regular basis investigating their perceptions of recreation quality and their responses to degrade environments and crowding.

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Conference Volume | 5th Symposium for Research in Protected Areas | 10 to 12 June 2013, Mittersill | pages 27 - 28

Addressing Challenges in Managing Recreation in Protected Areas in an International Context: the International Summer Schools on Natural Resource and Recreation Management in Protected Areas

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Keywords

Erasmus, international learning, national park, protected area management, recreation planning

Abstract

The management of natural resources and recreational activities in protected areas requires complex strategies. This is an important issue for recreation and environmental planners worldwide because conflicts are common wherever different land use activities occur in the same area. In order to successfully address these issues, recreation planners need to acquire a profound knowledge of ecological and sociological methodological skills and the ability to work in multi- and interdisciplinary environments.

The objective of the Erasmus-funded IP summer school is to enhance understanding for the complexity of protected area management and the need of involving several disciplines to develop sustainable solutions for these challenges. This summer school aims to contribute to the advancement of protected area management in Europe by training students from several countries (Austria, Czech Republic, Germany, Italy, The Netherlands, USA) in protected area management. The 2-week summer school takes place every year since 2011. The summer school is organised as a combination of indoor seminars at Leibniz Universität Hannover and several field days in Harz National Park where students work on actual planning case studies. This national park is heavily used and several conflict lines between recreation and nature conservation can be found. Topics covered during the summer school are habitat management, wildlife conservation, recreational and visitor planning, and environmental education. Students learn methods from various disciplines, including ecological (e.g. habitat and species mapping and monitoring), landscape design and planning (e.g. design plans) and sociological (e.g. visitor counts and surveys, conflict management) techniques and skills and apply these during their field days. Scientists and practitioners from relevant disciplines will contribute to the course.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 29 - 38

Dynamic processes as a key factor for biodiversity? A zoological case study in the largest rockslip area of the Eastern Alps

(Dobratsch, Austria; Arachnida: Araneae, Opiliones, Scorpiones; Insecta: Coleoptera)

Sandra Aurenhammer & Christian Komposch

Abstract

The calcareous, protected rockslip area "Schütt" at the Dobratsch mountain impresses with its remarkable landscape, marks a striking zoogeographical borderline and is one of the most important biodiversity hot-spots in Austria. Beside its geographical position inside the endemic-rich Southern Alps it is the dynamic processes which provide this long-term-habitat to enhance the richness of invertebrate fauna in this area.

Taking the long view, the southern part of the Dobratsch mountain in the Eastern Gailtal Alps in Carinthia, Austria was formed by two great rockslip events: a prehistoric one at the end of the last glaciation period and later by the greatest historical landslip of the Eastern Alps in January 1348.

The Schütt-area features the only Austrian locality with two scorpion species occurring sympatrically, *Euscorpius germanus* and *E. tergestinus*. The rare harvestmen species *Carinostoma carinatum* and *Leiobunum roseum* can there be found in what are probably the biggest national populations. Selected examples of a remarkable heliophilic and thermophilic spider fauna of the vegetation free rock debris include the salticid *Philaeus chrysops*. Piny, open screes of the Natura-2000-sites "Schütt-Graschelitzen" and "Villacher Alpe (Dobratsch)" are further characterised by large-dimensioned, sunlit deadwood structures. They promote the occurrence of rare and endangered Urwald-relict buprestids like *Buprestis novemmaculata* and *Dicerca moesta*, a xerothermophilic, Southeast European faunal element. The present national distribution of the very rare *Buprestis splendens* – protected by the Habitats Directive – is restricted to a single site in the screes of this rockslide area.

The key to this zoological diversity and the aggregation of remarkable, rare and endangered species is the high dynamics – on the one hand in the giant rock debris reaching downhill to the valley bottom and on the other hand creating plenty of deadwood inside the natural forests of the Dobratsch. Future nature protection activities should be based on the knowledge of the positive impact of natural dynamics in contrast to the degradation effects of timber harvest in this unique area.

Key-Words

screes, deadwood, succession, protected area, FFH-directive, Urwald relict species, xylobiotic insects, arachnids, Buprestidae, *Buprestis splendens*, Carinthia, Schütt

Introduction

„The role of dynamics and stochasticity in ecological systems has long been neglected."
PLACHTER & REICH (1998)

In Central Europe, and especially in the Alps, dynamic processes are quite diverse: landslides, inundations, avalanches, fires and windfall occur at very low frequencies and are spatially unpredictable. Humans see them as catastrophes, particularly as the cultural landscape spreads rampantly into free natural space. They are being combated and much money and energy is spent for their prevention. The last refuges of unhindered dynamic processes are found inside some restricted areas such as nature reserves and national parks. Despite several categories of nature protection, and decades of effort by the Natura-2000 network of the European Union, unspoiled near-natural river landscapes with dynamic gravel banks and flood-plain forests – reaching from the glaciers down to the large rivers – avalanche tracks, and other erosion areas including rockslip areas, screes and windthrow areas are deficiency habitat types. This lack of understanding of uncontrollable processes in our tamed landscapes is mirrored in the states of endangerment in these habitat types in Austria and Carinthia; the above mentioned biotope types are all regarded either as threatened by complete destruction or as endangered (PETUTSCHNIG 1998, ESSL & EGGER 2010, KEUSCH et al. 2010). However, even nature conservation strategies still seek to protect and "freeze" conditions in an "optimal" state (PLACHTER 1996).

Which Carinthian Natura-2000 sites now offers generous possibilities for dynamic processes? These are the Hohe Tauern National Park, the Wolayersee and its surroundings, the Inner Pöllatal, the Vellacher Kotschna, the Upper Drau, the Gail in the Lesachtal, the Lower Lavant, the Reifnitzbach and particularly our investigation area the Schütt-Graschelitzen and Villacher Alpe (Dobratsch) – altogether making up about 4.6 % of the country's territory (cf. GUTLEB et al. 2000, PETUTSCHNIG et al. 2002). Even Natura-2000-sites offer no guaranteed protection of dynamic processes, as the protection depends on the presence of listed animal- or plant species, or habitat types.

In particular dealpine dynamic processes, at lower altitudinal zones, are barely tolerated. Rare exceptions are small parts of the Lower Vellach near its entry into the Drau river (EGGER et al. 2002, KOMPOSCH 2009a) and the Gail in the Lesachtal.

Figure 1: The Dobratsch (Villacher Alpe, 2166 m) south face provides a mosaic of different habitat types including numerous heat islands. View of the screes northeast of Nötsch. (Photo: S. Aurenhammer/ ÖKOTEAM)

The Schütt, which is located on the southern slope of the Dobratsch (Villacher Alpe), is the largest dealpine rockslide area featuring unhindered dynamic processes (fig. 1). It is characterized by massive rock faces and steep screes. Two Natura-2000-sites, namely "Schütt-Graschelitzen" (AT2120000) and "Villacher Alpe (Dobratsch)" (AT2112000) extend over the rockslide area.

The present survey aims at a description of the dynamic processes affecting the Schütt, and relates their impact to the rockslide area's habitat structure and qualities. From this perspective, the occurrence of notable, rare or endangered arthropod taxa, including arachnids and xylobiotics, is discussed with particular focus on their habitat requirements and dependency on dynamic processes. This approach should promote the study of dynamics in terms of generating biodiversity and addresses the issue from the perspective of nature conservation.

Description of the study area and reflections on the zoological research

Formation

The rockslip area Schütt (fig. 1) is located on the southern slope of the Dobratsch (Villacher Alpe, 2166 m) in the Gailtal Alps; part of the Southern Alps. Geomorphologically the Schütt consists of fragmented limestone that covers an area of 13 km x 1.5 km. It extends from Saak in the west to Unterschütt in the east. Two rockslip events were essentially involved in the geomorphologic formation of this region, which is located directly on the Periadriatic Seam.

A prehistoric rockslip event most likely resulted from the destabilization of the mountain's southern face caused by the regression of the Gail-glacier after the last (i.e. Würm) ice-age. Hence the Gailtal was filled with 170 million m^3 of crashed down rocks which lifted its altitudinal level for about 100 meters. The old parts of the Schütt (Alte Schütt) are characterized by huge rocks of limestone and debris of various grain sizes filling the rock holes. A vegetated, water-holding humus layer now covers larger parts the weathered boulders.
Both geological and meteorological conditions were responsible for the second rockslip event in 1348 AD. Periods of heavy precipitation (1000 mm) and temperature extremes promoted further destabilization of the rock faces. On the 25^{th} of January a strong earthquake triggered the largest historical rock slide in the Eastern Alps. 30 million m^3 of rock crashed down, covered an area of 2 km^2 and raised the young parts of the Schütt (Junge Schütt) (TILL 1907, NEUMANN D. 1988, NEUMANN W. 1988, KRAINER 1998). The greyish limestone rubble fans out over the Alte Schütt and features a structure with numerous gaps and spaces. Large parts of the rockslide area are devoid of humus and vegetation (fig. 2).

Succession

Botanically, the Schütt can be characterized as a remarkably patchy biotope, as a complex of numerous small plant communities forming a mosaic of different habitats. The knowledge of dynamic processes in phytosociology is based on the observations of AICHINGER (1951). Referring to the harsh environmental conditions, he pointed out that under such circumstances competition phenomena get suppressed by the individual struggle for survival. He defined this biotope as a "complete mix-up" ("völliges Durcheinander") of different plant species and described the succession of different plant communities in the Schütt.

Figure 2: Rock habitats of the southern slope of the Dobratsch: Urwald SE Rote Wand (top left), "Paradies"/ Kanzel NE Nötsch (top right), Tscheltschnigkogel, slope near Egger Loch-cave (bottom left) and S Geklobene Wand (bottom right). (Photos: Ch. Komposch/ ÖKOTEAM)

The pioneer species *Dryas octopetala* is one of the first species rooting in what little soil is available on the screes without vegetation. Once it covers the harsh bedrock, it gradually gets replaced by *Erica carnea*. Thick covers of *E. carnea* then promote an accumulation of humus and enhance the water absorption capacity of the ground. This is the basis for the first trees to take root in the rocky, dynamic substrate. *Pinus sylvestris* and *P. nigra* are the dominant tree species of the rockslide area's screes. As discussed below, this habitat type has a key role in the occurrence of rare and endangered arthropod taxa. *Picea abies* colonizes the piny biotopes under the condition of sufficient water supply. This again increases the water-absorbing humus layer and allows deciduous tree species to succeed. The southern slope of the Dobratsch is characterised by various Mediterranean-Illyrian floral elements like *Fraxinus ornus, Ostrya carpinifolia* and *Pinus nigra* (PICHORNER 1998).
Zoological research on the Schütt has a long tradition. Already in the second half of the 19th century zoologists began to investigate its fauna (REUTER 1875, HOLDHAUS & PROSSEN 1900, SCHATZMAYR 1908). In 1935, a new species of Palpigradi, *Eukoenenia austriaca stinyi*, was described from the Eggerloch; which is part of the mountain's distinctive cave system (STROUHAL 1936). Fifty years later came the description of two new species of theridiid spiders, living in the screes of the Tscheltschnigkogel (THALER & STEINBERGER 1988). Until today, various zoological investigations have been made in the dynamic habitats of the rockslide area. These include, for example, the study of a subterranean trap in the rock fields of the Steinernes Meer (SCHLICK-STEINER & STEINER 2000), a long-term population study on the troglophilous carabid beetle *Laemostenus schreibersii* (Rusdea 1992) as well as numerous zoological investigations by the ÖKOTEAM (e.g. KOMPOSCH 1997, 2004, KOMPOSCH et al. 1998, HOLZINGER 2002, FRIEß 2001).

Figure 3: Methods: sweep netting with a 6 m stick (left) and an air eclector on a dead pine at the site Urwald SE Rote Wand (right). (Photos: Ch. Komposch/ ÖKOTEAM)

Material and Methods

The current zoological investigations are based on two projects: (1) a masters thesis dealing with coenoses of xylobiotic beetles, and (2) a broader zoological monitoring project in the Natura-2000 sites "Schütt-

Graschelitzen" and "Villacher Alpe (Dobratsch)", carried out by the ÖKOTEAM – Institute for Animal Ecology and Landscape Planning. The fieldwork extended – beside dozens of visits within the last 15 years at least – over 24 days (75 person-days) in 2012, spread over a 4 month period from May till mid-September. In total, 64 sample sites were investigated so far – mostly during daytime, partially at night – including the following methods: hand collecting (hc), beating of vegetation (bt), air eclectors (ecl) (15 qty., mid-July till mid-September, fig. 3), sweep net (sn, fig. 3), sieve (sv) and collecting deadwood (co) marked with exit holes. Spiders, scorpions, harvestmen, true bugs, leaf and plant hoppers and beetles were collected and transferred into ethanol or ethyl acetate.

Results

The biotopes of the rockslip area Schütt are affected by two types of dynamic processes. First, it needs to be mentioned that, up to now, two heavy rockslide events were responsible for the formation of the area and its rigorous modern characteristics. Second, we find that current dynamics permanently and continuously impinge on the steep and rocky biotopes. To these belong rockfall and the constant movement of fine debris. The Schütt now provides habitats for highly specialised arthropod coenoses that managed to adapt to the permanent dynamics and their impacts on the biotope. Initially, spider and scorpion species depending either on rock faces or the gap-rich structure of the screes are presented. Thereafter the focus shifts on xylobiotic coenoses depending on the presence of deadwood in the area's open pine stands.

Figure 4: Arachnids I: *Euscorpius germanus* (top left), *Carinostoma carinatum* (top right), *Leiobunum roseum* (bottom left) and *Megabunus armatus* (bottom right).
(Photos: Ch. Komposch/ ÖKOTEAM)

Rock and scree species

The rocky habitats of the Dobratsch and Schütt area are considered to be the most interesting for the arachnid fauna. Therefore our investigations over the years concentrated on the calcareous rocks, *Pinus*- and *Erica*-covered tali, moved tali, caves and gravel banks from the Alpine zone down to the Gail River.

On the rock faces of the Dobratsch summit (46°36'N, 13°40'E, 2150 m, 19.7.2011, H. Komposch & E. Hoffmann leg.) we successfully recorded the harvestman *Megabunus armatus* (fig. 4), which is endemic to the Southern Calcareous Alps. Quite high abundances could be documented for the long-legged sclerosomatid *Leiobunum roseum* (fig. 4). Frequent occurrences include the sites Tscheltschnigkogel (Egger Loch), S Storfhöhe, S Geklobene Wand, Schütter Wald, Urwald SE Rote Wand, NE Nötsch and Kanzel NE Nötsch. Remarkable is the presence of the very rare nemastomatid *Carinostoma carinatum* (fig. 4), found for example at the site S Geklobene Wand.

It is beyond the scope of this paper to mention the dozens of records of *Euscorpius germanus* (fig. 4) all over the investigated area; however unique was the discovery of *Euscorpius tergestinus* at the entrance of the Egger Loch cave at the Tscheltschnigkogel (46°35'N, 13°49'E, 550 m, 16.8.2012).

Selected examples of some remarkable spider species of the rock debris include the rare wolf spider *Pardosa pseudostrigillata* (fig. 6) at S Geklobene Wand. It shares the vegetation free rock debris and fine screes with the salticid *Philaeus chrysops* (fig. 6, e.g. Tscheltschnigkogel, S Geklobene Wand, NE Nötsch). Large calcareous blocks with some old pine trees in between are the habitat of the rare orb weaving spider *Araneus grossus* (fig. 6, NE Nötsch-dead-tree-line; 46°35'N, 13°38'E, 1050 m, 13.8.2012). Coming closer to the habitat's deadwood structures, the liocranid spider *Liocranum rutilans* (fig. 6) was found several times under the bark of dead trees (e. g. Schütter Wald, Urwald SE Rote Wand, NE Nötsch).

Xylobiotic species

During our zoological investigations in 2012, the occurrence of various rare and threatened jewel beetles (Buprestidae) was proven. These include *Dicerca moesta*, *Buprestis haemorrhoidalis*, *B. novemmaculata*, *B. octoguttata*, and *B. splendens* (figs. 5, 8).

Specimens were allocated as follows: *Dicerca moesta* (*n*=1; sites: S Geklobene Wand, 46°34'N, 13°46'E, 690 m; method: bt), *B. haemorrhoidalis* (*n*=11; S Geklobene Wand; N Nötsch, 46°35'N, 13°37'E, 670 m; NE Nötsch, 46°35'N, 13°38'E, 940 m; Storfhöhe S, 46°34'N, 13°47'E, 930 m; hc, ecl), *B. novemmaculata* (*n*=2; S Geklobene Wand; NE Nötsch; ecl.), *B. octoguttata* (*n*=10; S Geklobene Wand; NE Nötsch, Storfhöhe S; Schütter Wald, 46°34'N, 13°44'E, 600 m; hc).

The current occurrence of *Buprestis splendens* can be demonstrated by sightings and recent records (G. GAILBERGER, C. HOLZSCHUH, Ch. KOMPOSCH leg. et vid.). At least 6 individuals were recorded in the years 2008 to 2012 (fide C. HOLZSCHUH). The maximum number of individuals that could be observed during one day was 17 (G. GAILBERGER in litt.). All findings of *B. splendens* are, however, restricted to only one localised spot (1.5 ha) northeast of Nötsch (46°35'N, 13°38'E, 940 m).

All sites feature piny, open screes that are characterised by large-dimensioned, sunlit, and partly vertical deadwood structures (fig. 7).

Figure 5: Urwald relict buprestids *Dicerca moesta* (top left), *Buprestis haemorrhoidalis* (top right), *Buprestis octoguttata* (bottom left) and *Buprestis novemmaculata* (bottom right).
(Photos: S. Aurenhammer & Ch. Komposch/ ÖKOTEAM)

Discussion

<u>High biodiversity and faunistic and zoogeographic peculiarities caused by mosaic-like habitat complexes</u>

The large rockslide events, followed by dynamic processes and the differentiation of various states of succession create rich structured habitat mosaics in theses extreme biotopes. The most conspicuous ones are the treeless rock debris and screes (fig. 2). These erosion areas offer unique environmental conditions for stenotopic, rare and endangered taxa with both thermophilic and cold-stenothermic ecological demands. Determining factors of these rockslip areas are, due to the dynamic processes over thousands of years, the presence of biotope complexes, a partly consistent lack of trees as well as the dominance of rocks and scree slopes. Further characteristics are structures like old deadwood, a high insolation, extremes of temperature on the surface, a stable temperature and humidity regime below, a lack of competition and the deficiency factor food supply.

The Schütt rockslip area provides heat islands, with suitable environmental conditions for thermophilic, heliophilous species that are normally considered to have more southern distributions. Examples among spiders include *Dysdera adriatica*, *Eresus moravicus*, *Steatoda phalerata*, *Theonoe sola*, *Araneus angulatus*, *Pardosa bifasciata*, *Tegenaria tridentina*, *Cheiracanthium punctorium*, *Zelotes exiguus*, *Xysticus bifasciatus* and *Pellenes tripunctatus*. At the same time, sometimes just a few metres away, different stages of succession and different strata offer quite contrasting environmental conditions for cold-stenothermic and hygrobiotic species or even glacial relicts.

The high species diversity is clearly based on the indicators mentioned above. The following example should emphasize the importance of this rockslip area as a hot-spot of biodiversity: up to now we know more than 300 spider species from the Schütt and Dobratsch area (KOMPOSCH 2013)! This represents 45 % of the recorded species for Carinthia (KOMPOSCH & STEINBERGER 1999, KOMPOSCH 2000, KOMPOSCH unpublished).

Similar findings are true for the rockslide area's fauna of xylobiotic beetles. The contiguous presence of different types of forest habitats, which results from the mosaic-like habitat structure of the area, allows the occurrence of species having different environmental requirements. On one side, the Schütt is characterized by xerothermophilic species like *Dicerca moesta*; a Southeast European faunal element (KAHLEN & PEEZ 1977). In Northern and Central Europe *Dicerca moesta* is only found rarely and sporadically (FREUDE et al. 1979). In Austria the buprestid was found more frequently near Vienna in the middle of the last century (POCHON 1964). HEISS (1971) mentions two records from 1954 and 1952 from Northern Tyrol. In Germany's Red List of Threatened Species it is rated as "critically endangered" (GEISER 1998); for South Tyrol (e.g. KAHLEN & PEEZ 1977) it is classified as "rare" (KAHLEN & HELLRIGL 1996).

On the other hand, the adjacent moist, near-natural forests are home to rare and endangered montane species. Not far from the open screes, the lucanid beetle *Sinodendron cylindricum* develops in the rotten wood of mixed-beech forests (e.g. BRECHTEL & KOSTENBADER 2002).

Figure 6: Arachnids II: *Araneus grossus* (top left), *Philaeus chrysops* (top right), *Liocranum rutilans* (bottom left) and *Pardosa pseudostrigillata* (bottom right). (Photos: Ch. Komposch/ ÖKOTEAM)

Helio- and Thermophily

On the ground surface, the treeless rocky habitat types with their high heat capacity lead to higher temperature sums and therefore provide suitable conditions for heliophilic and thermophilous arthropods. The presence of several southern, Mediterranean and Submediterranean species reflects these special microclimatic conditions.

The jewel beetle family generally includes many thermophilic species (BRECHTEL 2002). Buprestid taxa occurring in Central Europe are further known to be exceedingly heliophilic. Their larvae develop only in (at least partially) sunlit deadwood; adults don't oviposit on shaded deadwood structures (ZABRANSKY 1998). The major parts of the Schütt are located in a southern or south-western aspect. The steep, open, piny screes (*Pinus sylvestris, P. nigra*) are warm and sunny habitats – rarely found elsewhere in Austria – and provide ideal breeding conditions for helio- and thermophilic taxa (fig. 7).

The heliophilic and thermophilic jumping spider *Philaeus chrysops* (fig. 6), recently investigated by NATMESSNIG (2005), probably finds its largest nationwide population in the Schütt area. The current exclusive records of *Araneus grossus* (fig. 6) across all of Austria are three sites in Southern Carinthia, including the Dobratsch area and the nearby Kanzianiberg S Finkenstein (KOMPOSCH 2000, THALER & KNOFLACH 2003). Several species like the small soil inhabiting spider *Protoleptoneta italica* (STEINBERGER 1987, 1988, personal observations), the litter inhabiting nemastomatid *Carinostoma carinatum* (fig. 4), critically endangered in Austria (KOMPOSCH 2009b) or the thermophilic rock inhabiting harvestman *Leiobunum roseum* (fig. 4), subendemic to Austria (KOMPOSCH & GRUBER 2004, KOMPOSCH 2009c), reach their northern distribution limits in this part of the Gailtal Alps.

Examples for the insufficiently investigated cold-stenothermic fauna and cave fauna include the giant-eyed harvestman *Megabunus armatus* (fig. 4) and *Gyas annulatus*.

Deadwood

The recorded buprestid guild depends on the presence of deadwood. All species of the documented guild breed in conifers and need – as far as is known – several years of development, and are fastidious in the selection of the deadwood structures they inhabit. Adult beetles feed on the green needles of their host plants (preferably *Pinus* spp.), which is part of their gestation period. For their development they depend on large-dimensioned, sunlit deadwood structures (POCHON 1964, MÜHLE et al. 2000, BRECHTEL & KOSTENBADER 2002, HELLRIGL 2010). All buprestids of this guild count as so-called "Urwald relict species". They depend on a sufficient amount and certain quality of deadwood structures and hence indicate the habitat tradition and structural quality of forest habitats (SCHMIDL & BUßLER 2004, MÜLLER et al. 2005).

For example, *Buprestis splendens* preferably develops in decorticated, solid, large-dimensioned, vertical deadwood (ZABRANSKY 2004, PAILL & ZABRANSKY 2005, own observations). Over the past decades *Buprestis splendens* was considered extinct in Austria. The latest finding reached back to 1954 and came to a single individual from Styria (HORION 1955). However, in 2001 the species was rediscovered in the Schütt (ZABRANSKY 2004) and could be found there repeatedly since. *B. splendens* is under the protection of the Habitats Directive; its present nationwide distribution is restricted to a single site in the screes of the rockslide area (PAILL & ZABRANSKY 2005). In Germany's Red List of Threatened Species it is classified as "extinct". The other species of *Buprestis* included in this guild are either classified as "endangered" or "vulnerable" (GEISER 1998).

Figure 7: Pine trees die back from rock fall, remain at the fringes of the screes and turn into large-dimensioned, sunlit deadwood structures. Sample sites: NE Nötsch (left), “Paradies”/ Kanzel NE Nötsch (top right), Urwald SE Rote Wand (bottom right). (Photos: S. Aurenhammer/ ÖKOTEA)

Due to forestry use of most Central European woodlands, large-dimensioned deadwood structures have become restricted to very few patches of near-natural biotopes. However, a few steep, rocky screes of this rockslide area feature a remarkably high density of such structures. Damaged by rock fall, pine trees die back at the fringes of the screes and turn into ecologically important microhabitats, being of high value for nature conservation (fig 7). They are most significant for rare, xerothermophilic beetle species and provide the basis for zoological biodiversity (KLAUSNITZER 1996). Additionally, these steep, rocky pine stands are very difficult to access. So far they remained untapped by forestry which again allows the accumulation of deadwood.

The recorded guild of Urwald relict buprestids must be considered as representative of a rare, endangered, stenoecious fauna (cf. KLAUSNITZER 1996, SCHMIDL & BUßLER 2004, MÜLLER et al. 2005) that directly benefits from the dynamic processes in the rockslide area.

A tight habitat selection of arachnids to deadwood is rather rare. An example is the wolf spider *Acantholycosa lignaria*, recently discovered in the Gesäuse National Park (KOMPOSCH & HORAK 2011). However, a quite large spectrum of scorpions and spiders shows a significant preference for deadwood; especially for the crevices under bark. Examples mentioned are the two thermophilic spider species *Segestria bavarica* and *Liocranum rutilans*. Even after many years of collecting scorpions in the field, the high abundances of *Euscorpius germanus* observed were surprising. Spread all over the Schütt area, we could observe several hundred individuals during the day using the efficient method of pulling bark form dead trees.

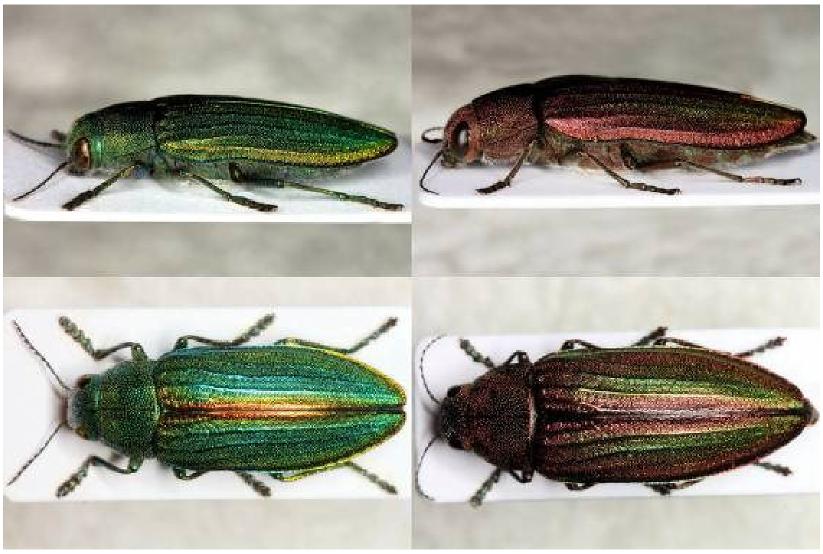

Figure 8: Lateral and dorsal view of two colour variants of *Buprestis splendens* belonging to the same population located northeast of Nötsch (Carinthia). (Photos: S. Aurenhammer/ ÖKOTEAM)

Conclusions

Recent results confirm that the rockslide area Schütt must be considered a national hot-spot of biodiversity. It is characterized by a mosaic of different habitat types and various threatened species and coenoses. Rare Urwald relict species develop in sunlit, large-dimensioned deadwood structures of the steep, piny screes. Although this habitat type widely remains unused by forestry and generally extends over considerable parts of the protected areas, large-dimensioned old and dead trees only occur locally and are generally sparse. The main parts of the Schütt are, however, either intensively or extensively cultivated by forestry. Protection concepts and management plans are necessary to sustainably protect the microhabitats of rare and endangered species in the Natura-2000-sites. In this context, dynamic processes are considered key factors of biodiversity and must be allowed to continue without hindrance to guarantee the maintenance of rare habitat types. Forestry use or the intensification of it is considered to be a threat to the region's forest habitats and sensitive coenosis living in there (compare KÖSTL et al. 2011). Continuous, scientific basic research and monitoring projects are strongly recommended for acquiring reliable information about the population dynamics of rare and endangered species and thus for the effective implementation of management plans. On the one hand, special attention should be paid to the crevice- and cave inhabitants by using pitfall traps – subterranean traps that should be located in the rock debris of all altitudinal zones, from the summit down to the Gail valley, in undercooled scree slopes or so called "ice-cellars" or "cold spots" – and hand collecting in caves. On the other hand, focus should be placed on xylobiotic Urwald relict species for their representation of a rare, endangered, stenoecious fauna and their dependence on scarce deadwood structures.

Figure 9: Negative impacts on the Schütt-area caused by forestry: clear-cut near Federaun (IX. 2012, top left), spruce plantation near Oberschütt (IX. 2012, top right), devastated karst source near Unterschütt (VI. 2012, bottom left) and timber-foresting near Nötsch/ Wasserleonburg (IX. 2012, bottom right). (Photos: Ch. Komposch/ ÖKOTEAM)

Acknowledgements

We would like to express our thanks to our colleagues and friends, Erwin Holzer, Carolus Holzschuh, Günther Gailberger, Hans Mühle, Manfred Kahlen, Harry Komposch, Eva Hoffmann and Ju Schwab who supported our work by active assistance in the field or with identification-checks, providing data, literature and Apfelstrudel.

The Naturwissenschaftlicher Verein für Kärnten (Helmut Zwander, Christian Wieser, Werner Petutschnig et al.) supported the master thesis financially, the Amt der Kärntner Landesregierung, Abt. 8, (Johann Wagner) the nature-conservation project. Jason Dunlop kindly corrected our English and Kristina Bauch invited and encouraged us to present these results, organized this wonderful Symposium and did everything possible making this event familiar and successful – muchisimas gracias Kristina!

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 39 - 42

The Zen of driving a motorcycle through a national park: Reconciling group-oriented with practice-oriented research approaches
(working paper)

Norman Backhaus

Abstract

Hikers in the Swiss National Park often complain about noise from motorcycles. The park management consequently seeks to mitigate conflicts that are imminent between hikers and motor-bikers. Management-oriented research in protected areas often focuses on specific groups of tourists. The identification of such actor groups and their behaviour is used to improve the supply of goods and services, to minimize negative impacts and conflicts, and to create satisfying experiences. While this actor- or group-oriented approach seems to be useful for many issues, it has the disadvantage of nailing down individual tourists to (allegedly) behaving according to certain group-specific characteristics (i.e. "motorcyclists create noise"). In contrast, practice-oriented approaches rather focus on certain tourist or park visitor practices. This allows for a more flexible approach taking into account that people act differently in different contexts and not (always) according to a pre-defined group's profile. Moreover, issues such as noise created by the practice of motorcycling are pinpointed to the practice and not to the characteristics of a person or group. Consequently, solutions to conflicts can be sought with reflecting on practices rather than on specific visitor groups. Using examples of our own (group- *and* practice-oriented) research in PAs the paper discusses advantages and limitations of both approaches and explores ways how they can be fruitfully combined.

Keywords

Tourist groups, practice, protected area, Switzerland, Malaysia

Introduction

Many protected areas (PAs) are tourist attractions or situated in an area that is attractive for tourists. They offer a variety of activities and can be visited for shorter or longer visits. Tourists can both be a blessing and a curse for the management of PAs. With their spending they provide means for protection and contribute to regional development and as (satisfied) visitors they serve as multipliers of the idea of nature conservation and sustainable development etc. But they also have negative impacts on PAs' and their environment's ecosystems and with increasing numbers they also cause grievances among themselves (i.e. by crowding). Hence, for park managements it is interesting and important to know whether and how tourist behaviour varies. Therefore, management-oriented research in PAs often focuses on specific groups of tourists. Knowing how and why specific groups behave like they do helps to improve services and to avoid unwanted effects caused by tourists (i.e. ARNBERGER et al. 2010; KIM 2013). Visitor groups to PAs are identified by their social background such as civil status, gender, age (e.g. for golden agers see TRACHSEL & BACKHAUS 2011), nationality (i.e. PRENTICE 2004; BACKHAUS 2005) by their activities (i.e. hikers (e.g. FARÍAS TORBIDONI 2011), bikers (e.g. HEER et al. 2003), motorcyclists (e.g. JAUSS 2012; JAUSS & BACKHAUS under review), or by their attitude (i.e. LOHAS, Lifestyle of health and sustainability; e.g. LUTHE et al. 2012), hedonists, recreational generalists (e.g. RYAN & STERLING 2001) etc. To each of these groups distinct attributes are assigned (i.e. demands, needs, motivation, impact, spending behaviour) that consequently can be dealt with. This group-oriented approach has its advantages. It compartmentalizes and focuses issues on few causal factors that can be handled individually and with great precision. Subsequently problems can be mitigated and services will be provided accordingly. However, this approach has the disadvantage of nailing down individuals to behaving according to the group they have been assigned to. It is therefore rather rigid and not very context-sensitive.

In contrast practice-oriented approaches (i.e. SCHATZKI 2002) rather focus on certain practices that occur in relation to contexts such as a PA. Practices and performances furthermore include bodily movements as well as emotions (CROUCH 2004). This allows for a more flexible approach taking into account that practices may differ between contexts and that they do not (always) occur according to a pre-defined group's profile. Moreover, issues such as noise created by the practice of motorcycling are pinpointed to the practice and not to the characteristics of a person or group. Consequently, solutions to conflicts can be sought with reflecting on certain practices (i.e. "cruising vs. racing" or "hiking vs. biking"), rather than on specific visitor groups. Consequently, mitigation processes rather focus on changing practices than on changing people.

Drawing on examples of our research in PAs of Switzerland and Malaysia the paper discusses advantages and limitations of both the group-oriented and the practice-oriented approaches and explores settings in which they can be fruitfully combined.

Group-orientation vs. practice-orientation

The classification of people into groups is a common aspect of every-day life. People compartmentalise their social environment into entities that can be handled easier. Individuals who share certain attributes are – often unconsciously – put together in more or less clearly defined groups. In tourism, groups are often formed according to gender, age, activity, lifestyle or habitus. Assuming that the individuals sharing such attributes also share their behaviour (which consequently is distinctly different from members of other groups), it also makes sense to draw on such every-day experiences of grouping when doing research in tourism. Moreover, if a PA's management wants to ascertain which visitors like what and what not, who is a potential threat to the environment, and who a multiplier of green ideas, it needs to make groups. Groups can be formed *ex ante* based on theoretical assumptions or as a result of an empirical study (i.e. observation, survey). For a PA's management it is good to know whether a specific group is large or not and whether its needs or impacts are a challenge, threat or easily met.

While being useful, this approach has its limits when it comes to address the individual and his/her behaviour and what sense he/she makes of what he/she does (CROUCH 2004). Indeed it is important to know what sense people make of their and others' doings and sayings, if problematic or unwanted developments shall be changed for the better. For this, knowledge about practices can be helpful. According to SCHATZKI (2002) practices can be conceived as an organized nexus of actions, they comprise occasional, rare, and novel doings or sayings. "Participating in a practice is operating in an arena where certain actions and ends are prescribed, correct, or acceptable on certain occasions" (ibid). A person who is practising "hiking through a PA" refers to social customs such as wearing a certain type of boots and clothes, carrying a knapsack (and a Swiss Army knife), reading a map or signs indicating a path. The person, moreover, moves in certain measured pace and more or less clear direction and takes in his/her surroundings in a way that is different from going to work. And hiking is embedded in a context that involves certain types of landscapes and physical infrastructure (i.e. paths, signs, bridges), and an affinity to tourism or leisure. The practice of hiking is also intelligible by others as such if they have learned about its meaning. It is not fixed and allows for a variety of forms and interpretations and still is recognized as hiking. The same doing (or saying) can be part of several practices. Hence, besides hiking, walking through a PA can also be part of the practice of bird watching, exercising in order to lose weight, recreation, taking pictures etc. A practice can be at the same time multifaceted and highly complex and easily intelligible as something distinctive what people do. A practice can be identified and described by observing people. However, the sense people make of it, can best be accessed by talking to them.

If certain practices are in conflict with each other, this of course also involves individuals. However, not certain characteristics of a person are responsible for a conflict in the first place but the practices and the way they are performed and perceived. I do not want to say that practices are independent from the people who are performing them, but people's attributes are not in a causal relation to practices. Consequently, if problems arise from certain practices it is not the characteristics of people that have to be addressed but the practices themselves, the meaning that is connected to them, the sense they make for people who are engaged in them, and alternative practices with less impact.

In the following chapters a few examples shall illustrate the uses of and differences between both approaches to tourism research.

1 Adventure and picnics in Malaysian national parks

Malaysia protects 5% of its surface area and advertises it as nature destination for tourism (BACKHAUS 2005). A former slogan of Tourism Malaysia goes "Malaysia nature*a*lly". The national parks are mostly accessible for tourism and also have infrastructure to accommodate visitors. The majority of them is covered by tropical rainforest. While tropical rainforests have been attractive for Western tourists for a while – they are regarded as exotic, teeming with wildlife and moreover they are deemed as threatened. In Malaysia, however, their attractiveness for domestic tourists is relatively new. For one thing not long ago farmers had to wrest agricultural land from forests in which animals lurked that either destroyed crops or were dangerous to people. Moreover, rainforests also were (and are) regarded a source for valuable timber that can be exploited and sold. Only since recently a growing urban middle class gets sensitised to environmental questions and regards nature conservation as important. Consequently, this group starts to regard Malaysian national parks as a part of their heritage, which they also like to visit. One of the questions in my research on the political ecology of Malaysian national parks (cf. BACKHAUS 2008) was whether there is a difference between overseas and domestic tourists. Hence, the focus was on groups (the group of the overseas or Western tourists was subsequently divided into individual and group tourists; Malaysians almost all are group tourists, at least they were at that time). The experts from the realms of tourism and nature conservation that have been interviewed made this distinction as well. The results show that there is indeed a difference. Western tourists rather want to silently contemplate landmarks, birds or the forest itself, while domestic visitors tend to seek fun, action, and good group experiences. The former complain about crowding, not seeing animals, and inadequate accommodation, the latter about too few attractions such as river rafting or fishing spots (fishing is allowed in most Malaysian national parks) and places to have a picnic or barbeque. The Westerners basically seek adventures in a foreign and exotic context, the Malaysians a pleasant group activity. The PAs have been established for the protection of nature and often tourism came only into existence when accommodation used for researchers was converted to host tourists and when accessibility was improved. Therefore, most PAs do not have the infrastructure for leisurely group activities.

In this case it made sense to concentrate on a group approach in order to identify basic needs of Western and domestic tourists that obviously differ. A consequence of these results could be that park managements (as some already do) resort to treat foreign visitors differently from domestic visitors, which is in most cases useful and productive. However, the demands of individuals that are grouped here can change. For instance there is a growing number of Malaysians who become members of NGOs or societies concerned with nature (i.e. bird watchers, insect aficionados) and subsequently have different needs. Therefore, it is useful to concentrate on practices such as bird watching, barbecueing, or hiking in order to mitigate problems and to better manage visitors and their needs in the future.

2 The Zen of driving a motorcycle through a national park

Motorcyclists driving through or near PAs are often perceived negatively by park visitors and the park management. Their pastime is regarded as a threat to the environment. Hence, they are seen as people who unnecessarily pollute the air, make noise and jeopardize other people by reckless driving. Visitors to the Swiss National Park complain most about noise caused by motorcycles; that is if they have anything to complain (LOZZA 2009). The Ofenpassstrasse that cuts through the park is an important connection to Italy. Moreover, motorcyclists (but also bicyclists) regard it as a fine curvy road in a stunning landscape that leads to other passes such as the Stilfserjoch or the Umbrail. In our study on motorcyclists' perception of the Swiss National Park and their own practices of driving through it (JAUSS & BACKHAUS, under review), we focused on this denigrated group. It is a fact that engine noise from larger motorcycles is perceived as being louder than a car's (which it objectively – measured in decibels db(A) – is only above 100 km/h) because of its frequency pattern. Moreover, lower frequencies carry further (especially in mountainous areas), and lastly motorcycle engines emit more of these lower frequencies because they cannot be muffled as well as a car engine (HEUTSCHI 2010).

The results of our study show that motorcyclists are a heterogeneous group with different notions about driving and nature conservation. Most of the older motorcyclists relish the ride through the pine-scented valley, enjoy the measuredly released power of their vehicles, the precise shifting of gears and their engine's subtle drone. Hence the mountain pass road is a perfect site to perform what motorcycling is all about. Most of them ride sturdy touring motorcycles, fewer large cruisers or racing machines. Almost all claim to adhere to traffic laws but at the same time concede to speed outside inhabited areas "when it is safe". Many have already visited the national park before. However, they did at that time not use their motorcycles to access the park, they came by car or by public transport. Hence, it became clear that motorcyclists are not a group with clearly drawn characteristics and a distinct lifestyle. Practicing motorcycling can be part of an individual's lifestyle but it rarely is a lifestyle in itself.

We could establish that motorcycling at the specific site of a mountain pass leading through the Swiss National Park is a practice with different characteristics (i.e. cruising, racing, alone, in groups, with low or high engine rounds etc.). This practice is embedded in contexts that reach further than the driving, such as traffic controls (people with inadequate or bored-up mufflers are fined), driving schools, technical aspects of motorcycles, or being regarded as a nuisance by people who do not use a motorcycle. Mitigation processes aiming at reducing noise and speed of motorcyclists better address aspects of these practices and their context that could or should be changed than on criticising a certain lifestyle and the group that is identified with it.

Conclusion

Both the group approach and the practice approach have their advantages. With focusing on groups distinct characteristics of individuals who are visiting PAs can be established or put in relation to the specific context of conservation areas. Moreover, distinguishing groups makes it easier to directly address individuals as they can easily be identified by their characteristics. A danger of this approach may be that it is not very flexible and reproduces clichés (i.e. the difference between Western and Malaysian tourists or between motorcyclists and hikers) that consequently are cemented. The group approach seeks closure whereas the practice approach is more open to subtle changes in how practices are enacted. A combination of both approaches can make sense and the sequence can go in both directions. Approaching first a topic by defining groups narrows down the range of potential stakeholders and allows for focusing on the (grouped) people's issues, needs, and problems. Subsequently, a focus on certain practices makes it possible to see what is actually done, how so and what sense it makes to people. The other way round, first establishing practices and then distinguishing between groups that are involved in these practices can yield interesting results too. In doing so one needs to be careful not to establish causal relationships between a group member's characteristics and certain practices. Research agendas that can combine these two approaches can (in my opinion) result in interesting outcomes.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 43 - 44

Creation of value through tourism in the UNESCO Biosphere Reserve Val Müstair Parc Naziunal

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Keywords

Creation of value, tourism, Biosphere Reserve Val Müstair Parc Naziunal, Swiss National Park

Abstract

The poster presents the results of a recent study on the value creation through tourism in the UNESCO Biosphere Reserve Val Müstair Parc Naziunal (BACKHAUS et al. forthcoming) and compares it with earlier studies and results from the Biosphere Reserve Entlebuch (the second of its kind in Switzerland; KNAUS 2012). The research area consists of the Swiss Nationalpark that serves as the biosphere reserve's core area and commits its hundredth anniversary in 2014, and the recently established and added Biosfera Val Müstair where buffer zone and transition area are located. This combination is unique and in terms of value creation quite a challenge. It was the aim of the study to establish the revenues created by tourists visiting the area and their contribution to the regional income. Moreover, the project makes a distinction between general revenues and those that were specifically created through visitors of the national park and of the Biosfera.

Close to 3000 people participated in the survey that was conducted during the summer months in 2012. Besides situating the research area on a map, the poster explains the methodology and the background of how to define value creation in terms of nature conservation. Moreover, it will differentiate between the two labels "Swiss National Park" and "Biosfera Val Müstair" in order to ascertain the impact on tourism revenue by an old and well-established attraction versus the one by a newly gazetted conservation area. Results show that there is indeed a great difference in terms of value generation through tourism by these two institutions.

KÜPFER (2000) conducted a similar research in 1998 and calculated that the Swiss National Park (the biosphere reserve did not exist at that time) generated ca. 17 million Swiss Francs through tourism. The poster shows whether this amount has increased since that time or not and finds explanations for this development. A spatial comparison will be made with the "Biosphere Entlebuch" where a similar study has been conducted in 2011 (KNAUS 2012).

The poster concludes with a discussion of pros and cons of such studies and recommendations regarding a comprehensive monitoring of economic revenues through tourism in conservation areas.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 45 - 48

Impact of climate warming – Upslope shift in the distribution of a land snail species in the Swiss National Park

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Abstract

Predicted biological responses to climate warming are changes in phenology and polewards shifts or upslope displacements of the distribution of species. National parks are ideal for investigating effects of climate warming because protected landscapes allow us to examine long-term responses to climate change without confounding effects of land use changes and disturbances by human activities. We investigated changes in the upper elevational range of the land snail *Arianta arbustorum* by repeating historical records from 1916– 1917 on nine mountain slopes in the Swiss National Park in 2011–2012. We found that the upper elevational limit for snail populations has risen on average by 164 m in 95 years, accompanying a 1.6 °C rise in mean annual temperature in the investigation area. The higher temperature results in a longer activity period of the snails and in an upslope shift of the vegetation. On some slopes we found that the snails have already reached natural barriers (vertical rock walls with no soil) preventing any further upward dispersal. Thus, on many mountains further upslope dispersal may be hindered by the lack of suitable habitat. To our knowledge, this is the first evidence for an invertebrate species with low dispersal capacity ascending to higher elevations in the Alps in response to climate warming.

Keywords

Arianta arbustorum, climate warming, dispersal, elevational distribution, gastropod, habitat requirement, land snail.

Introduction

Recent climate warming induces physiological and ecological responses in plants and animals throughout the world, apparent in the phenology and distribution of species (PARMESAN 2006). Alpine areas belong to those regions expected to experience above average warming with continued global climate change (BENISTON 2003). Indeed, there is increasing evidence that the range of plants and animals are moving in response to recent climate warming towards higher elevations (GRABHERR et al. 1994; WALTHER et al. 2005; LENOIR et al. 2008). In this way the organisms escape the increased temperature. However, responses to climate warming in mountain areas have so far predominantly been studied in animals with good dispersal capacities such as birds (e.g. MAGGINI et al. 2011) and butterflies (e.g. WILSON et al. 2007). Species with poor dispersal abilities, sedentary lifestyles, and specialized habitats are assumed to be potentially the most vulnerable to effects of climate warming (PARMESAN 2006). Terrestrial gastropods are among the poorest active dispersers in the animal kingdom. Numerous gastropod species have narrow habitat requirements and react sensitive to changes in environmental conditions and disturbances (NEKOLA 2010).

BÜTIKOFER (1920) investigated the gastropod communities in the Swiss National Park (SNP) in the Eastern Alps and presented detailed information on the upper elevational limit of the land snail *Arianta arbustorum* (Linnaeus, 1758) on twelve mountain slopes in the years 1916–1917. SNP is a strict nature reserve with no human disturbance or land-use change since 1914. Thus, any change in the distribution range of a species in the SNP is not confounded by human activities. We resurveyed the same mountain slopes after 95 years to examine whether there is a shift in the upper elevational limit of *A. arbustorum* in relation to changes in temperature and precipitation measured in the SNP during this period.

Materials and methods

Study species

Arianta arbustorum is common in moist habitats of northwestern and central Europe, living in the lowlands and mountainous areas reaching elevations up to 2700 m a.s.l. in the Alps. The upper elevational limit of the species is determined by the length of the snow-free period and habitat characteristics (BAUR 1986). On mountain slopes, *A. arbustorum* can be continuously distributed over large areas or occur in small, relatively distinct populations. Individuals become sexually mature at 2–4 years, and adults live another 3–5 years (maximum 14 years; BAUR &

RABOUD 1988). During winter, the snails hibernate in leaf litter or buried in the soil. Mean dispersal of adult snails averaged 12 m per year in an alpine grassland with coarse scree (BAUR 1986).

Study area and temperature measurement

The Swiss National Park (SNP) was established in 1914 in the Eastern Alps, Switzerland (46° 39' N, 10° 12' E). As a strict nature reserve (category Ia; IUCN/WCMC 1994), its main targets are ecosystem protection without any influence of humans or domestic animals, and scientific research. There is no habitat and wildlife management, and public access is permitted only on marked paths in summer months. The SNP measures 170.3 km^2 and includes an elevational range from 1215 to 3180 m a.s.l. Forests cover 32% of the park area, alpine grasslands 20%, waters 1% and rocks and scree fields 47%. Dolomite is the dominant bedrock.

In Buffalora, situated at the edge of SNP at 1968 m a.s.l., temperature and precipitation were constantly measured since 1917. The mean July temperature is 9.9 °C (average from 1961–1990), the mean annual temperature –0.3 °C, and the mean annual precipitation 902 mm (METEOSWISS 2012). All mountain slopes examined were situated within a distance of 16 km from the weather station in Buffalora.

Snail monitoring

BÜTIKOFER (1920) surveyed the mollusc fauna in the newly established SNP and its surroundings in the years 1916–1917, paying particular attention to the upper elevational limit of *A. arbustorum*, whose shells can relatively easily be found. BÜTIKOFER (1920) presents a map (scale 1 : 150 000) and descriptions of the sites where the uppermost individuals of *A. arbustorum* were found on 12 mountain slopes.

We repeated his survey in August 2011 and in June and August 2012. We subdivided each slope in 10-m elevational bands. Depending on the topography, the breadth of the elevational bands varied between 15 m (in gullies) and 400 m (on homogeneous slopes). Beginning at the slope's base, two or three persons searched carefully for individuals of *A. arbustorum* in the lowest elevational band. If a living individual or an empty shell was found, we recorded both its geographical coordinates and elevation using a GPS receiver (Garmin, Geko 201, Romsey, U.K.), and continued to search in the next higher situated elevational band. This procedure was repeated until we did not find any snails in five successive bands. We defined the upper elevational limit as the elevation where the last snail was found. In the case of empty shells, at least one living individual had be found within an elevational range of 10 m. For each slope, we also assessed the mean inclination based on maps (scale 1 : 25 000) and aspect using a compass.

We excluded three slopes examined by BÜTIKOFER because of dangerous access to the site (one case) or the site of former snail occurrence was not described in enough detail (two cases). Hence, we resurveyed nine of the twelve mountain. Using the geographical coordinates, we draw small-scale distribution maps of snail individuals found on each slope and compared the current distribution with the upper altitudinal limit recorded in 1916–1917.

Results

Mean temperature increased by 0.16 °C per decade in the SNP over the past 95 years. In contrast, the amount of annual precipitation did not change over the period considered.

On the nine mountain slopes examined, the upper elevational limit of *A. arbustorum* raised 146 m (s.e. = 27 m; range 5–250 m) in the past 95 years (paired *t*-test, $t = 5.42$, $n = 9$, $P = 0.006$). On one slope, where a shift of 5 m was found, the upper distribution range of the snail had already reached the foot of vertical rock walls of mountain Piz Murters in 1916, preventing any further upslope dispersal. If data from this slope are removed from the analysis, the upper elevational limit for snail populations has risen on average by 164 m. In the recent survey, individuals of *A. arbustorum* were found to have reached natural barriers (vertical rocks wall) preventing further upwards dispersal on two slopes. Upslope extension of snail distribution was larger on south to south-east exposed slopes (mean ± s.e. = 233 ± 8 m) than on north to north-east exposed slopes (122 ± 18 m; unpaired *t*-test, $t = 4.50$, d.f. = 6, $P = 0.0041$). However, upslope extension of snail distribution was not influenced by the inclination of the slope (Pearson correlation: $r = -0.25$, $n = 9$, $P = 0.53$).

Discussion

The present study provides meteorological evidence for recent warming in SNP, and shows that this trend is accompanied by a significant upslope range extension of the land snail *A. arbustorum*. On all but one mountain slope, we found an increase in upper elevational limit of *A. arbustorum* compared to the data collected 95 years earlier by BÜTIKOFER (1920). The exception can be explained by the presence of a geographical barrier preventing further upslope dispersal in the past decades. The observed magnitude of elevational range shift of *A. arbustorum* clearly exceeds any potential measurement uncertainty due the use of different types of altimeters in the past and present. BÜTIKOFER (1920) also provided evidence for the occurrence of a few other alpine snail species at higher elevations on the slopes examined. This indicates that BÜTIKOFER (1920) may not have underestimated the upper elevational limit of *A. arbustorum* in 1916–1917. Considering the mean dispersal distance of 12 m per year measured in tagged *A. arbustorum* on mountain slopes (BAUR 1986), an upslope range extension of 62 to 250 m as recorded in the present study is feasible over a period of 95 years.

National parks are ideal for investigating effects of climate warming because protected landscapes allow us to examine long-term responses to climate change without confounding effects of land use changes and disturbances by human activities. SNP is a strict nature reserve with no human disturbance or land-use change since 1914. Thus, the rise in the upper elevational limit of *A. arbustorum* cannot be explained land-use changes or human activities.

Global warming is influencing most natural systems on Earth, but the impact on high elevation ecosystems is especially pronounced. The European Alps are perhaps the best-endowed mountain system in terms of climatological and environmental data. The warming experienced in the Alps, while synchronous with the global warming, is of far greater amplitude than in the lowlands and reaches up to 2 °C for individual sites (Beniston et al. 1997). Similarly, in Buffalora at the edge of SNP, an increase of 1.6 °C was recorded. Climate change in this region is characterized by an increase in minimum temperatures of about 2 °C, and a more modest increase in maximum temperature, but no change in precipitation data, resulting in a prolonged period of vegetation growth.

Shifts at the upper edge of elevational range agree with the hypothesis of an upslope trend to escape rising temperatures. This is also the most widely used explanation for the recorded plant species' shifts on mountain peaks in the European Alps (Grabherr et al. 1994; Camenisch 2002) and in Scandinavia (Kullman 2002). Climate is the major factor limiting plant species richness at high elevations. Elevational shift over the last century varied in plant species from 46 to 532 m (mean 258 m) on mountain slopes in the Upper Engadina, 40 km west of SNP (Walther et al. 2005). Similarly, the Ibex (*Capra ibex*) shifted its activity range 250 m upslope in the SNP in the past 70 years (R. Haller, personal communication). Our results confirm the elevational range shift in another group of organism that has so far not been examined.

Acknowledgements

We thank M. Baur and N.A. Willy (SNP ranger) for field assistance, T. Konzelmann (MeteoSwiss) for providing temperature data, and R. Haller and C. Schmid (both SNP) for GIS-support and drawing small-scale distribution maps.

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Conference Volume | 5th Symposium for Research in Protected Areas | 10 to 12 June 2013, Mittersill | pages 49 - 52

Extracurricular Environmental Education in the Nationalpark Hohe Tauern

Magdalena Bernsteiner

Abstract

The past 40 years have shown a growing interest in the field of environmental education and global learning. Subsequently, the need for quality research and impact analysis has also risen, explicitly in recent years. This thesis follows the path of quality research and its central focus is therefore an evaluation of a part of the environmental education program available for school groups at the Nationalpark Hohe Tauern.

In the theoretical part, basic concepts such as environmental education, ecological awareness, pro-environmental behaviour, nature experience and nature- and experiential education practiced at environmental centers are defined. Additionally, both the historical development as well as the present situation of environmental education are briefly described.

Further on, an overview of the offered educational program at the National Park Hohe Tauern is presented. Education outside the context of school generally works according to the following principles: Practical research and exploration of natural phenomena, problem-oriented learning and learning through experience, reality-connected situations and social interaction. The underlying idea is to encourage in our children and adolescents a feeling of global responsibility and the development of ecological decision-making competences. In order to fulfil these high aimed educational objectives, the management team at the Nationalpark Hohe Tauern Mittersill has constantly to improve their work. This is done via quality controls, training courses and numerous innovations in their program.

Efficient implementation into practice is often difficult – this becomes obvious during the evaluation phase in the empirical part of the thesis. **Research questions** have been formulated in the beginning in order to gain clear and consistent results. Cognitive knowledge, student's expectations as well as their attitude towards the National Park have been central aspects from the start:

- How big is the **increase of cognitive knowledge** for students after visiting the educational program in the Science Center?
- Which **expectations** and concepts do pupils have when they arrive at the Science Center?
- Are these expectations being fulfilled?
- How strong is the **acceptance** of the National Park Hohe Tauern among teachers and pupils?
  After an attendance of the module, is there a change in their attitude traceable?
- If necessary, how can the **module** "alpine animals – alpine ecology" be **improved**?

Keywords

environmental education, nature experience, pro-environmental behaviour, extracurricular education, long-term effects, teaching situation

Methods

The study has been divided into three parts and consists of a questionnaire investigation concerning the module "alpine animals" conducted at the Science Center Mittersill. Students as well as teachers and Nationalpark Rangers teaching at the Science Center have been polled. Survey 1 took place in spring 2010 before the school groups went to the Science Center, survey 2 right after the module, and survey 3 four weeks afterwards.

Results

Following results could be gained: The quality of the educational program is generally very high. A consistent basic structure is traceable (a „red thread"). However, due to the overall very pedagogical/didactic competent Nationalpark Rangers, the teaching method is often adapted according to the situation.

The feedback of students as well as teachers is generally optimistic. Even in phase 1, before the visit to the Science Center, the participants were rather interested and showed a positive attitude towards the Nationalpark Hohe Tauern. Nevertheless, a slightly negative development between evaluation phase 2 (directly following the lesson at the Science Center) and evaluation phase 3 (four weeks after) can be traced. Overall, there were no obvious improvements noticeable in the field of cognitive knowledge.

The evaluated module shows also some weak points: The size of the group (stated as 15 members in the program folder) has several times reached a maximum of over 20 people per group which resulted in negative feedback from students as well as teachers. In addition, the level of student's activity and practical reality-based learning could be further improved.

Conclusion

As a conclusion I would like to emphasize the importance of a cooperating partnership between schools and environmental centers, such as already practiced by the Nationalpark Hohe Tauern. By doing so, numerous advantages for the future could be enabled. Nevertheless, an increased integration of the Nationalpark program into the teaching program at school is necessary. For the future, this is the real challenge for research and quality management to improve the effect of environmental education, especially in protected areas.

Long-term effects (output-oriented) can only be achieved if preparation time as well as follow-up activities are planned as part of the whole project. Furthermore, by means of a good organization and information beforehand, it will be much easier to meet student's interests and expectations efficiently.

Learning by doing, combined with enough space for creativity and a connection to the everyday life of the students are the key points of educational programs. Exactly these aspects have been positively remarked by the children in the survey. The results also show very clearly, how sensible students react to external factors such as time pressure and equipment of the classroom. This underlines once more the great pedagogical importance of the teaching situation and is especially relevant in the field of environmentally oriented, extracurricular education.

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Conference Volume	**5th Symposium for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 53 - 56

Tourist typology research in protected areas

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Abstract

Nature tourism is both a dynamic and heterogeneous phenomenon and causes new challenges for protected areas. Therefore, marketing becomes increasingly important for protected areas. A theoretical consideration analyses some nature tourist segmentation approaches to discuss the practicability and benefits of this marketing method for tourism management in protected areas. The necessary connection between tourist segmentation and tourism-impact research is highlighted by a suggested tourist typology.

Keywords

nature-based tourism, tourist segmentation, tourist typology

Introduction

The tourism demand is in constant change, as it is shown by the steady rise of international tourist arrivals, the emergence of new destinations and source markets (UNWTO 2012) and the appearance of new tourism trends. Acknowledged by many authors (e.g. COCHRANE 2006; STRASDAS 2001) the experience of nature during leisure time and holidays becomes more important. Due to this demand natural settings and protected areas are attractive tourism destinations (HAWKINS & LAMOUREUX 2001). The rising use of protected areas by tourists is expected to continue in the future (EAGLES 2007). International designations like „World Heritage“ or „National Park” are seen as positively occupied trademarks. Therefore, they are of special interest for travellers (EAGLES 2007; JOB & WOLTERING 2009). Heterogeneous as tourists in general, the visitors of protected areas are a multifaceted demand type (ARNEGGER et al. 2010; WIGHT 2001). That tourism can have negative impacts, especially on the environment is undeniable. Whether outdoor activities cause environmental damage depends on various factors like intensity of use, carrying capacity, form of activity, behaviour of the individuals and tourism management (JOB & VOGT 2007; STRASDAS 2006).

To develop an ecologically sustainable tourism management that meets the needs of nature conservation as well as of tourism it is necessary to obtain information about the visitors. Thus, marketing - in the sense of market research - is very important for protected areas. This paper treats the segmentation method with respect to segmentation designs and segmentation criteria in order to discuss its practicability and usefulness as a marketing tool for tourism management in protected areas, and its contribution to tourism-impact research.

Investigation design

The heterogeneity of tourism demand makes market segmentation a useful marketing tool for tourism management (HALLERBACH 2007; DOLNICAR 2002). There are two basic segmentation approaches, the a priori (commonsense) and the data-driven (a posteriori, post-hoc) segmentation. A priori segmentation is where the grouping criteria are known in advance or are specified beforehand. Data-driven segmentation, however, in order to derive a grouping, applies quantitative techniques of data analysis to an empirical data set (DOLNICAR 2002; UNWTO 2007). Typologies are conceptual, multidimensional segmentation approaches (DOLNICAR 2002). Data segmentation based on a typology may be regarded as a priori segmentation. Commonly used grouping criteria are demographic (age, gender, education), geographic (location of residence), psychographic (benefits, attitudes, values), and behavioural variables (UNWTO 2007).

The trend towards experiencing nature in leisure time and holidays can be considered as a sub-segment of tourism. For this sub-segment the different terms "nature(-based) tourism", "ecotourism" and "sustainable tourism" exist. There is no general agreement about the meanings of these terms. Referring to STRASDAS (2001; 2006), nature or nature-based tourism is “a form of travel to natural areas where nature is a key motivation of the tourist.” The definitions of sustainable tourism and ecotourism describe not only the form of tourism but also imply effects of these tourism types. Sustainable tourism is tourism that meets the principles of sustainability (contribution to economic, ecological, social and infrastructural development), and ecotourism can be interpreted as sustainable nature tourism. STRASDAS (2001; 2006) claims tourists being ecological aware and interested in educational elements is not a criterion for ecotourism because the impacts of tourism depend also on management strategies. He considers sustainable and ecotourism more as a concept than a demand type.

To implement sustainable tourism in protected areas, detailed data on the visitors are necessary. It is important to gain information on all visitors, which means that protected areas have to consider the sub-segment of nature tourism. This way no useful information will be lost, especially regarding to the impacts of visitors.

As protected area visitors are a heterogeneous group, nature tourist segmentation in protected areas is a crucial marketing instrument to explore the demand structure. Due to the change of tourism market from producer to consumer market and multi-layered tourists, segmentation has become a complex task (ARNEGGER et al. 2010; HALLERBACH 2007). Traditionally used segmentation variables, like geographical or socio-demographical ones, are not sufficient anymore. Qualitative characteristics (e.g. motivation, attitude and activities) additionally should be used to segment nature tourism demand (HALLERBACH 2007; STRASDAS 2001).

In the following some segmentation concepts are consulted in order to discuss the different segmentation designs and the used segmentation criteria with respect to their practicability and usefulness as a marketing tool for protected areas. For that matter, it was not the purpose to draw a complete picture of existing approaches; rather the concepts were used as the discussion basis. The consideration starts by a brief description of the segmentations, continues with the discussion on practicability and usefulness for protected area management and eventually ends in a suggestion of a new typology approach.

Nature-based tourist segmentations

STRASDAS (2006) presents a segmentation that refers to Western European and North American nature-based tourists. He distinguishes six groups according to the tourists' commitment to ecology. To describe the categories five items (main interest, importance of intact nature, demands on guides, standards of comfort and quantitative demand potential) were used.

FENNELL (2001) discusses the areas and needs in ecotourism research and, amongst others, he points out the research dealing with the benefits attained through leisure activities. He highlights the recreation experience preference (REP) approach. REP scales are useful instruments to separate different kinds of nature tourism from each other.

ZIENER's (2001) investigation in five German national parks and biosphere reserves identified six groups with regard to visitors' activities. In her research she discusses the correlation between the recreational types and the interest in nature and nature conservation. Additionally she surveyed the tourists' estimation on conservation measures.

COCHRANE (2006) worked out a tourist typology to protected areas based on qualitative field research, mainly conducted in developing countries. To stereotype the visitors she uses demographic and behavioural characteristics and visitors' preferences for facilities and experiences. She argues that the perception of nature and attitude towards nature depend, amongst other reasons, on the tourist's cultural and social background. To highlight the differences between national and international visitors, she developed a seven-scale typology for international and a six-scale typology for domestic nature tourists.

The theoretical framework "a product-based typology for nature-based tourism" of ARNEGGER et al. (2010) is a product-oriented classification that uses a two-dimensional matrix for categorisation. The first dimension mirrors the relevance of nature for tourists. Four classes show whether nature is subject of participation (e.g. active participation in nature protecting programs), subject of interest, backdrop for activities, or only has a secondary background function. The second dimension shows "the degree of individuality inherent in service arrangements" (ARNEGGER et al. 2010). The four classes are called "independent", "á la carte", "customized" and "fully standardized".

SÆÞÓRSDÓTTIR (2010) investigates nature tourists in different nature destinations in Iceland. She classifies the tourists according to their nature- and service-orientation by using the so-called Purist Scale, consisting of the four groups "strong purists", "moderate purists", "neutralists" and "non-purists". She argues that with this typology (showing how close to nature the visitors are) in conjunction with the model of Recreation Opportunity Spectrum (showing how close to nature the areas are) and the concept of carrying capacity (showing the limits of tourism use in an area) a useful tourism management tool is given.

The research of ZOGRAFOS & ALLCROFT (2007) employs market segmentation to explore the potential ecotourism market in Scotland. They investigate how the individuals' environmental values influence the demand for ecotourism. Using the New Ecological Paradigm they identified four segments ranging from anthropocentric to ecocentric values. The research results show that anthropo- and ecocentric individuals have a similar understanding of ecotourism that not only ecocentric people are interested in ecotourism activities and that the four identified tourist types have different trip characteristics.

Practical use of tourist segmentations for protected areas

Tourist segmentations can in different ways be useful for tourism management in protected areas. The practicability and benefits of segmentations depend partly on the chosen segmentation method.

The above mentioned concepts are (excluding the approach of ZOGRAFOS & ALLCROFT (2007), the REP approach and the Purist Scale) a priori segmentations as they treat the sub-segment of nature tourism or focus on visitors of special areas (DOLNICAR 2004). The segmentation of the potential ecotourism market in Scotland (ZOGRAFOS & ALLCROFT 2007) is pure data-driven as it analyses the entire Scottish tourism market. Segmentations like that can be understood as a planning tool because by characterising a potential demand structure needs can be identified, and the following implementation can be aligned accordingly. Potential visitor segmentation is also useful for sales policy. The Purist Scale and the REP approach, not exclusively designed for nature tourism, are a priori segmentations because the grouping criteria are pre-judged. The concept of ARNEGGER et al. (2010) is in two ways a commonsense segmentation; it refers to nature tourism and the grouping criteria are specified beforehand.

A priori segmentation with fixed limits of each category is a suitable instrument to compare tourist types in different regions or settings (SÆPÓRSDÓTTIR 2010). The advantage of data-driven segmentation is that the classification process may consider site-specific factors, whereas a priori segmentation has to stick to the predefined variables. Thus, the classification criteria must be chosen wisely. Referring to the process of segmentation, DOLNICAR & GRUN (2011) acknowledge commonsense segmentation as the simpler method because there are no methodological traps.

To what extent segmentations give insights into tourism demand that are relevant for tourism management in protected areas depend on the selected classification criteria.

Segmenting tourists according to their practised activities (=behavioural variable), like ZIENER (2001), "may be seen as an essential accounting procedure for tracking, maintaining or improving a destination's tourism performance" (UNWTO 2007). Knowing the activities practiced by tourists in protected areas, it is possible to draw conclusions about how nature is used. Approaches that segment tourists according to the value the tourists assign to nature during their stay (=psychographic variable), like the concepts of STRASDAS (2006) and ARNEGGER et al. (2010), can add further information how nature is stressed by tourism. Segmentations based on psychographic variables are also valuable to show whether the tourism demand is consistent with the preconditions of an area, as is shown by the research of SÆPÓRSDÓTTIR (2010) who with the Purist Scale engaged a benefit segmentation. Benefit segmentations like that or the REP approach, allow to identify that visitors of one and the same destination or apparently homogenous segments may in reality be different benefit seekers (UNWTO 2007). Classification based on geo-demographical variables is also a kind of psychographic segmentation, as it is assumed that people of the same origin may share similar characteristics and also may have similar consumption patterns (UNWTO 2007). Being attractive destinations for international tourism, protected areas should distinguish national and international tourism demand, like COCHRANE (2006) did. ARNEGGER et al.'s (2010) approach in the second dimension segments tourists based on trip patterns (=behavioural variable). According to UNWTO (2007) "trip structures and patterns form the heart of the tourism experience." Knowing the frame conditions of tourists' trip patterns, can help to reveal the starting point for tourism management strategies.

Segmentations may be used differently for tourism management in protected areas, they may hold planning, promotional, inventory or monitoring functions. ZIENER (2001) acknowledges that tourist typifications in protected areas should focus primarily on two aspects: (i) activity specific use-requirements on the area (ii) ecological impacts of outdoor activities. Generally spoken, tourist segmentations can be considered as an interface between research and practice. Thereby segmentations should be as complex as necessary and as practical as possible (ARNEGGER et al. 2010).

An approach to discuss

Due to the sought practicability and the claim of ZIENER (2001) an a priori segmentation is proposed which includes the consideration of tourism impacts. It is suggested to employ the "product-based typology for nature-based tourism" (ARNEGGER et al. 2010) to show how visitors "consume nature" and how they organise their trips. To draw conclusions about the impacts, the four "nature-consumption groups" shall be further subdivided according to whether the tourists comply with conservation measures. Since eight groups for one dimension is a lot, the groups shall be reorganised to maintain the four groups. The groups of this dimension shall be labelled "true ecotourist" (interested and engaged in nature (protection), compliance with the measures), "pretended ecotourist" (interested and engaged in nature (protection), no compliance with the measures), "hidden nature sound tourist" (not or barely interested in nature, compliance with the measures) and "anti-ecotourist" (not or barely interested in nature, no compliance with the measures). Agreeing in COCHRANE's opinion (2006) about the correlation between cultural/social background and the attitude towards nature, it is suggested to observe domestic and international tourists separately. Additionally, it is considered reasonable to distinguish the local from the domestic tourists. Empirical testing of this approach is needed to decide whether this approach is as complex as necessary and as practical as possible.

Conclusion

Tourist segmentation is an essential marketing tool for protected areas due to the heterogeneous nature tourism demand. Tourist segmentations offer the opportunity to illustrate the demand side in a compacted manner. In addition to a target-oriented identification of the tourism demand, segmentation can be used for monitoring, sales policy or planning processes. In combination with approaches such as the carrying capacity, or by selecting appropriate classification criteria tourist segmentations can contribute to tourism-impact research. Tourism use-requirements and ecological impacts of tourism are of particular interest for protected areas. This should be considered for the development of a tourist typology for protected areas.

The proposed typology offers an approach that is easy in application, and with the treatment of tourists' compliance with conservation measures it joins tourism-impact research. The empirical testing of this approach in different kinds of protected areas and different countries is needed to figure out whether this typology is a practicable, international valuable marketing instrument. Future research in the field of tourist segmentation in protected areas should emphasise the impacts of tourism. A cross-cultural and cross-national practicability of the approaches should also be considered to enable comparisons of tourist types at different regions and settings.

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Conference Volume | 5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill | pages 57 - 58

A transnational lichen inventory of the Alps: a long overdue task

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Abstract

The procedure for the buildup of a transnational lichen inventory of the Alps as well as the projected final products, an annotated printable checklist (open access) and an online database with an extended scope of operation, are described. The importance of this extensive project is briefly discussed.

Keywords

Alps, biodiversity, checklist, ecology, inventory, lichenized ascomycetes

Introduction

The Alps are one of the largest continuous natural areas in Europe, stretching approximately 1,200 kilometres across eight countries, and including fourteen national parks. The Alpine Convention emphasizes the importance of this area and encourages transnational research and conservation projects. Lichens as unique models of fungal symbioses with macroscopically recognizable, light-exposed individuals are a predominant symbiotic life form of higher altitudes in the Alps. Printed national checklists or catalogues exist for Austria (Hafellner & Türk 2001, Türk & Hafellner 2010), France (Roux 2012), Germany (Wirth et al. 2011, 2013), Italy (Nimis 1993, Nimis & Martellos 2003), Liechtenstein (Hafellner & van den Boom in prep.), Slovenia (Suppan et al. 2000, supplementary data in Mayrhofer 2006) and Switzerland (Clerc 2004). Updates for Italy (Nimis & Martellos 2008) and Switzerland (Clerc & Truong 2012) are available on the web. The compilation of such a catalogue has been initiated as a multi-authored project by P. L. Nimis more than ten years ago, which has unfortunately come to a standstill. We are now summarizing the abundant but scattered baseline information on lichen biodiversity in the Alps, which will lead to a transnational inventory of all lichen taxa present in the Alps, including data on their ecology.

Material and Methods

The lichen inventory will be based on published records only. National checklists of Austria, France, Germany, Italy, Liechtenstein, Slovenia and Switzerland and the most recent floristic and taxonomic treatments have to be evaluated for the taxa occurring in the Alps. After updating the nomenclature, a database with all the available information of the checklists has been created. Additions and corrections are in progress. Finally, we will generate a printable checklist (open access) with an appendix listing frequently encountered synonyms, as well as an online database with an extended scope of operation.

Outlook

A completed record will consist of the following information: Taxon, distribution data (countries and regions), ecology (substrata and altitudinal range) and a note (distribution, frequency, endangering, nomenclatorial, taxonomical problems, more detailed information on the ecology of the taxon etc.).

Example of a widespread lichen:

Alectoria ochroleuca (Hoffm.) A.Massal.

AT: V, T, S, K, St, O, N. IT: Frl, Ven, TAA, Lomb, Piem, VA. DE: OB. CH: BE, GR, TI, UR, VD, VS. FR: 3.1, 3.2, 4.1, 4.2, 5. (ter; mon-niv). [ter = on soil, terricolous mosses and plant remnants]

Note: an arctic-alpine, circumpolar species, found on windy ridges in moss-lichen heaths, more frequent on siliceous substrata, but sometimes also occurring in areas with dolomite.

The online database will provide further features as a query interface which generates lists of species, for instance, all taxa of the Austrian region Tyrol, which are distributed at the alpine belt. Furthermore, we are planning to insert distribution maps and photos for a large number of the presented lichen taxa.

Discussion

A comprehensive checklist of the lichens of the Alps is long overdue and will enable us to compare, for instance, the genera or species diversity of the Alps with those of other mountain systems of the world (e.g. the Tatry Mountains – LISICKÁ 2005). URBANAVICHUS (in prep.) is conducting a similar study for the Caucasus Mountain Range. Lichen species only known from high-altitude plots of the Alps are potential organisms for protection and monitoring. Species restricted to the highest altitudes will become more and more threatened in the future due to global warming. This information will be of use for experts, decision-makers, and citizen scientists.

Acknowledgements

Financial support from the Austrian Science Fund (FWF, project P25078-B16) is gratefully acknowledged.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 59 - 64

Monitoring of French altitude lakes in multi-stressors situations: focus on 5 lakes in Haute-Savoie

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Abstract

Lakes are valued for their role in the water cycle and services including supply of drinking water, fishing, recreation, and tourism. The major types of stressors that potentially combine to affect lakes biodiversity, functioning and services include eutrophication, acidification, toxic materials, climate change and species introduction. At present days, most of European lakes have suffered from perturbations, including high altitude lakes although long considered as pristine sanctuaries.

The response dynamic of lakes facing changing conditions and anthropogenic stressor is a crucial issue for protected areas managers aiming at maintaining or restoring these ecosystems.

In the multi-stressors situation, it is critical to better understand and predict the response of the lake biodiversity and functioning in face of changing environment and climate, and to monitor it. In the French Alps and in Corsica, ecosystems managers and scientists from physical, biological and social sciences joined into a network called "Sentinel Lakes" aiming at enhancing the share of information and data about the future of lake biodiversity and functioning in the context of the global change.

Since 2009 this network brings together researchers from different institutes, French National Parks, National Natural Reserves, Water Agency, French National Fishery Federation and ONEMA (French Water and Aquatic System Board). Protected areas currently implements protocols to monitor the physical and biological parameters of altitude lakes that aims to be standardized. Some of the lakes have been studied since 15 years, such as five lakes in the National Natural Reserve of Haute-Savoie. The first results show that the five studied lakes are characterized by contrasted structure and composition of phytoplanktonic communities. These differences reveal contrasted functioning of the lakes' food webs.

Keywords

High altitude lakes, monitoring, sentinel lakes network, plankton, lake food web, ecological diagnosis.

Introduction: Why a 'Sentinel lakes' network ?

High altitude lakes are important for their biodiversity and the ecosystem services they provide. They also have great cultural and socio-economic value, being the place for numerous human activities, such as tourism and outdoor activities, fishing or hydroelectricity production.

At elevations between 1800 and 2800 m, in some cases ice-covered for 8 months of the year, they constitute unique ecosystems in Europe. As they are distant from large urban areas and rather difficult to reach, high altitude lakes are usually considered as natural land preserved from the impacts of human activities. However, recent international studies have challenged this view, showing that they have been subjected to severe human stresses, on both local and global scales, sometimes for ages.

There is particularly a growing concern about the impact of global changes on the ecological state and future trajectories of these lakes. Indeed, some European altitude lakes have been shown to be contaminated by atmospheric inputs of nutrients (nitrogen fertilizer and phosphorus) or pollutants, such as metals (Lead, Mercury - ARNAUD et al. 2004; THÉVENON et al. 2011) or persistent organic pollutants (PAH or pesticide residues, DDE), carried over long distances (BATTARBEE 2005). They were also repeatedly shown as affected by fish stocking and fishing and warming linked climate change (EMERGE project, 2000, EU FP5).

Lake managers face a dilemma since they are required to preserve the lakes' 'natural' state while maintaining traditional human activities linked to these areas. Each of these activities is likely to trigger, in the short or longer term, substantial changes in the ecological state of these mountain lakes (SCHINDLER 2001; KNAPP 2001), especially since their peculiar properties (small size, extreme climate conditions, remoteness, small number of species) make them highly sensitive to any biological or chemical disturbances in the environment.

Recently, rangers and scientists surveying mountain lakes in the French Alps and in Corsica have observed recent changes in their status, such as an increase in the algal production and the appearance of cyanobacteria (CAZAUBON 2006), reduced water quality, hypoxic conditions at lake bottom (GIGUET-COVEX et al. 2012), introduction and loss of species. But there is still a lack of knowledge about the reasons for these changes, the impact of the multistressors on lakes and about the means to protect or restore them. Currently, managers face up three main issues:

- What are the consequences of local human activities?
- What is the impact of global changes on the behavior and state of conservation of these ecosystems?
- How do these environments evolve? How to diagnose and correct for possible dysfunction?

In this context, ecosystems managers plus scientists from physical, biological and social sciences have joined a network called "Sentinel lakes". Its aim is to enhance research and information and data sharing on high altitude lake biodiversity and functions in a context of global change. It is coordinated by Asters (the manager of the nature reserves of Haute-Savoie) and includes researchers from universities, from the National Centre for Scientific Research and INRA (National Institute for Agricultural Research) as well as managers and stakeholders from French National Parks, National Nature Reserves, Water Agency, French National Fishery Federation and ONEMA (French Water and Aquatic System Board) from the French Alps and Corsica (BIRCK et al. 2013, accepted in Ecomount).

The objective of this article is to present the experience of the monitoring of the Haute-Savoie lakes, carried out within the framework of the French network "Sentinel lakes", which investigates how mountain lakes respond to local or global stressors.

Methods

Study sites and Framework

Initiated by the Scientific Committee of the Nature Reserves of Haute-Savoie, Asters (the manager of the nine nature reserves located in Haute-Savoie, France) has implemented a monitoring on 5 mountain lakes (table.1) that started 15 years ago. Chemical, physical and biological parameters are measured each year by the rangers to assess the evolution of the ecosystem. INRA of Thonon carries out the analyses.

Table 1: Morphological and physic-chemical characteristics of the 5 studied lakes

Lakes	Brévent	Cornu	Pormenaz	Grand Jovet	Anterne
Nature Reserve	Aiguilles Rouges	Aiguilles Rouges	Passy	Contamines-Montjoie	Sixt-Passy
Geolocation	45°92'N ;6°82'W	45°95'N;6°84'W	45°96'N ;6°79'W	45°75'N ;6°73'W	45°99'N ;6°79W
Altitude (m)	2159	2276	1945	2173	2063
Depth max (m)	20.4	22.0	9.4	8,5	12.5
Volume m3	230 000	550 000	168 000	330 000	760 000
Surface ha	2.9	5.3	1.3	5.5	11.5
Depth (average) (m)	7.9	10.4	12.8	4.4	6.6
Stocking with alevins	Stopped in 2011	Yes	Yes	Stopped in 2011	Yes
Chlorophyll *a* (µg/L)	2.30	1.42	1.09	1.45	0.66
Secchi depth	5.5	10.5	8.5	3.3	8.5
Chemical analyses on integrated sample (0-5m)					
PO4 (mgP/L)	0.003	0.004	0.001	0.004	0.002
NO3 (mgN/L)	<0.005	0.02	0.01	0.12	0.01
NH4 (mgN/L)	0.001	0.003	0.007	0.006	0.015
N total (mgN/L)	0.15	0.11	0.19	0.13	0.13
COT (mgC/L)	2.49	0.95	1.73	0.59	0.94

Sampling and analyses

The monitoring is designed to allow an easy sampling and field measurements for the rangers.
For each lake, sampling is carried out once a year, in September, at a reference sampling station located above the deepest part of the lake.

Various physical, chemical and biological parameters are followed:

- Water transparency is estimated from Secchi disk measurement.
- Vertical profiles are obtained along the water column using a multiparameter device for measurements of water temperature, pH, conductivity, dissolved oxygen concentration and conductivity.
- Sampling for metazooplankton counting is performed using a 60-µm-mesh zooplankton net from a vertical haul from near-bottom to the surface.

- From an integrated sample (5L obtained for the stratum 0-5m), a first sub-sample (500mL) is preserved for microphytoplankton counts, a second subsample (50 ml) is used to quantify the abundance of picophytoplankton (i.e. picocyanobacteria and small autotrophic eukaryotes) by and a third sub-sample (1L at least) is used to collect Chlorophyll-a on Whatman GF/C filters.
- Chemical analyses are performed both from the integrated sample (0-5m) and from a water sample taken at deepest depth of the water column. The total organic carbon (TOC) and nutrient concentration (N total, NH4+, NO3-, SiO2, P total, PO43-) are measured according to the standard french protocols AFNOR (details available at http://www.thonon.inra.chimie.net/page/public/analyses.asp).

Figure 1: Sampling in lake Anterne by the ranger of the natural reserve (ASTERS).

Results

Not all the results are detailed in this article but we rather focused on the main characteristics of the lakes:

<u>Chemical parameters</u>

As described previously by WINIARSKY (2000) these lakes are considered oligotrophic (in terms of availability of dissolved nutrients and transparency of water) however one lake of these (Lake Brévent) is characterized by higher concentrations of total organic carbon and total nitrogen and lower water transparency which confirm a potential enrichment of this system that could lead to disturbances in food web functioning.

<u>Biological parameters</u>

As generally expected for high altitude lakes, the chlorophyll-a concentration are low. In our case, the highest concentrations, measured in Lake Brévent, does not exceed 2.3 µg/L, while the lowest value (0.66 µg/L in 2012) is estimated in Lake Anterne. However, phytoplanktonic biomass while moderate, is not extremely low in comparison to biomasses recorded in large deep lakes (i.e. Lake Brévent exhibited phytoplanktonic biomasses that varied from 400 000 µm3/mL to ~3 500 000 µm3/mL)

It's worth mentioning that the phytoplanktonic composition of these 5 lakes is contrasted. Indeed the dominant taxa in lakes Anterne & Jovet (the most oligotrophic systems) are mainly diatoms (with especially centric diatoms as *Cyclotella* spp in Lake Anterne and pennate diatoms as *Staurosira* (which is generally considered as a benthic species) or *Amphora* in Lake Jovet). The importance of diatoms is consistent with rather high concentrations in silica in these 2 lakes exhibited the lowest phytoplanktonic biomasses (Figure 2). In contrast, in Lake Cornu, Dinophyceae and Chrysophycées dominate the phytoplanktonic biomass with especially *Peridinium and Gynmnodinium, while* Chlorophyceae dominate in Lake Pormenaz (with especially small chlorophyceae as *Oocystis* and *Chlorella* spp.) and Lake Brévent is characterized by the dominance of Zygophyceae (particularly *Spondilosium* (small size plankton <10µm)) and the lowest value for Shanon diversity index.

Discussion

<u>Methological aspects</u>

This monitoring protocol differs widely from protocols requiring intensive monitoring, as it is the case for some environmental observatories (SOERE GLACPE; http://www.allenvi.fr/?page_id=775), but it is considered sufficient to observe the status and trends of these small mountain lakes. Protocols are likely to evolve over the years, particularly with the implementation of the project "sentinel Lakes". For instance, a recent ecological diagnosis performed on Lake Brévent confirmed, based on a benthic indicator (Indice Biologique Lacustre, VERNEAUX et al. 2004), the existence of perturbation in the ecological status of this lake (BELLE 2012).

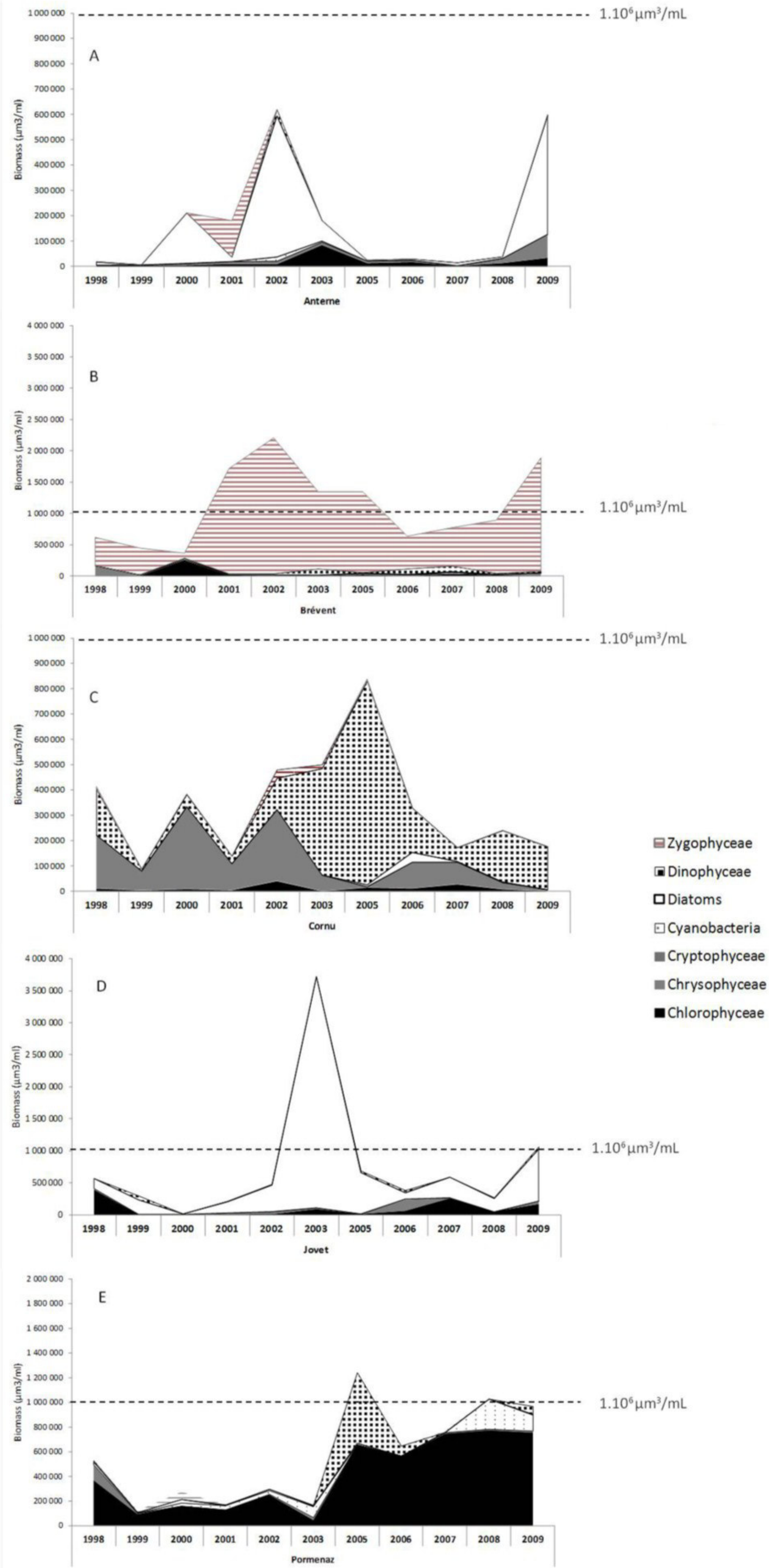

Figure 2: Temporal dynamics of phytoplanktonic biomass (expressed as µm3/mL) in the five lakes over a 10 years period.

Apart from the relevance of the physical-chemical-biological parameters, the robustness of the protocol depends on the availability of rangers (time devoted to research in proportion to police and management work in Natural Reserve), access to the site, partnerships with research laboratories for analysis.

It's necessary to distinguish in first hand the establishment of monitoring "routine" where managers are independent at least for the sampling and in the other hand a full monitoring on specific sites where managers supports the scientists in logistical knowledge of the field.

<u>Knowledge on food web structure is essential for lake characterization.</u>

Biodiversity has been identified as one of the key factors determining lake resilience. Consequently, a crucial issue for lake management is to unravel the controlling factors of biodiversity. High altitude and latitude lakes are supposed to have low biodiversity and resilience**.** Indeed, high altitude and latitude lakes commonly have low species richness, mainly due to a short growing season, high UV radiation, low nutrient levels, limited food resources, low temperature, low habitat heterogeneity, small lake size, and geographical isolation that create migration barriers and enhance the "island effect". As a consequence, in such lakes, the functional redundancy is theoretically initially low and therefore any loss of species caused by changing conditions (local and global changes) should induce a shift toward less desired state which is probably higher in these "sentinel" lakes than in initially more diverse systems.

However, it seems rather clear from our data that all high altitudes lakes cannot be considered similar in terms of biological diversity and structure of biological communities. Indeed the five studied lakes are characterized by contrasted structure and composition of phytoplanktonic communities. These differences reveal contrasted functioning of the lakes' food webs; as a consequence, we can expect that the effect of forcing factors may lead to different types of responses according to the considered lake.

The major types of stressors that potentially combine to adversely affect lake biodiversity, functioning, and services include eutrophication, acidification, toxic pollution, climate change, and species introduction (among which fish, which are able to impact the structure and functioning of lake food webs via top-down effects). Even high altitude lakes long considered as pristine sanctuaries can be deeply impacted.

In the multi-stressors situation, this is a critical issue to get a better understanding and prediction of the response of the lake biodiversity and functioning to changing environment and climate.

<u>In prospect…</u>

The creation of a mountain lake observatory at the scale of the French Alps will be a priority to provide an evaluation and decision support tool to the management of protected areas. It will require a standardized monitoring of the lakes from the northern Alps to Corsica to have a set of data (physicochemical, biological…) which are consistent on the whole territory before extending them to other mountain ranges. Once validated and analyzed by scientists, the data will constitute a key component for sharing information between different stakeholders in the framework of this network.

The network will also allow the synergy between research and managers on identified studied sites.
The goal is both to detect modifications in the ecological state of lakes (modifications which could be linked to changes in "lake-uses" (tourism, fishing etc)) and progress on the understanding of specific ecological process in order to, *in fine*, apply the adapted remediation.

Conclusion

There is evidence that, in spite of their remote position, high-altitude Alpine lakes have undergone modifications triggered by human pressure. Multidisciplinary research can help to understand how the ecosystem responds to these multi-stressors conditions. Monitoring of a large number of mountain lakes and sharing the results within the network will also enable better protection and management of these habitats.

In the future, there is a need to better characterize the causes of changes observed in these lakes, through further investigation and coordination of specific research project.

Other scientists and/or protected areas managers working on or interested in the subject are kindly invited to contact us.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 65 - 70

Induction and Spread of a spruce bark beetle outbreak in the Wilderness Area Dürrenstein, Austria

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Abstract

Mass outbreaks of the spruce bark beetle (*Ips typographus*) currently represent the largest threat to spruce dominated forests in Central Europe. Besides the high reproductive capacity and the aggressiveness of the beetle itself, climatic conditions affect the number of possible generations per year, and thus the occurrence of high population densities of the insect. The aim of this study was to investigate the uninterrupted influence of microclimatic site and stand conditions on the dynamics of population densities of the spruce bark beetle in a valley end of the Wilderness Area Dürrenstein (IUCN Cat.1).

A retro perspective analysis of the areas infested by the beetle during the years 2003-2011 was done regarding climatic conditions (temperature, irradiation, and precipitation) as well as stand and site related predisposition factors. The results show that high amounts of trees killed by bark beetles only occurred after extreme events (e.g. avalanche or wind throw) and that there was no direct or delayed relationship between temperature conditions and new infestations. South facing slopes showed higher predisposition and were infested earlier than east, west or north facing slopes. The site variables geomorphology and snowbreakage, as well as the stand variables proportion of spruce, stand age and storm hazard were crucial for the study sites predisposition towards bark beetle infestations.

In 2012, spruce bark beetles marked with fluorescent powder were caught in pheromone traps to examine the beetles' dispersal (flight direction and distance). Most beetles were found in south-western direction and within 100 m (>50%), 93% within 500 m. Very few individuals (<0.2%) managed to fly over a 1500 m high mountain ridge and were found in pheromone traps up to 5 km away from their hatching site.

The areas predicted temperature increase of +1.1° to +2°C (2021-2050) and +3° to +3.9°C (2050-2071) will severely influence the development of *Ips typographus* from currently a univoltine development at higher elevations to a mulivoltine development in future. This may have a significant effect on beetle's population growth and trigger longer, more intense, and larger epidemics.

Keywords

Ips typographus, dispersal, voltinism, predisposition , protected area,

Introduction

Mass outbreaks of the spruce bark beetle (*Ips typographus*) currently represent the largest threat to spruce dominated forests in Central Europe. Besides the high reproductive capacity and the aggressiveness of the beetle itself, climatic conditions affect the number of possible generations per year, and thus the occurrence of high population densities of the insect.

The presence of large amounts of potential breeding materials are essential in order for mass outbreaks of the spruce bark beetle to occur and this often occurs after storms, snowbreakage or avalanche events. If these are followed by warm and dry weather conditions, a rapid population increase of the beetle can be triggered. Apart from the beetles' high reproductive capacity, climatic conditions mainly influence the development and the number of generations per year. In order to estimate the risk of bark beetle outbreaks and to initiate control measures in good time, it is necessary to have knowledge about the vulnerability of the stands and sites towards disturbances through extreme weather events (predisposition). It is also crucial to have knowledge on the possible numbers of beetle generations per year (voltinism of the beetle) as well as about their dispersal behaviour.

Without protective forestry measures mass outbreaks of the spruce bark beetle can lead to eruptive dimensions as can be seen upon the example of the Bavarian Forest National Park. Debates revolving around the conservation of natural heritage on the one hand and the protection of economically valuable natural resources on the other hand are ongoing in the Dürrenstein area and many other areas close to protected areas such as National Parks. Managers of adjacent forests are worried about possible "germ herds" which are harboured in the Wilderness and threaten to weaken or even destroy their harvest. It is extremely important to communicate and prove the real situation by means of thorough research. The unique study site in the Wilderness Area Dürrenstein enabled detailed research of an undisturbed bark beetle outbreak.

The aim of this study was to investigate the influence of microclimatic site and stand conditions on the population density, voltinism and dispersal behaviour of the spruce bark beetle *Ips typographus*. Initial predisposition of a secondary spruce forest was calculated and compared to the actually infested areas during a time period of nine years. Climate change scenarios were implemented upon the study area to simulate the possible development of the spruce bark beetle in the future.

Materials and methods

The research was carried out in a valley end of the Wilderness Area Dürrenstein (IUCN Cat.1) which is located in the eastern part of the northern limestone Alps, near to the border between the provinces Lower Austria and Styria. The area covers 2.400 ha and encloses the largest remainder of primary forest in Central Europe. A large area of the Wilderness Area also consists of secondary spruce forests which are slowly transforming naturally. In a valley end of one of these forests a bark beetle infestation, undisturbed by protective forestry measures, has been monitored since 2003. Storms, snowbreakage, as well as avalanche events have allowed massive amounts of potential breeding material to accumulate, giving a unique opportunity to survey the processes involved in the dynamics of a spruce bark beetle outbreak.

The spruce bark beetles dispersal was studied after infested logs (12x 1,5 m) had been covered with fluorescent powder in May, 2012 and emerging beetles marked themselves. A total of 23 pheromone traps were placed around the hatching site at distances between 50 m and 7 km. The traps were emptied at least once a week. The total number of caught beetles was assessed and marked beetles were determined by looking at the catches under UV light.

A camera (Type: AXIS – 1347, MP 5 Resolution), taking one photo per minute, was placed directly above the emerging site to monitor beetle activity. A climatic station located next to the emerging site recorded temperature, precipitation, wind direction and wind speed. The photo taken at noon each day was compared to the previous day's photo concerning general beetle activity, new boring holes, sawdust and out-boring beetles. Beetle activity was examined in accordance to temperatures, precipitation and wind speed during the beetles' potential swarming time. On behalf of the climatic data, the phenology model PHENIPS (BAIER et al. 2007) calculated *Ips typographus* developmental stages and enabled an insight into the beetles activities without being in the field.

The number of infested trees during the years 2003-2012 was analysed in accordance to the factors influencing the beetles' development (temperature, precipitation and potential breeding material through storms and avalanche events). The areas initial predisposition towards bark beetles was assessed by the Predisposition Assessment Model (PAS) (NETHERER & NOPP-MAYR 2005).

The regional climate models PROMES, RegCM3 and Aladin were used to simulate the potential voltinism of *Ips typoraphus* under changing climate conditions for the periods 2021-2050 and 2071-2100.

Results

A total of 1478 spruce bark beetles marked with fluorescent powder were caught in the eleven pheromone traps in the "Hundsau" area. This represents a capturing rate of approximately 22% of the emerged and marked beetles. More than 50% of all marked bark beetles were recaptured within a radius of 100 m from the emerging site, predominantly in south-western direction; 93% were recaptured within a radius of 500 m. Very few marked beetles (<0.2%) managed to overcome the height difference of 600-700 m and flew over the mountain ridge where they were trapped at distances up to 5 km from the emerging site (Figure 1).

Beetle activities were significantly correlated with diurnal mean and maximal temperatures and significantly negatively correlated with precipitation during potential swarming times in the afternoon. Wind speed had no direct effect on outboring activities.

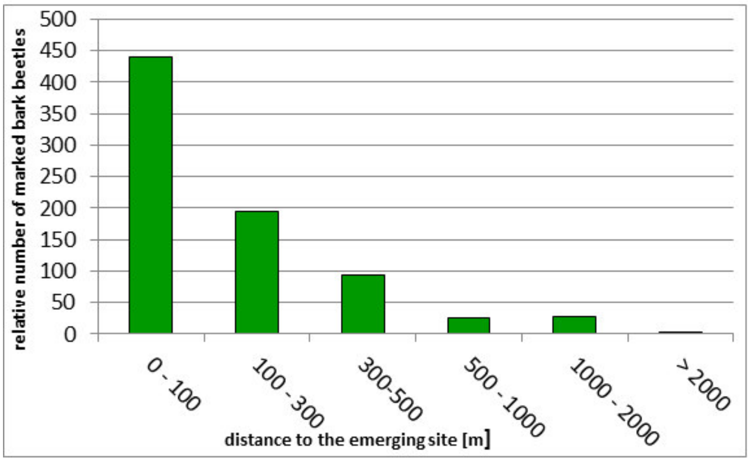

Figure 1: Distances of the pheromone traps to the emerging sites (m).

The results of the retrospective analysis show that high amounts of trees killed by bark beetles only occurred after extreme events such as the avalanche in 2009, after which massive amounts of potential breeding material was available. New infestations were mostly found within 500 m of preyear infestations. If precipitation in April was high, significantly fewer trees were infested in the course of the year. No direct or delayed relationship between temperature conditions during the vegetative period or the calculated number of potential generations and new infestations of trees was found. Even the exceptionally warm summer of 2003 did not result in a rise of the beetles' population density.

Of the 3788 examined grid cells, 4% were in the class with no predisposition, 10% were classified as low, 29% were classified as having moderate predisposition and 57% were classified as highly predisposed towards an attack by *I. typographus* (Figure 2).

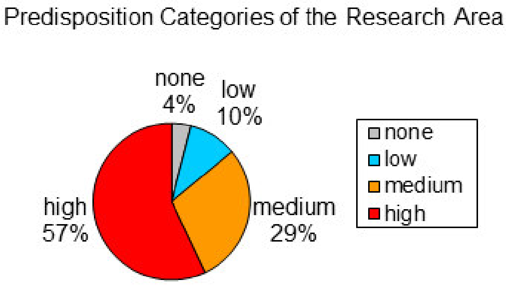

Figure 2: Percentages of predisposition categories in the research area

Of the total area of the Wilderness Area Dürrenstein the south facing slopes were in notably higher predisposition classes and were also preferably infested compared to north facing slopes. A rate of 11% of the 3788 grid cells (30x30m) were infested by the spruce bark beetle during the period between 2003- 2011. Grid cells were preferably infested where the predisposition model PAS calculated a high risk level due to high percentages of spruce trees (>50%), stand age (60-100 years), geological position (hill or mountaintop, middle slope) as well as high vulnerability towards storms and snow breakage (Figure 3).

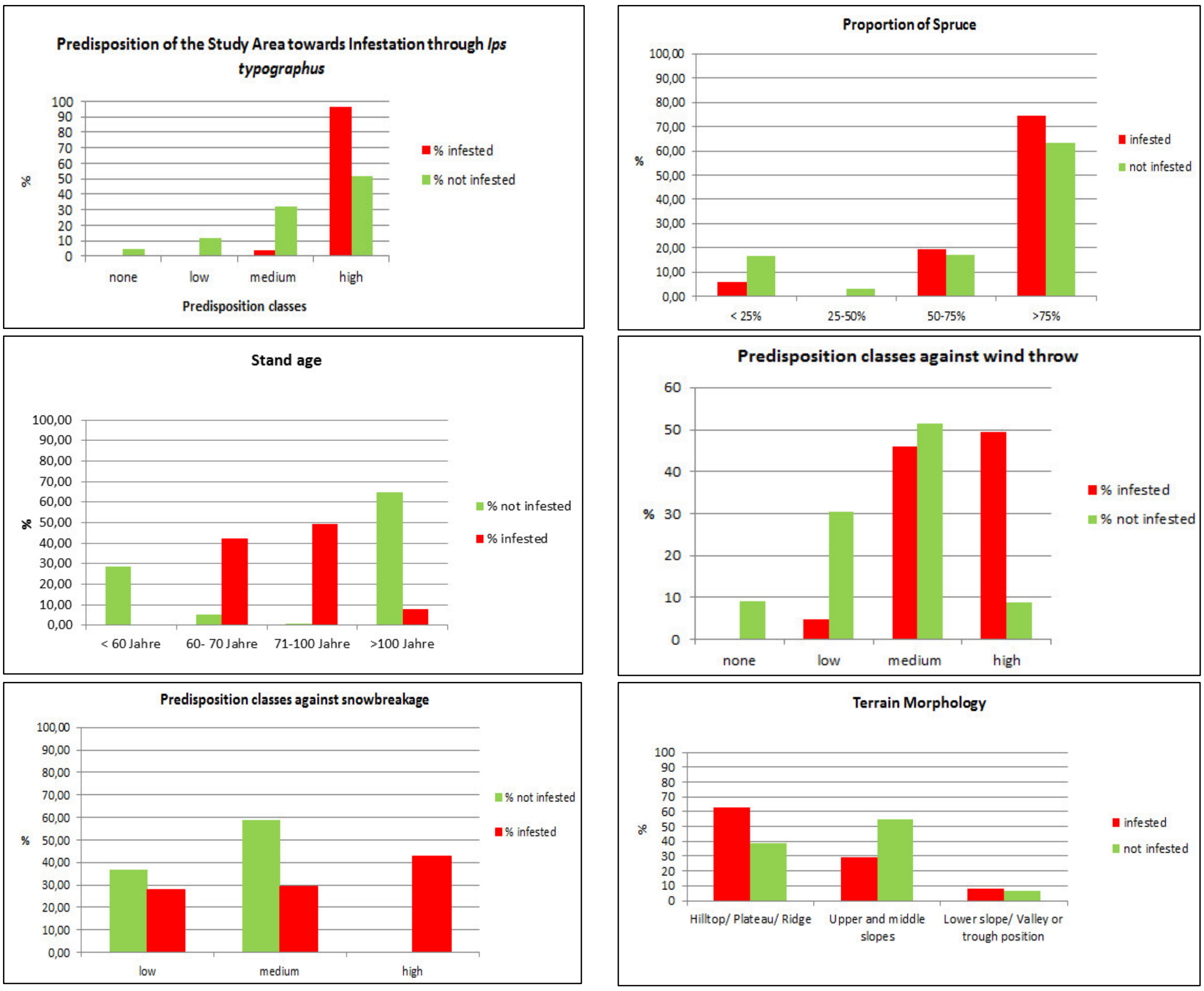

Figure 3: Relative percentages of infested and not infested grid cells in accordance to their predisposition towards infestation by *I. typographus*, proportion of spruce, stand age, terrain morphology as well as predisposition classes towards wind throw and snowbreakage.

Projected changes of mean air temperatures from April to October for the period 2021-2050 are most pronounced for RCM PROMES, intermediate for the model Aladin, and least for RegCM3. For the period 2071-2100 mean air temperature increases by 3.91°C and 3.04°C for the two RCMs Aladin and RegCM3. The comparison of the observed gridded mean temperature in 1991-2009 (present-day climate) with the climate normal period revealed an increase in air temperature of 0.92°C for the region Wildalpen/ Hochschwab. For the winter months December- February the model Aladin calculates a temperature increase of 1.22°C for 2021-2051 and 1.98°C for 2071-2100 (Table 1).

Table 1: Deviations between observed (E-OBS) and projected (RCMs Aladin, PROMES and RegCM3) mean air temperature and mean precipitation sum from April- October.

Differences of the mean temperatures from April - October (°C)			
	Mean	**Max.**	**Min.**
E-OBS (1991-2009) - (1961-1990)	**0,92**	**1,06**	**0,81**
Aladin (2021-2050) - (1961-1990)	**1,62**	1,70	1,56
PROMES (2021-2050) - (1961-1990)	**2,03**	2,05	2,00
RegCM3 (2021-2050) - (1961-1990)	**1,14**	1,15	1,12
Aladin (2071-2100) - (1961-1990)	**3,91**	4,00	3,81
RegCM3 (2071-2100) - (1961-1990)	**3,04**	3,07	2,98

The modell Aladin prognoses an increase of precipitation for 2021-2051 and a decrease for 2071-2100. The modell RegCM3 prognoses an increase for both time periods (Table 2).

Table 2: Differences between observed (E-OBS) and prognosed (Aladin, PROMES, RegCM3) precipitation rates during the winter months (December-Febuary).

Differences of the mean precipitation from April - October (%)			
	Mittel	**Max.**	**Min.**
Aladin (2021-2050) - (1971-1999)	**4,41**	5,72	3,05
RegCM3 (2021-2050) - (1971-1999)	**3,8**	5,02	3,2
Aladin (2071-2100) - (1971-1999)	**-8,94**	-7,31	-11,56
RegCM3 (2071-2100) - (1971-1999)	**3,29**	4,48	2,21

Calculations from the climate models indicate that the former predominately univoltine development of the spruce bark beetle will shift to bi-/multivoltine development. The inter-annual variability of successful established generations will also decrease. In comparison to the climate normal period, a change in potential as well as actual generation development can be detected.

Discussion

More than 50% of all marked and captured bark beetles were recaptured within a radius of 100 m from the emerging site. This finding corresponds with other recapture experiments such as ZUMR (1992). Most beetles were caught in south-western direction. Former studies assign tree exposition to the south and west to have higher attack probabilities (BLACKWELL 2011, LEXER 1995). Under epidemic conditions, 90% of new infestations are found to occur within 500 m of an old attack (WICHMANN & RAVN 2001, KAUTZ et al. 2011). This corresponds to the findings in our study, where 93% of the marked beetles were captured within a radius of 500 m. As only few beetles (<0.2%) managed to overcome the mountain ridge with the height difference of 600-700m, mountain ridges and valley ends can have a natural barrier effect.

The Predisposition Assessment Model (PAS) appears to be a reliable tool for assessing susceptibility towards bark beetles as 100% of the infested grid cells were in the medium or high predisposition class. A spruce percentage of over 50% is significantly correlated with infestation.

If the climate scenarios prove to be right, another shift towards multivoltine developments might take place. Together with increasing amounts of extreme weather events this can have significant effects on population growth and trigger longer, more intense, and larger epidemics (BAIER et al. 2011).

Conclusion

Using fluorescent powder to mark infested logs proved to be a good method of surveying *Ips typographus* flight dispersal. An undisturbed bark beetle infestation in a protected area does not necessarily pose a threat to adjacent managed forest stands as only 7% of the beetles flew further than 500 m and mountain ridges as well as valley ends can have a natural barrier effect. The predominant swarming direction as well as infestation direction of *I.*

typographus was south-west. The predisposition model PAS is a reliable tool for assessing susceptibility towards bark beetle attacks. If climate scenarios are correct then more intense, longer, and larger epidemics of the spruce bark beetle can be expected in future.

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Conference Volume	**5th Symposium for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 71 - 74

Destructive and constructive effects of mudflows – primary succession and success of pasture regeneration in the nature park Sölktäler (Styria, Austria)

A. Bohner, S. Winter, B. Kraml, W. Holzner

Abstract

In July 2010, several catastrophic mudflows devastated the mountain pastures in the nature park Sölktäler (Styria, Austria). From a nature conservation point of view, mudflows are natural processes that create pioneer habitats. Therefore restoration measures should be avoided in protected areas. On the other hand, mudflows are natural disasters that lead to the devastation of agricultural land. From an agricultural point of view, rapid re-vegetation measures are necessary. As such, there are conflicting interests concerning re-establishment of vegetation in protected areas. Our study was aimed at assessing the initial vegetation development on sown and on untouched (= not sown) erosional and depositional sites both from a nature conservation and an agricultural perspective. For this investigation 59 permanent plots on untouched and 52 permanent plots on sown sites were established in 2011 and 2012. Results show that the natural regeneration of vegetation on humus-free sites is a slow and long-term process due to the extreme abiotic conditions of the site. In an early stage of primary succession the vegetation is, with a few exceptions, characterized by a low vascular plant species richness. Re-vegetation measures using commercial seed mixtures accelerate grassland re-establishment, leading to a species-poor plant community which is dominated by a few sown grass species and legumes. The effects of different restoration measures (liming, application of straw or farmyard manure) on vegetation are discussed in this article.

Keywords

Mountain pastures, pioneer habitats, plant species richness, re-vegetation measures, seed mixture

Mountain pasture heavily affected by the mudflow with massive layers of deposited timber (S. Winter)

Introduction

Mudflows are a common natural phenomenon in mountainous regions world-wide. They are induced by heavy rainstorms or continual rainfall. Mudflows are easily triggered on steep slopes if the soils are water-saturated. Climate change may lead to more frequent heavy rainfall events (Berg et al. 2013). Thus, in mountainous regions the risk of mudflows might increase.

From a nature conservation point of view, mudflows are natural geomorphic processes which create pioneer habitats. Mudflows modify existing landforms through the formation of erosional and depositional zones and thus they increase habitat diversity. Hence in protected areas mudflows should be regarded as a natural process and, therefore, restoration measures should be avoided. On the other hand, mudflows are natural disasters that cause heavy damage to buildings and infrastructure and devastate agricultural land. From an agricultural point of view, re-vegetation measures on heavily disturbed sites are necessary. Thus in protected areas there are conflicting interests concerning re-establishment of vegetation following mudslides.

Today, natural initial ecosystem development can rarely be observed in Central Europe (SCHAAF et al. 2011). Therefore from a scientific point of view mudflows present a great opportunity to study ecosystem development and primary succession from the initial stage.

In July 2010, due to heavy rainfall (120 mm in 3 hours) several catastrophic mudflows led to the devastation of mountain pastures in the nature park Sölktäler. Large areas (220 hectares) of grasslands were covered with mudflow deposits in the valley Schwarzenseetal. Fortunately, the disastrous mudflows did not result in any injuries, but produced substantial damage to roads and bridges. Immediately after this natural disaster 150 hectares of mountain pasture with no or sparse vegetation cover was re-vegetated since pasture was needed for livestock. In order to minimize costs a commercial seed mixture was used. The seed mixture (HR 260) contained the following 11 species: *Trifolium repens, T. hybridum, Lotus corniculatus, Poa pratensis, Festuca rubra, F. pratensis, Phleum pratense, Dactylis glomerata, Lolium perenne, Agrostis capillaris* and *Cynosurus cristatus* (for details see www.hesa.co.at). In addition lime, straw or farmyard manure was applied on some sown areas. The remaining areas of destroyed grasslands, especially areas next to the stream (Schwarzenbach) and on very steep slopes were left to natural succession. Despite of re-vegetation measures, the forage yield of mountain pastures is much lower than before the natural disaster two years ago. So far, the number of livestock has had to be reduced by 40 %.

The aims of our study were:

- documentation, analysis and evaluation of the initial vegetation development on sown and on untouched erosional and depositional zones,
- assessment of the nature conservation and agricultural value of different re-vegetation measures and
- analysis of the potential of plant species to invade the neighboring sown sites from undisturbed sites.

Study Area

The study area is situated in the nature park Sölktäler and in the Natura 2000 Special Area of Conservation "Niedere Tauern" in the northwestern part of the federal state Styria, Austria (47° N, 13° E). The valley where several mudflows occurred, is roughly north to south oriented. The highest mountain peaks extend up to 2,500 m. The entire park area was glaciated during the Pleistocene, resulting in U-shaped valleys with steep slopes. This topographic condition provides optimum terrain for the development and occurrence of mudflows. The bedrock in the study area consists of different types of gneiss (FLÜGEL & NEUBAUER 1984). Glacial and alluvial sediments are prevalent on the valley floor. The climate can be classified as sub-oceanic: the mean annual precipitation exceeds 1,100 mm and the mean annual air temperature is approximately 5.8°C, varying from -2.6 °C in January to 14.6 °C in July. The growing season is relatively short due to the long snow cover, lasting 106 days a year on average. Thunderstorms mainly occur from May to September, also representing the period with peak precipitation (ZAMG 2002). In the study area, the most widespread soil types on freely drained sites are carbonate-free, acid, nutrient-poor Leptosols (Rankers) and Cambisols with a loamy sand texture. The grassland is primarily utilized as pasture during the summer season. The pastures which were devastated by mudflows, are grazed by cattle. The few meadows on the valley floor are cut once a year and are occasionally fertilized with farmyard manure. The pastures are mainly covered with a *Homogyno alpinae-Nardetum* community (*Nardo-Agrostion tenuis* alliance) and the meadows with a *Festuca rubra-Agrostis capillaris* community (*Polygono-Trisetion* alliance). *Picea abies-Abies alba* communities represent the potential natural vegetation in the montane belt. The riparian forest vegetation on the valley floor belongs to the *Alnus incana* community.

Methods

We established 59 permanent plots on untouched sites in 2011 and 2012 and 52 permanent plots on freshly sown sites in 2012. All plots were located in the montane belt (1,000 to 1,300 m a. s. l.). Slope angle varied from 0° on the valley floor to more than 30° on slopes mainly exposed to west or east. All permanent plots on freshly sown sites had the same plot size of 16 m^2 and were largely homogenous concerning topography and debris accumulation. The size of the permanent plots on untouched sites varied from 16 to 36 m^2 due to the different size of the newly established sand or gravel banks. Each plot was permanently marked with large metal nails or hard-rubber pegs (depending on the substrate) that were inserted at two opposite corners of the plots. In addition, we recorded the geographical position in the center of each permanent plot with a GPS device and made photo documentation. In 2011 and 2012, vegetation surveys were carried out at each plot using the methods of BRAUN-BLANQUET (1932) with a modified scale. Furthermore, total vegetation cover, bryophyte cover, cover of species groups (grasses, herbs, legumes), cover of straw layer and type of substrate were recorded. The nomenclature of vascular plant species follows that of FISCHER et al. (2008).

Results and Discussion

Mudflows create new, more or less humus- and vegetation-free surfaces through removal of the humus-rich topsoil. In the study area, mudflow deposits are a mixture of unconsolidated siliceous debris of different grain size. The fine earth fraction is very low at most sites. Both the erosional and depositional areas created by mudflows are characterized by a very low availability of plant nutrients in the almost humus-free substrate, resulting in extreme abiotic site conditions.

The freshly sown and untouched sites differed considerably with regards to total vegetation cover, plant species composition and physiognomy. In the second year following re-vegetation measures, the range of total vegetation cover was between 5 and 90 % (mean: 49 %), mainly depending on the substrate type. On areas with a particularly high content of coarse fragments, re-vegetation measures were less successful than on areas with a higher content of fine-textured substrate. The mean coverage of grasses, herbs and legumes was 56 %, 1 % and 43 %, respectively. Bryophyte cover averaged 4 % (minimum: 1 %, maximum: 20 %). The average number of vascular plant species within a plot size of 16 m^2 was 22 (minimum: 11, maximum: 43).

The vegetation was frequently dominated by *Festuca rubra*, *Agrostis capillaris* and/or *Trifolium repens*. Either *F. rubra* or *A. capillaris* were the dominant grass species. Both species are typical of moderately nutrient-poor soils. *F. rubra* has a wide ecological amplitude and is therefore a successful colonizer in many different habitat types. *Trifolium hybridum*, *Lotus corniculatus*, *Festuca pratensis*, *Phleum pratense*, *Dactylis glomerata*, *Lolium perenne* and *Cynosurus cristatus* were also abundant. All these established species were present in the commercial seed mixture. Among the sown species, only *Poa pratensis* did not establish very successfully so far. The absence of *P. pratensis* on many sown plots can be explained mainly by the slow germination rate of its seeds.

On many sown areas, the cover of nitrogen-fixing legumes was exceptionally high. *T. repens* was often the dominant legume. T. *hybridum* and *L. corniculatus* also reached a relatively high cover. *T. repens* is characteristic of intensively used grasslands, whereas *L. corniculatus* is a typical species of extensively used grasslands, indicating base-rich, nutrient-poor soils. *T. hybridum* naturally occurs in wet meadows. Obviously, the lack of humus causes a nitrogen deficiency in the mudflow deposits, which in turn limits the growth of some grass species, particularly *L. perenne* and tall grasses such as *D. glomerata*, *F. pratensis* and *P. pratense* did not grow vigorously. Since legumes are almost independent of the nitrogen supply from the substrate (LLOYD & PIGOTT 1967), they achieved high cover on many sown areas, gradually increasing the nitrogen content in these nitrogen-limited ecosystems. Low-intensity cattle grazing is a suitable measure to reduce the dominance of *T. hybridum*, which in turn provides opportunities for the successful establishment of plant species from the local species pool.

Up to now, only a few non-sown species were able to invade the freshly sown areas. Herbs were underrepresented in the early stage of grassland re-establishment. The majority of the invaders were common and widely distributed grassland and forest species. Tree seedlings, particularly of *Acer pseudoplatanus*, and shrubs (e. g. *Alnus alnobetula*, *Salix myrsinifolia*) were also recorded. On some sown areas, wetland species were present. Furthermore, a few individuals of “weeds” originating from the seed mixture appeared. Some of these are rare and endangered plant species (e. g. *Cyanus segetum*).

A comparison of the floristic similarity of the sown vegetation with that of the surrounding untouched grasslands indicates a low nature conservation value of the sown vegetation, at least in an early stage of grassland re-establishment. The pastures of the *Homogyno alpinae-Nardetum* community are dominated by *Nardus stricta* and harbour approximately 48 vascular plant species within an area of approximately 40 m^2 (WINTER 2005)

In the second year after application, cover of straw layer ranged from 10 to 80 % (mean: 47 %), indicating a very slow decomposition rate resulting from low microbial activity. The effect of straw application on vegetation development was quite low. Presumably, due to the addition of straw some cereals such as barley or triticale and a few weeds appeared. Obviously, certain weed species are also dispersed by straw, increasing species richness on some sites for a short time. On the other hand, a thick straw layer generally prevents both sown and non-sown species from germinating and establishing. Furthermore, due to a wide C:N ratio the addition of straw presumably increases nitrogen deficiency in the substrate. Therefore, straw application to nitrogen-limited ecosystems such as mudflow deposits should be avoided.

The application of farmyard manure to sown areas increased total vegetation cover. Obviously, on bare surfaces a continuous addition of organic matter is of utmost importance for the improvement of environmental conditions, which in turn enhances plant productivity and consequently accelerates initial soil formation. Up to now, liming showed no effect on total vegetation cover, cover of species groups and plant species composition, possibly because nitrogen deficiency in the substrate is the major factor limiting plant growth.

With few exceptions, the current successional stage on the not-sown sites is characterized by a low total vegetation cover. The extreme abiotic site conditions may be responsible for the slow primary succession, whereas competition was not relevant because of the low above- and below-ground phytomass. Some of the present species were typical pioneer plants. Up to now, many of the characteristic species of the surrounding *Homogyno alpinae-Nardetum* community did not establish. Their absence may be linked to their inability to grow on humus-free bare surfaces. In all permanent plots invasive neophytes were missing.

Species diversity at the untouched sites ranged from zero at newly established gravel river banks to 65 at a sandy river bank with dominant *Juncus articulatus* adjacent to a large area covered by a massive layer of deposited timber. Mean species richness was 36 excluding the “zero-plots” with no vegetation. The vegetation was a mixture of species from the mountain pastures, pioneer plants and plants from the riparian forest vegetation (*Alnus incana* forest). The pasture plants have either been swept to these newly established sites or survived at small elevated patches, and where not buried below sand or scree. Sometimes even species from the seed mixture like *T. hybridum* have been swept to the untouched sites. Vegetation cover varied from 0 to 100 %, with a mean of 33 % (without the “zero-plots”) and bryophyte cover ranged from 0 to 50 %, with a mean of 11 %. The most common species were *Agrostis capillaris*, *Festuca rubra* agg., *Trifolium repens*, *Ranunculus repens*, *Trifolium pratense*, *Potentilla erecta*, *Lotus corniculatus*, *Achillea millefolium* and *Juncus articulatus*. These species are also common at the mountain pastures; *R. repens* and *J. articulatus* prefer wetter areas alongside the stream. Most of the species are of low nature conservation value as they are common species of the mountain pastures and the riparian forest vegetation. However, these pioneer habitats may be valuable for a range of species (especially animals) that prefer or depend on open areas.

Conclusion

In protected areas, there exist different opinions regarding the decision if re-vegetation measures are necessary. If the rapid re-establishment of pastures is the key goal, re-vegetation measures with site-adapted seed mixtures and farmyard manure applications are necessary for long-term success. In an early stage of grassland re-establishment liming is not necessary and the addition of straw to bare surfaces should be avoided. Extensive cattle grazing on mountain pastures is recommendable if wetlands and areas alongside the river are excluded.

If, on the other hand a high habitat and plant community diversity is the key goal, restoration measures should be avoided. However, one must consider that natural re-vegetation on bare surfaces is a slow process. If the total area of devastated grasslands is small, addition of hay with viable seeds from species of the local flora or transplantation of sods from the surrounding species-rich grasslands may possibly accelerate primary succession in a conservation-friendly manner.

Our findings are representative for siliceous sites in the montane belt of the nature park Sölktäler. Further systematic studies on primary succession and re-vegetation measures in different areas, at different altitudes and on different substrate types are necessary for a more comprehensive evaluation of the initial vegetation development on areas devastated by mudflows. It must be emphasized that our study has been restricted to two years. In addition, the permanent plots next to the stream have been flooded again after the mudflow; these sites are characterized by frequent disturbances. In order to assess the success of different re-vegetation measures more precisely, long-term investigations are necessary. Nevertheless, our preliminary findings can be used for optimizing re-vegetation measures at similar sites both from a nature-conservation and an agricultural point of view.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 75 - 76

Organization of Environmental Monitoring in Protected Areas

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Summary

Based on the literature analysis and our elaborations we suggest new principles of the environment state control as exemplified by the Middle Urals, Russia. We have chosen objects of studies and suggest for usage in protected areas a complex of standard methods for the laying sampling and discount sites, obligatory standard methods of observations, typical forms for the environment account based on the obtained results.

Keywords
monitoring, natural environment, bioindicators, plant communities

The Ural mountain system is 40 to 130 km broad and is stretched over 2000 km from the Karsk sea in the North to the middle stream of the Ural river in the South. It includes the main water-parting and several side ridges. The Urals are subdivided into the Polar, Subpolar, Northern, Middle and Southern Urals. Its foothills on the West and East are called the Preurals and Transurals, accordingly. The demarcation line between Europe and Asia is the eastern slope of the main water-parting ridge. The Urals are remarkable for their diverse natural conditions: goltsy barrens and tundras, various forests from pretundra to steppe kolkas, vast steppes.

In the Middle Urals (Sverdlovsk region, Russia) there are 5 vegetation complexes: 1-mountain tundra, 2- open woodland crooked forest, 3- mountain taiga (mild mountain complex), 4- foothill taiga (low mountain foothill complex), 5- valley taiga (foothill valley complex). The last three vegetation complexes predominating in the mountain landscapes are the most anthropogenously affected ones, therefore, they require a special attention to their state, assessment of changes, protection and recovery, if necessary.

The Middle Urals have a long (over 300 years) history of economic (primarily industrial) development; therefore monitoring effect on all their natural complexes is very important (BOLSHAKOV et al. 2009). To protect natural complexes in the Middle Urals a network of protected natural areas at various levels - from the UNESCO biosphere reserve "Visimsky" 335000 ha in area to small genetic reserves – landscape, mineralogical, hydrological, etc., natural parks, park forests.

The conception has been elaborated in the Institute of Plant & Animal Ecology (Russ. Acad. Sci. Branch), the project being ordered by the Ministry of Natural Resources and Ecology of Sverdlovsk region. According to this conception vast protected areas should be equally distributed in the region and be connected with each other by natural corridors, should include all ecosystems, unique natural features, cultural and historic sites; traditional nature management should be considered. Within the framework of this conception to preserve unique and typical natural complexes natural parks, forest parks, landscape, biological and hidrological reserves should be protected areas. The basic areas for the organization of the environment monitoring are natural parks "Olenji Ruchji" (23.200 ha), "The Chusovaya River" (77146 ha), "Bazhovsky Mesta" (39938 ha) and the natural mineralogical park "Rezhevsky" (32300 ha).

Presently natural areas of preferential protection of various levels occupy 1 367 377 666 ha, or 7.04% of the region area. Principles of monitoring the main ecosystem components in the protected areas are suggested, the choice of monitoring sites is substantiated, standard methods for discount site laying and observations are developed.

Usage of bioindicators for the assessment of the state of natural complexes has allowed to estimate long-term trends and the buffer ability of the biosystems to resist various disturbing factors most frequently affecting simultaneously. The state of three main blocks of biocoenotic components are monitored - producers, consumers and reducers – is observed, as each of them is equally responsible for the resistance of the biocoenosis to external factors. (KUZNETSOVA et al. 2012).

For plant communities, a special attention is paid to vascular plants: community composition, basic dynamic indices (projective cover degree, plant viability, presence of synanthropic species, etc.) on the stationary test sites are reported.

In conditions of strictly regulated moderate land use the state of the vegetation cover is stable. In case of increased anthropic load (including recreation) synanthropization increases. Its forms may be diverse: introduction of synanthropic species into the plant community, replacement of the natural plant communities with secondary or synanthropic ones, decreased species diversity, structure simplification, lower productivuty of plant communities (GORCHAKOVSKY 1984). Such negative changes in communities have been noticed in regularly visited places in protected areas. The man-made transformation is evaluated as strong or very strong: plant communities are suppressed, the total projective cover does not exceed 30%, in some cases – 20-25%, the rest is trampled down, the vegetation cover is low. The percentage of synanthropic species is up to 50% from the total number of species. Totally up to 50 species of vascular plants of 45 genera and 23 families are represented in the studied plant communities. The identified indicator species of synanthropization are *Amoria repens (L.) C.Persl, Poa anua L., Plantago major L., Polygonum aviculare L.*

In the kingdom of animals bioindicators are water invertebrates, hill ant of the genus Formica, ornitocomplex. Studies of the state of hill ants have revealed trends common for all investigated areas. In the control zones family and superfamily structures of ants reach maximum development. Conditions of moderate recreation are also favorable for ants.

The state of communities of wood destructing basidial fungi has also been investigated. Their high sensitivity to climate and man made changes is used as “a test system” of the tree stand state. To register climatic and weather peculiarities during the period of studies the main phenological indices are marked, the primary dendroclimatic analysis is made.

The ecological state of the investigated river sites is estimated from zoobentos indices widely used in hydrobiology.

As an indicator in monitoring ornitocomplex reveals the anthropic effect degree in a vast area – in the whole protected area, as the disturbed sites are usually small and the damage cannot be adequately estimated. Bird species composition and the relation between various species numbers is an adequate index of the biota state.

The results of studies have shown a satisfactory state of the nature complexes: disturbance caused by recreation load does not reach critical values. The vegetation cover suffers most of all: transformation degrees of sites affected by recreation are moderate to very strong.

Forest sites with a strong recreation load have a trend common for all protected areas: species number and diversity decrease, generative and competitive activities of forest-destructing fungi are suppressed.

In all protected areas rivers are not polluted as evidenced by the macozoobentos state. The state of the indicator-hill ants- is stable in the investigated projected areas. The anthropic effect- thinning of the tree stand as a result of cutting- has provoked ant settling in new places. Ornitocomplexes are slightly disturbed communities in all investigated areas.

The obtained data and further investigations of the state of indicator objects and of the character and degree of changes at the early transformation stage caused by human activity will reveal natural dynamics in the state of undisturbed natural complexes, the character and degree of the anthropic effect on recreation sites in protected areas.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 77 - 84

Protected areas in Columbia – on track to sustainable development?

Axel Borsdorf & Carla Marchant

Abstract

On the way to sustainability the Colombian biosphere reserves, national parks and protected areas of civil society have changed their main goals from conservation to establishing regions of sustainable development. On the basis of studies in the southern and northern Colombian mountain ranges, this paper evaluates the concepts, strategies and measures in terms of the livelihood approach. The objective is to analyse if organic farming, tourism or export of cash crops can diminish the vulnerability of ecosystems and people. It becomes clear that only small-scale tourism (eco-tourism and farm tourism) may be regarded as sustainable solutions if they respect and enhance the livelihood of the people.

Keywords

sustainable development, livelihood, tourism, subsistence, coffee, Sierra Nevada de Santa Marta, Cinturón Andino, Colombia

Introduction

Biosphere reserves (BRs) are conceived as 'model regions of sustainable development' (LANGE 2005). Below we evaluate the development paths of Colombian protected areas in terms of how they adapt to global change by utilizing their opportunities and eliminating hazards and in how far they are capable of setting sustainable developments in train. The possibilities for adaptation are many and varied. They can add value to secure subsistence, to develop tourism or to emphasize exports. We chose protected areas with different legal status (BRs, national parks (NPs) and protected areas of civil society), different exposure to climate change (varying elevations) and different adaptation responses to globalization.

From this emerge the following questions:

Which challenges must be met to reduce vulnerability, promote resilience and attain sustainability?

Can tourism in Colombian protected areas be run on sustainable principles? What is the value of incorporating farmers in ecotourism (Asofintur) proposals?

Can Colombian coffee plantations be run sustainable in the face of world market requirements? How important is the size of the enterprise?

Can organic farming and the formation of associations secure livelihoods sustainably and contribute to stabilizing the ecosystems?

Study area

For our study we chose Cinturón Andino BR and Sierra Nevada de Santa Marta BR. In 1979 UNESCO recognized the Cinturón Andino and the Sierra Nevada de Santa Marta as BRs. Cinturón Andino is located in the *Macizo Colombiano* and includes three NPs (Nevado de Huila, Puracé and Cueva de los Guacharos) with a total area of 855,000 ha (Figure 1). The highest elevation is the Nevado de Huilo with 5750 m. It includes a variety of geological formations, volcanic craters, mountain lakes, waterfalls, hot springs, fumaroles, sulfatares (BORSDORF et al. 2011).

Sierra Nevada de Santa Marta BR covers 2.1 million ha and includes the territory of Tayrona NP (56,250 ha) and Sierra Nevada de Santa Marta NP (675,000 ha), which is the highest coastal mountain range in the world (the summits of Cristóbal Colón and Simón Bolívar reach 5775 m). From coast to glacier it includes all altitudinal zones of the tropical climate (Figure 2) and of tropical vegetation (TRIBIN et al. 1999: 14, 18).

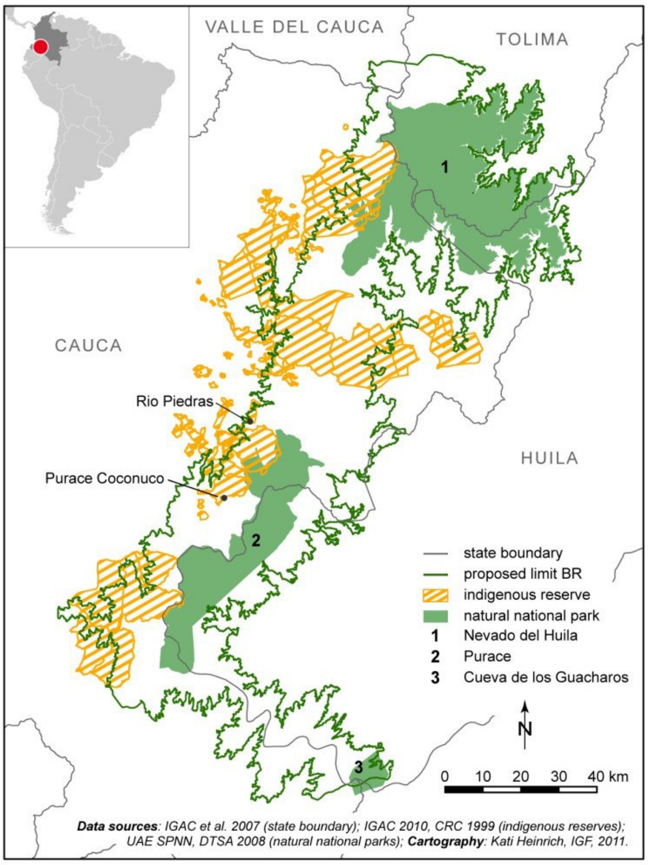

Figure 1: Cinturón BR, Southern Colombia

The BR also includes various protected areas of civil society, of which we selected the protective corridor of Rio Toribio as a case in point. It covers ca. 20.000 ha and is designed to protect the habitat of rare and endangered birds (STREWE 2005) as well as the mountain landscape, plus encouraging sustainable development for small farmers (WÜST 2006). It stretches from the headwaters of the river on the San Lorenzo ridge (3.000 m) to its estuary on the Caribbean Sea west of Santa Marta.

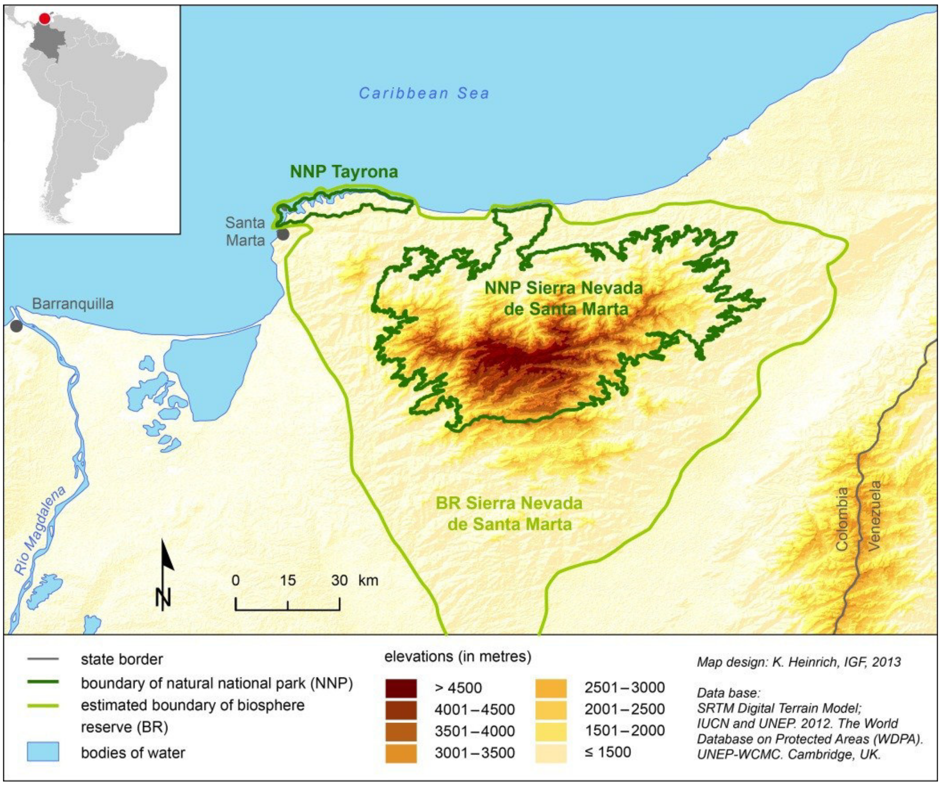

Figure 2: Sierra Nevada de Santa Marta

Theoretical framework

The livelihood approach is an analytical framework that aims to make livelihood systems more sustainable and less vulnerable: "A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base." (CHAMBERS & CONWAY 1991).

The framework (Figure 3) attempts to present the interdependencies of assets, framework conditions and livelihood outcomes. RAUCH (2009) describes the framework thus: "The livelihood framework adheres to the logic that people will react to environmental conditions with strategies for action that make use of their potentials and take into account the framework conditions, all aimed at attaining secure living conditions."

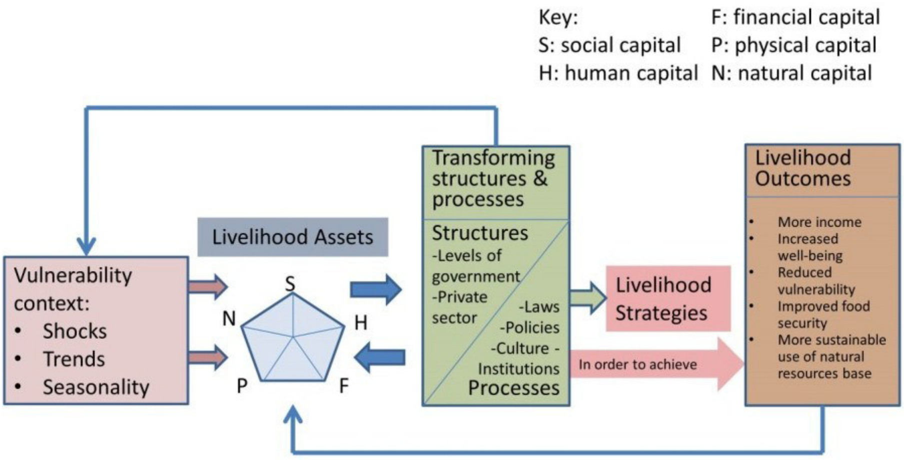

Figure 3: The sustainable livelihood framework (DFID 1999a), modified.

Central element of the framework is an analysis of the livelihood assets, shown here as a pentagon (Figure 3). They are made up of human capital (knowledge, skills, capabilities, health), social capital (social networks, social security systems), physical capital (infrastructure, means of production, transport), financial capital (savings, access to loans) and natural capital (soil, climate, water; ASHLEY & CARNEY 1999).

Methods

Diverse methods were used in this study. The captured data were integrated using a triangulation of methods to mitigate the weaknesses of one method with the strengths of another (Figure 4).

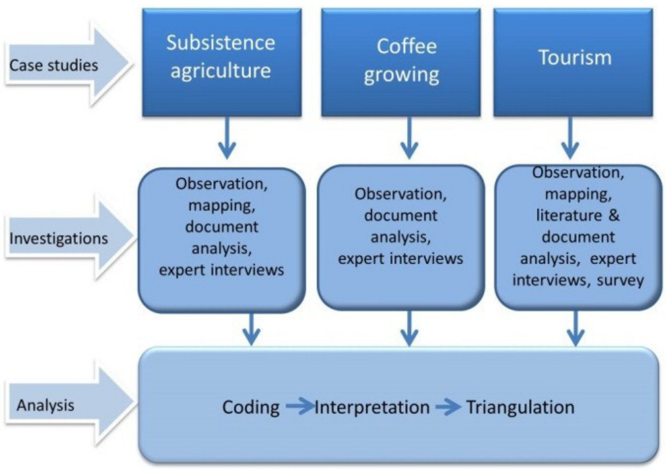

Figure 4: Methodology

State of the art

UNESCO BRs (LANGE 2005) modified their objectives with the introduction of the Seville Strategy (1995) and the Madrid Plan (2008). In Seville demands were made for zoning and for concrete development measures, in Madrid it was decided to include urbanized regions. In Colombia other protected areas exist besides BRs. The most important are the NPs, which fulfil the IUCN categories (DUDLEY 2008), and the protected areas of the civil society, which are run by private individuals or by NGOs (MCNEELY 1999).

Issues of tropical agriculture were first presented in aggregated form by MANSHARD (1968). In this context, subsistence economy plays an important role (WERLHOF et al. 2003). In many Colombian protected areas *campesinos* and *indígenas* still practice this form of economic activity, which aims for self-sufficiency with only marginal involvement in the market (BORSDORF et al. 2013). In these and other protected areas, however, you can also find strategies of tourism development (SCHUNCK 2009) and of exporting agricultural products.

This is especially true of coffee export. Coffee as cash crop has undergone dramatic changes in recent decades, triggered by the development of new hybrid varieties (BORSDORF 2006) and the emergence of new producing countries in Asia, as well as by changes in consumer behaviour and new marketing strategies of the coffee roasters in industrial countries (high-pressure devices, coffee capsules). To compete better, the *Federación Nacional de Cafeteros* has switched Colombian coffee production completely to the new hybrid varieties. RAPPOLE et al. (2003) have compared and discussed the pros and cons of shade-grown vs. sun-grown coffee.

Results

Case study Cinturón Andino

The results of this study have already been published (BORSDORF et al. 2011). Here we only discuss the livelihood assets of subsistence farming *campesinos* in the Asocampo cooperative in the Río Piedras region. Jointly they try to face the challenges of climate change by organic farming, bioengineering and education. The natural (NC), social (SC) and human capital (HC) of the region is high. Fertile soils, abundant water, the (normally) good climate conditions and the variety of possible agricultural products across the different elevation levels provide a favourable basis for agriculture. Local expertise and openness for innovations form an important basis for future developments. Social and economic networks (*cabildos*, cooperatives) increase the strengths of the region. Music bands enhance social contacts. However, financial capital (FC) is precarious (state subsidies, low capital in the *fincas*) and physical capital is reduced to land ownership, the farms and their livestock. Thus the livelihood pentagon is reduce to only three pillars, i.e. the natural, social and human capital, of which the natural capital is vulnerable to climate change effects (Figure 5).

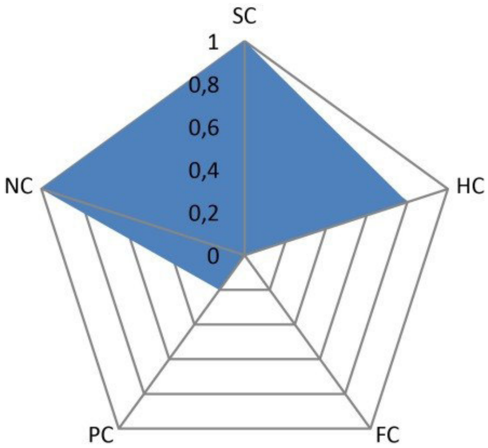

Figure 5: Livelihood assets in the Río Piedras region, Cinturón Andino BR

Case study coffee-growing Hacienda La Victoria

Today the whole area of the Hacienda la Victoria, founded in 1892, covers 800 ha in the *tierra templada* and the *tierra fría* of the Sierra Nevada de Santa Marta. 400 ha of it are protected forests (*reserva forestal*). At elevations between 800 m and 1450 m, Arabica and hybrid varieties like Castilla, Caturra and Colombia are grown. Most of the coffee, including the hybrid varieties, is grown under the canopy of other trees.

Despite good basic conditions for coffee growing, some fertilization is necessary, but no pesticides or artificial fertilizers are used. Hybrid varieties grown as monoculture without shading trees need regular applications of fertilizer. The tropical soil cannot hold the nutrients due to its low capacity for exchange. In shade-grown cultures this deficit is mitigated by the large quantities of leaf fall of the shading trees. The nutrients remain in the topsoil and reach the coffee plants via mycorrhizae. The plants are doused with a concoction that is rich in microorganisms, both to supply the plants with nutrients and to ward off diseases. In addition, a mixture of earthworms and the hulls of the coffee cherries is spread on the ground and contributes to a closed nutrient cycle.

Currently all the coffee produced at the hacienda is exported to Europe via one large customer. The plan for the future is to market the coffee via e-commerce, work on the marketing is under way.

Figure 6 shows that La Victoria has good natural capital that is not diminishing. The human capital is very good, given the experience of the owner, similarly to the social capital. The workers are well cared for and conflicts with guerrillas and paramilitaries have ceased. The physical capital is old but still functions well and is suitable for producing high-quality coffee. The only vulnerability of the system and the people involved stems from the lack of financial capital. Direct marketing to Europe is a step in the right direction.

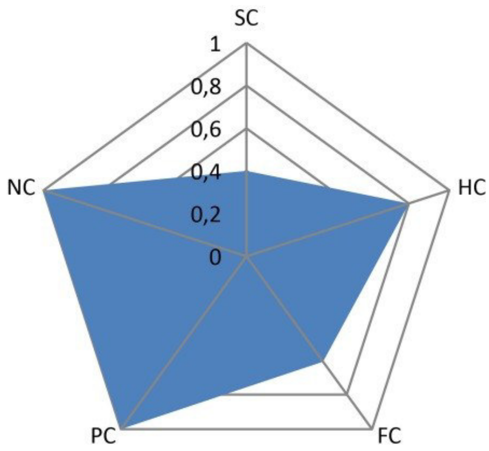

Figure 6: Livelihood assets of Hacienda La Victoria

<u>Case study tourism</u>

The most important region for tourism in Colombia is the Caribbean. Visitor numbers for the NPs make the value of tourism for the study areas clear. In 2011 Tayrona NP had a total of 241,460 visitors, while Sierra Nevada de Santa Marta NP has hardly been touched by tourism. Only 325 visitors were counted there in 2011 (Ministerio de Ambiente y Desarollo Sostenibilidad 2011). This puts the overall number of visitors for the BR at almost 242,000.

Colombia focuses on ecotourism to promote sustainable development. One way of achieving this is the association of several farmers in cooperatives with a joint range of ecotourism offers. The *Asoción de Fincas Turísticas* (ASOFINTUR) is such a cooperative in the study area.

Surveys of tourists and tourism experts have shown that substantial improvements in information policy are necessary if the park is to fulfil its education mission. To a degree this is already happening in the eleven *fincas* affiliated to ASOFINTUR (Figure 7). In addition to the accommodation, they offer low impact activities such as horse riding, walking or mountain biking. Such additional income strengthens the financial capital of the *fincas*. Average stay of the mostly foreign visitors is between 14 and 30 days.

Figure 7: Location of the *fincas* affiliated to ASOFINTUR.

Tourism in the BR does not adequately strengthen the physical and financial capital because it is too small, particularly in the mountains. Nor is it easy on the valuable natural capital, except on the ASOFINTUR *fincas*. Given the low visitor numbers, this is not yet a problem. The human capital with extensive local knowledge is not being leveraged and the social capital is only strengthened at ASOFINTUR (Figure 8). Tourism does not fulfil the criteria of sustainability unless great improvements are made in information policy, cooperation of the stakeholders and environment-friendly tourist infrastructure.

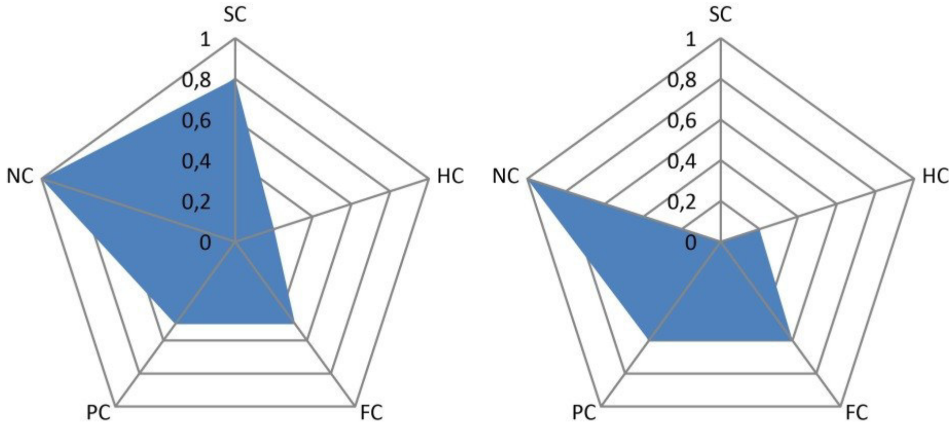

Figure 8 a & b: Livelihood assets in tourism at Sierra Nevada de Santa Marta,
left: coast, right: ASOFINTUR

Case study protective corridor Río Toribio

In the hydrographical basin of the Río Toribio tourism plays only a subordinate role. In our study we analysed the Finca La Cumbre and the Finca Vega as typical examples (Figure 9). La Cumbre has 62.5 ha land, of which 30.5 ha are used as pasture, the remainder is natural forest reserved as bird sanctuary. In terms of elevation the used area ranges from 1850 m to just under 2600 m, which means that most of the area falls into the *tierra fría* zone (above 2000 m). Animal husbandry with cheese production is adapted to these conditions. Slightly below this *finca* is the Finca Vega, a triangular farmstead at nearly 1600 m with a small coffee plantation of 2.5 ha reaching up to 1700 m, thus situated in the altitudinal zone of the *tierra templada*, which is very suitable for coffee growing.

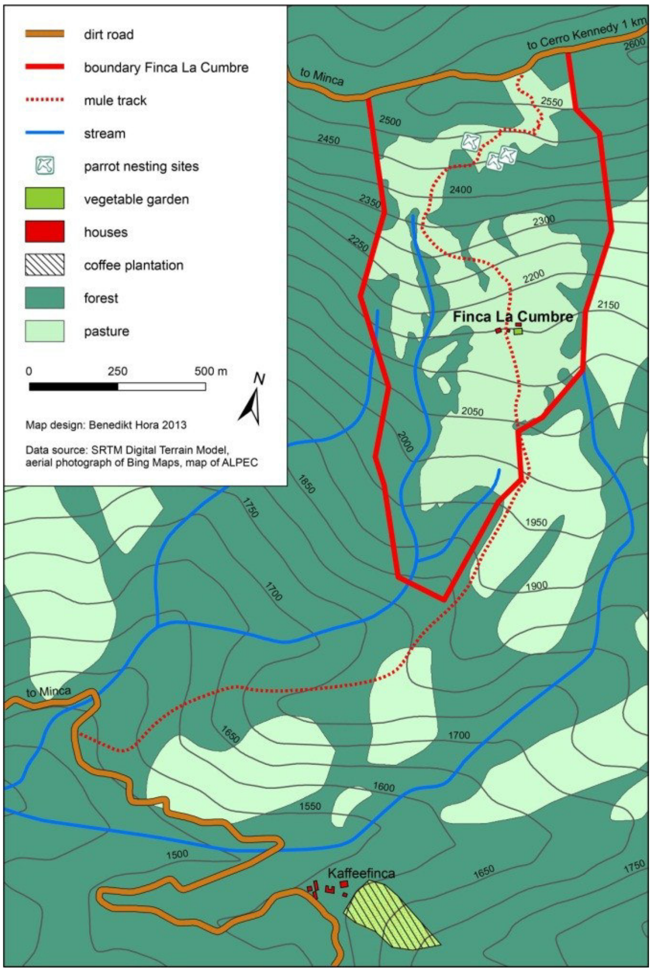

Figure 9: Map of the fincas in the upper part of the Río Toribio basin

The coffee variety grown here is Caturra, a hybrid variety of Arabica. In 2008 the plants had matured enough to produce the first harvest. In the coming years the production is to be converted completely to organic farming. To this end shading trees have already been planted to protect the vulnerable coffee plants from coffee rust, which currently is an occasional problem. A shelling and washing system for the coffee berries has already been purchased.

The problem for small producers is the fact that powerful actors dictate the market conditions for selling the beans, which reduces the potential profit for the producers. The *Federación Nacional de Cafeteros de Colombia* in particular is keen to push its monopoly for coffee export to the world market. Many small producers, however, prefer to deal with actors like the German organization Kaffee K.U.L.T. (Thiel & Eiffler 2011) as this is the only way to make a profit from the more demanding organic growing method.

From this *finca* a rutted track leads to Minca and Santa Marta. In contrast, the Finca La Cumbre has no direct link to the road and can only be reached on foot or on horseback (Figure 8). The mountain scenery and the tropical vegetation and species diversity in the valley might attract adventure tourists and bird watchers. However, tourist infrastructure is only beginning to emerge. A guesthouse was built at La Cumbre and initially attracted many groups of students but by now visitor numbers have dwindle to just a few.

Hence the *finca*, like everybody in the protective corridor, depends on earnings from agriculture and particularly from dairy farming. At 3 l/cow, milk production is very low and only processed into cream cheese, which only yields small incomes. The earning situation could be improved if the fincas succeed in producing hard cheese that can be stored and transported (Wüst 2006).

In addition, the members of ASOTORIBIO endeavour to replant the slopes with indigenous species. Tree nurseries have been established and by August 2005 some 28,000 trees had been planted (Wüst 2006). The project includes education *in situ*, which takes place in *socios* meetings and in schools.

Here, too, we find a mixed result in terms of the livelihood approach (Figure 10). The natural capital is now adequately protected and even improved by reforestation. Physical and financial capital are week and make for a vulnerable livelihood of the valley population, but they do have high human and, through the *Asociación*, social capital.

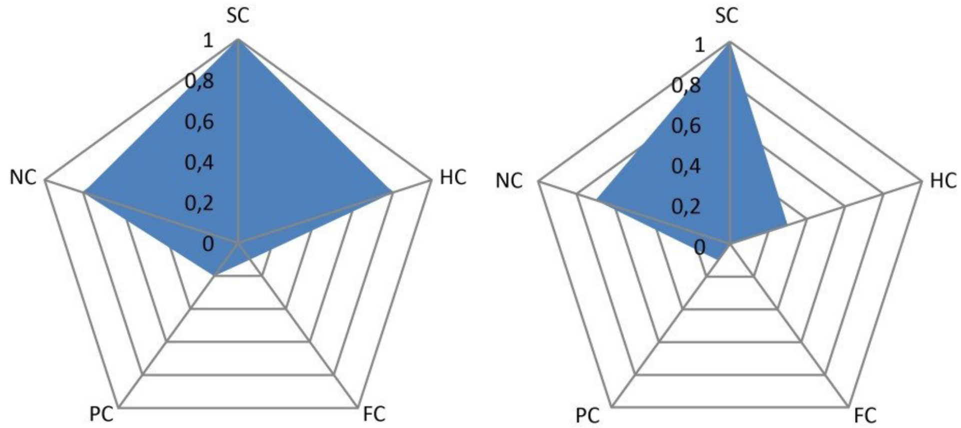

Figure 10 a & b: Livelihood assets of the Finca Vega (left) and the Finca La Cumbre (right)

Discussion

The three case studies present an uneven picture. In conservation terms, both the efforts at La Victoria and those of ASOTORIBIO must count as positive. While the *hacienda* also has high physical capital, ASOTORIBIO does not and in both cases there is very little financial capital. However, both boast high human and social capital.

Assessment of tourist developments is less positive. Neither is the educational mission of protected areas fulfilled nor are the simplest control mechanisms in place. This vulnerability affects not so much the humans but the natural world. In contrast to the love of nature and the environmental awareness of the Weber family on La Victoria and the families living in the protective corridor of Riotoribio, responsibility for the vulnerable and in parts already impaired environment falls by the wayside in tourism, as does any sense of community and participatory ways of cooperation, with the exception of the members of ASOFINTUR, who combine business sense with idealism.

So we are left with a varied result. Compared with a study on Río Piedras in Cinturón Andino BR, the uncontrolled tourism, particularly on the coast, cannot be called sustainable. The situation is different in coffee growing, particularly of organic shade-grown coffee. This method emulates the natural ecosystem and can be profitable if marketed directly in Europe.

Considerable improvement is needed in management. Currently the protected areas are administered by the Colombian ministry of agriculture, which has awarded the license to run Tayrona NP to a private operator whose interest is in making profit. There is not local management for either the NP nor for Sierra Nevada de Santa Marta BR. While the NP is at least sign-posted, this is not true for the BR, whose boundary is not even exactly defined. If the criteria of the Madrid plan were applied, the urban centres of Santa Marta and Cienaga could be integrated into the BR. However, this would necessitate strict management and on-going quality control as well as the introduction of rangers and scouts. The civil society regulated protective corridor is managed in a participatory fashion by the small farmers involved, yet here, too, there is no control by a higher level.

Conclusion

The answer to our initial question is therefore: in an effort to reduce vulnerability, promote resilience and achieve sustainable regional development, organic farming and – given the difficult national marketing paths in the coffee sector – direct export need to be expanded. If conservation concerns, which currently centre on the habitats of rare birds, can successfully be expanded to cover the preservation of the whole ecosystem and the economic basis is strengthened through refinement and export, then vulnerability will be reduced and sustainability achieved.

Tourism can be a main or additional source of income, but it will only meet the criteria of sustainability if information about conservation and diversity is improved, infrastructure expanded and visitor flow channelled. Small scale visitor management, for instance in the *Asociaciones* of the small farmers is easier on the environment than mass tourism on the beaches.

Colombian coffee has its own global niche market if it is organically grown and offers the traditional Arabica variety, which has all but disappeared from the world market. Coffee growing is ecologically viable if the natural ecosystem of the mountain rainforest is emulated by mixed crops and canopy trees. The size of the farm is irrelevant.

Campesino associations strengthen the economic foundations as well as the human and social capital. They reduce the vulnerability of individual small farmers and can contribute to the preservation of ecosystems if they are oriented on protected area criteria. Tourism in the shape of individual and ecotourism may strengthen the economic base.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 85 - 90

Observer bias and its causes in botanical records on summits

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Abstract

Long-term monitoring in protected areas or areas with limited access, such as the Alps, serve as a versatile tool to assess changes in plant communities. In this study, we want to enhance knowledge about factors influencing observer bias in botanical records in the Alps. We repeated historical surveys of vascular plants, with a subset of 48 summits collected by two independent observers. Rates of pseudo-turnover between observers were compared to turnover between historical and recent surveys. Observer-dependent and -independent variables were tested for influence on pseudo-turnover and the number of species missed by one of the observer. Furthermore, the effect of plant characteristics on species detectability was tested. With an average of 13.6%, pseudo-turnover between observers was almost three times smaller than species turnover over one century. Pseudo-turnover and the number of species missed increased with difference in botanizing time between observers and with a longer ascent to the summit, with more species missed in combination with a high species richness on the summit. Species were difficult to detect if they occurred on many summits but with a low abundance, if small in stature and if they belonged to certain taxonomic plant groups. The results of this study confirm that the floristic changes over time found on alpine summits represent an ecological pattern. Comparison to previous studies shows that these factors and their importance change with conditions and environment a study is conducted in. In remote and mountainous terrain, special attendance should be paid to factors closely dependent on observer. To minimize observer bias in floristic studies in general, its possible causes should be specified in advance according to the particular environmental and survey conditions.

Keywords

Pseudo-turnover, species detectability, between-observer variability, vegetation records, long-term monitoring, re-survey studies, Summit Flora Project

Introduction

Ecosystems have been changing rapidly in recent decades due to climate and land-use changes. Revisitation studies are an effective tool to detect, monitor and analyze changes in ecosystem composition. However, research is always vulnerable to undesired influences affecting data quality, and especially in studies based on fieldwork, a certain fraction of variability may be introduced by environmental conditions or observer characteristics. While quantification of observer bias should be included in all studies, a logical further step would be to minimize possible error sources in advance. For this, further investigations about which factors are important for studies in all vegetational surveys and which factors are specific to certain conditions and environment are needed.

While several variables have been tested for influence on data quality by previous studies, conclusions about the direction and magnitude of influence are still generally undecided. Furthermore, factors having a major influence in lowland situations may have a completely different effect in an alpine environment, where remoteness, exposed terrain and mountain climate may pose particular challenges during fieldwork. To date, only few studies have examined observer bias in an alpine field study (VITTOZ & GUISAN 2007; VITTOZ et al. 2010) but no special attention has been paid to which factors related to this particular environment could have a influence on data quality.

The Summit Flora Project (STÖCKLI et al. 2011) is a revisitation study conducted in such an alpine environment. By repeating historical vegetation records of summits that were visited by botanists one century ago, long-term changes in plant community composition, species richness and species distribution can be assessed. For the Summit Flora Project as well as for other field studies, it is important to quantify observer bias and to test which factors are causing it in order to account for them in study design and data analysis, and eventually, minimize variability in field records. The objective of this study is thus to (1) quantify observer bias and variability between field records, (2) discover the main factors causing them, and (3) ensure data quality of the Summit Flora Project data.

Methods

Study sites, record protocols and tested variables

The study area of the Summit Flora Project comprises of 124 summits in the southeastern Swiss Alps, of which historical inventories of vascular plant species found approximately a 100 years ago exist. These summits were re-surveyed between end of June and mid-September in 2010 and 2012 by at least one botanist of a team of three permanent and eight temporary field botanists. On a subset of 48 summits, re-surveys were assembled by two independent observers on the same day to analyze the correspondence between simultaneous records.

For each summit, a list of vascular plant species was assembled for the uppermost ten altitudinal meters. Each plant species was recorded with its highest occurrence, along with coordinates, time stamp, altitude and an estimate of the species' abundance. Each of the two observers made an inventory of the whole 10m-area, following the descriptions of the historical records especially from Braun-Blanquet (BRAUN 1913). Variables that could have influenced the composition of species lists in our records were quantified either from data collected in the field, from already existing data or from personal knowledge (Figure 1).

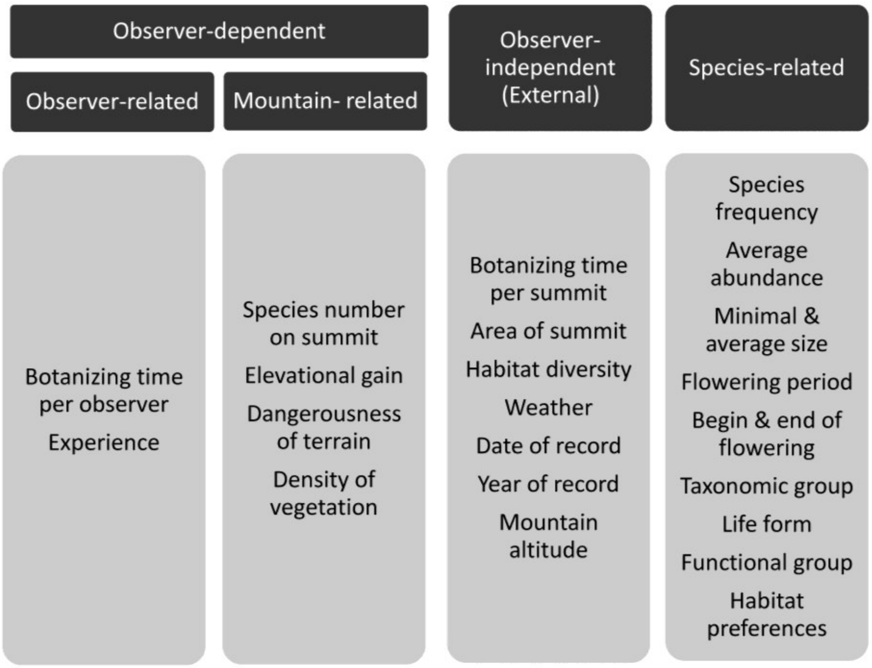

Figure 1: All Variables analysed in this study potentially influencing observer bias.

Statistical analyses

Species turnover between historical and recent records as well as pseudo-turnover between two records made at the same site *and* the same time were calculated as

$$\boldsymbol{T} = \mathbf{100} \times \frac{(\boldsymbol{A} + \boldsymbol{B})}{(\boldsymbol{S}_{\mathbf{A}} + \boldsymbol{S}_{\mathbf{B}})} \qquad (1)$$

(NILSSON & NILSSON 1985), where A and B are the number of species exclusive to each of two records, and S_A and S_B are the total number of species in each record. While pseudo-turnover is a relative measure of observer bias including species richness in its calculation, we also calculated the number of exclusive species per summit (A + B in formula (1)) as an absolute measure of observer bias. Pseudo-turnover and number of exclusive species per summit were analyzed with linear models (models M1 and M2, N=48) with observer-dependent and observer-independent (external) variables as explanatory variables (Figure 1). Species detectability (as the probability that a species found on the 48 summits was missed by one of the observers) was analyzed using a GLM (generalized linear model, package 'stats', model M3, N =252) with plant characteristics as explanatory variables (Figure 1). Finally, we compared species turnover over time and pseudo-turnover between two observers with paired student's t-test. All statistical analyses were performed in R (version 2.14.1., R Development Core Team, R Foundation for Statistical Computing, Vienna, Austria).

Results

For the 48 summits analyzed, pseudo-turnover between two contemporary botanists ranged between 0% and 33.3% with a mean of 13.5% ± 7.9 (SD). Compared to pseudo-turnover, species turnover between historical and recent records was almost three times higher (41.4%±16.3%; t paired = -11.0, df = 42, p-value < 0.001; Figure 2).

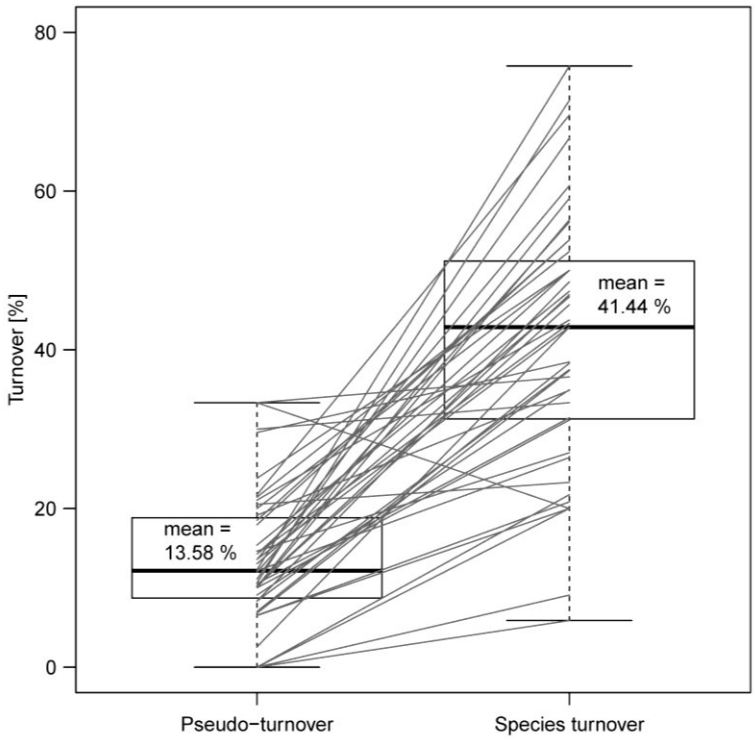

Figure 2: Pseudo-turnover and species turnover for the 48 summits that were recorded by two independent observers. Grey lines connect the same summits.

A large difference in botanizing time between observers was the major cause of a high pseudo-turnover (model M1, Figure 3a). This was confirmed in model M2 showing that more species were missed by one of the observers when difference in botanizing time was high (Figure 3d). Generally, a record took longer to complete (linear regression, $F_{1,46}$=112.4, p <0.001) and recording time differed more between observers (linear regression, $F_{1,46}$ =7.42, p <0.001) on summits with higher species richness. A long ascent (in terms of elevational gain) increased pseudo-turnover (model M1, Figure 3b) and the number of species missed by one of the observers on a summit (model M2, Figure 3e), although a long ascent did not seem to have led to time constraints during the record, since there was no significant relationship between ascent length and botanizing time (linear regression, $F_{1,46}$ = 0.19, p = 0.66) or difference in botanizing time ($F_{1,46}$= 0.56, p = 0.46). More species were missed on summits with higher species richness (model M2, Figure 3c), especially when difference in botanizing time between observers was high and the ascent was long (Figures 3d and e).

Species occurring on many mountains (with a high frequency) but with low abundance had a higher chance to be missed (model M3). The taxonomic plant group a species belongs to had a highly significant effect on the probability with which the species was missed, with a tendency that species were more often missed if they belong to Liliaceae/Orchidaceae (z = 2.3, p = 0.021), Asteraceae (z = 1.89, p=0.058), Scrophulariaceae (genus *Veronica*) (z = 1.76, p=0.078) or Juncaceae (z = 1.65, p =0.098). Finally, species with a small minimum size had a marginally higher chance of being missed.

Discussion

Species turnover vs. pseudo-turnover

Although most records of previous studies were made in much smaller plots of well-defined size and in lowland grassland where vegetation is denser than in alpine terrain, pseudo-turnover in the Summit Flora Project corresponds well with the measured pseudo-turnover in those publications (NILSSON & NILSSON 1985; VITTOZ et al. 2010). Species turnover between historical and recent records is significantly higher than measured pseudo-turnover, confirming that the turnover over time cannot simply be attributed to inter-observer variability or recording protocol alone, but constitutes an ecological pattern.

Causes of observer bias

The time invested into a record is considered a prevalent source of observer bias. Detection probability generally increases with survey effort (KÉRY et al. 2006; CHEN et al. 2009) and, crucial for many biodiversity studies, rarer species are generally found towards the end of a record (ARCHAUX et al. 2006). It is thus remarkable that in our study, the absolute duration of the record had no effect on observer bias. The absolute duration to find a certain proportion of the species present on a summit seemed to depend on characteristics of the respective summit and thus was an observer-independent variable. Difference in botanizing time, however, depended on the observers working on the mountain. Since each observer decided when the record was finished, a possible negative influence of different searching methods or botanizing technique could be more pronounced on species-rich summits, explaining the significant influence of difference in botanizing time on observer bias in combination with a high species richness.

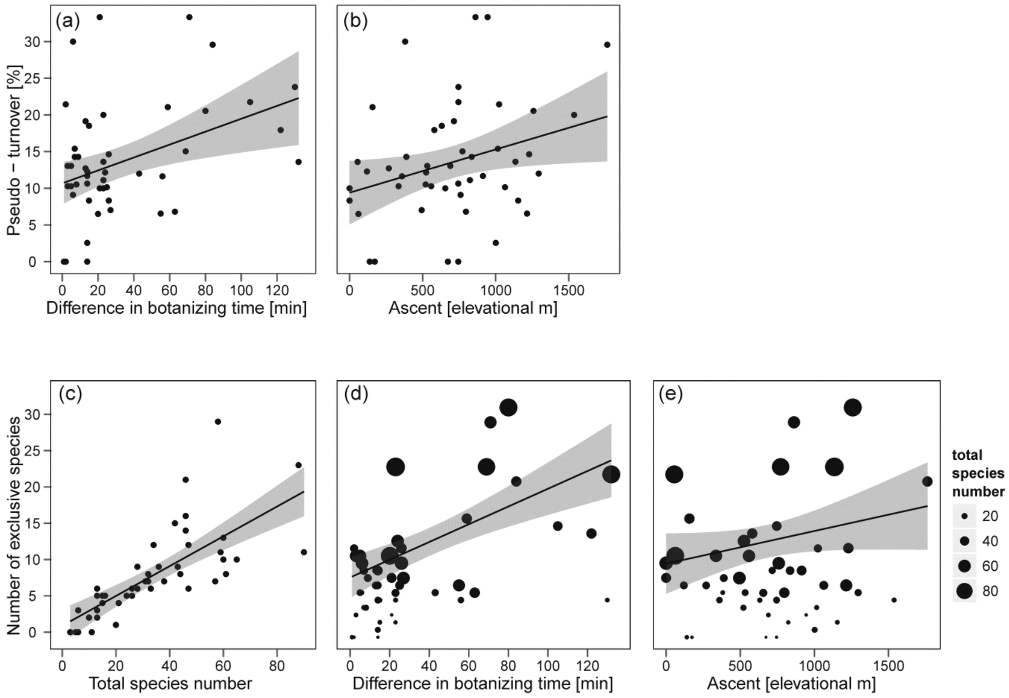

Figure 3: Model results showing significant and marginally significant variables influencing observer bias. 'total species number' refers to the total species number per summit, represented by size of the points in the plot. 95%-confidence intervals are shown in grey.

Our study is to our knowledge the first to make a connection between physical strain and quality of field data, as our data show that a longer ascent (in terms of elevational gain to reach the summit) led to a higher observer bias. Since ascent length was unrelated to altitude of a mountain, species richness, or time spent on a record (all correlations $p>0.1$), any artifacts related to species richness or time constraints could be excluded. A simple explanation is that a longer ascent is more exhausting to observers, making their record more prone to errors. It is likely that physical fitness interacts with other observer-related traits, such as experience, as experienced observers probably cope better with a long ascent or work more reliably even when tired than less trained observers. Also the finding that ascent length had a particularly large influence on record quality on summits with a high species richness, could be due to more experienced or physically fitter observers being better able to deal with a rich species composition after a strenuous ascent.

In summary, in our study, the factors with a significant influence on observer bias were observer-dependent, either directly (difference in botanizing time) or indirectly in the form of mountain characteristic that influenced observers differentially (ascent length and species number on the summit). It seems that in the alpine environment, the effect of physical and mental abilities of the observers, and how they cope with the demands of mountainous terrain can override the importance of external, observer-independent factors or environmental factors that presumably influenced all observers equally.

Species detectability

That frequent species have a higher chance to be overlooked by one of the observers is a simple matter of probability. In agreement with other studies (LEPS & HADINCOVÀ 1992; RICH & WOODRUFF 1992; KERCHER et al. 2003; VITTOZ & GUISAN 2007) is the finding that species with a low average abundance are missed more often. As our records covered a relatively large area, and as our protocol did not prescribe to cover each possible spot of it, species that usually occur in a low abundance had matter-of-factly a higher likelihood to get missed. Since many species on our summits occur near their uppermost distribution limit, they often grow vegetatively and are rather small in stature. This inconspicuousness does not only make detection more unlikely, but could also interfere with correct species determination.

That some taxonomic plant groups were particularly often overlooked probably had to do with the reasons stated above. Orchidaceae, Liliaceae and Scrophulariaceae, for instance, often occurred as only one or few individuals per summit. While Asteraceae are a notoriously difficult group for species determination, they were also generally frequent, increasing their chance to be missed. The same may be true for Juncaceae (genus *Luzula* and *Juncus*) which were also often difficult to determine when growing vegetatively.

Conclusions

The large data set of the Summit Flora Project and a representative subset of summits with two independent records enabled us to calculate the proportion of turnover that could be attributed to inter-observer variability. It also made it possible to find out which factors have a major influence on observer bias in the context of our study. The influence of difference in botanizing time and ascent length show that it is especially important to consider factors that are strongly dependent on the observer in such an extreme environment as alpine summits.

We recommend that issues of botanizing time should be considered closely in every study design. For studies like ours with sample sites of different area and structural complexity, no standardized time frame for the record can be pre-defined, but refined criteria on when to conclude a record could help to reduce inconsistencies between observers. Recommendations about how to deal with inconspicuous, rare and difficult taxa seem to be universally valid for all kind of vegetation studies. In the Summit Flora Project it proved to be helpful to discuss difficult and rare taxa before and during the field season and to establish determination keys for species, genera or families known to be difficult.

This study gives a new understanding of observer bias. We want to point out that most factors causing observer bias are likely to vary in importance depending on the particular environment and conditions a vegetational record is conducted in and thus have to be considered for each study anew.

Acknowledgements

The Summit Flora Project is carried out on behalf of the Federal Office for the Environment (FOEn, Switzerland) and is supported by the VELUX Foundation and the Swiss Federal Institute for Forest, Snow and Landscape Research WSL. This study is additionally supported by the 'Alpenblumenfonds' of the Swiss Academy of Science (SCNAT, Switzerland).

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Landscape Observatories as Tools for the Management of Protected Areas: The Case of Sierra Nevada (Spain)

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Abstract

The rapid and profound changes of the territory in recent decades require implementation of new methodologies which would make monitoring and study of transformations of landscape possible. In this way the main dynamics of change can be detected ensuring the ultimate goal of facilitating territorial and landscape planning.

Protected Areas are spaces characterized by ecological uniqueness and by high susceptibility to changes. For these reasons systematic monitoring of the processes of transformation that affect their landscapes is especially important.

In this context, Landscape Observatories form optimal tools for monitoring of the landscape. They provide a basis for its synchronic and diachronic analysis through the use of photography which enables us to appreciate the visual aspect of transformations and to identify dynamics of change. Moreover, the use of photography at ground level, capturing human-eye perspective, permits the implementation of mechanisms of public participation. In this sense Landscape Observatories facilitate fomenting of awareness and involvement of the population in the management of Protected Areas. Through the emphasis on achieving public consensus, they provide an efficient foundation for successful protection and conservation policies.

We present here our experience of cooperation with the Protected Area of Sierra Nevada, focusing specifically on the subject of Public Participation. Through the involvement of experts, managers, administration, associations and the population in general in this process, the viability of the project and inclusion of the demands of the population in the planning documents are ensured.

Keywords

Landscape Observatory, Protected Areas, Public Participation, Sierra Nevada.

Introduction

Throughout the recent decade Protected Areas (PA) in Spain have been significantly extended, covering today more than 11% of the national territory (EUROPARC 2012). The increasing present social demands, political trends and guidelines enforced by the European Union through the ratification of the European Landscape Convention by the majority of member states (European Parliament 2008) all indicate that this tendency will be maintained in the future.

The landscape, viewed from a geographical perspective and as one of the most prominent elements of PA, may be used as an efficient instrument for studying and managing these areas (Hirschnitz-Garbers & Stoll-Kleemann 2011; Houet et al. 2010; Peyrache-Gadeau & Perron 2010). This project aims at developing a Landscape Observatory as a new methodological tool for effective management of PA consisting of monitoring landscape dynamics and creating mechanisms for public participation (Carré & Métailié 2008; Ministère de l'écologie, de l'énergie, du développement durable et de l'aménagement du territoire 2008). The construction of the observatory is based on exhaustive fieldwork and the analysis of secondary data. The core of the project consists of research on current dynamics both ecological and socio-economic and a prospective study of the documents of spatial planning. Areas are selected for photographic monitoring according to their internal characteristics and detected dynamics. Through their systematic tracking, the methodology of the observatory aims at improving the strategies of governance that affect the conservation and preservation of natural characteristics of PA.

It is also designed as a participative tool given that in the final phase of the project an online landscape observatory web database of monitored zones has been created. It will serve as a platform for analysis of landscape dynamics for researchers and public administration as well as a source of information for local communities. The methodology described will be implemented in the Sierra Nevada Natural Park, a protected area with one of the greatest biodiversity in Europe.

Objectives

Profound territorial and socio-economic transformations have lead to visible alternations in the functioning and configuration of landscapes. In this context, landscapes serve as depositaries of heritage whose effective monitoring and governance should be guaranteed. The orientation of dynamic processes reassuring the preservation of landscapes of quality is therefore a priority in the management of the resources of PA and in the planning of models of conservation and sustainable development (Martínez de Pisón 2007; Panareda & Arozena 2008).

The study of landscape dynamics allows understanding of the processes, both natural and socio-economic in character, which accelerate the transformation of environment and territory (Cardille et al. 2005; Hernández 2009). Furthermore, it permits the evaluation of local communities' perception of these changes, which serves as a base for the future development of these landscapes.

This research aims to conduct a methodological study for the introduction of landscape observatories in PA. According to the guidelines for the application of the European Landscape Convention, observatories constitute tools for the description and analysis of the state of landscapes and for the provision of elements for understanding the existing tendencies and construction of prospective scenarios. They also create a framework for establishing procedures for citizen participation (Council of Europe 2000).

This project utilizes the Sierra Nevada Natural Park as a pilot area and aims to design a methodology applicable to other networks of PA.

The primary objective of this research consists of establishing the methodological fundamentals for the design of an observatory that will allow an effective monitoring of the evolution of landscapes in PA. The detection of main trends of change is not of less importance given that its aim is the sustainable future management of these landscapes according to the demands of population. By way of contributing to the implementation of the clauses included in the European Landscape Convention this research aims to assess the current state of landscape resources in Sierra Nevada PA and identify and evaluate the processes and dynamics with effect on the evolution of landscapes by detecting the principal alternations induced by them and their impact on the final configuration of the landscape.

Results of the design and implementation of the methodological project

The Landscape Observatory and Archive of the Sierra Nevada PA has been designed as an operational tool which implements a specific protocol for collecting, archiving and classifying data aiming at the systematic monitoring of the processes and dynamics which affect landscape. Furthermore it provides a base for identification of functions and values that the society attributes to their landscapes and therefore it contributes to raising awareness and participation in the management of landscape resources (Conrad et al. 2011; Mannigel 2008). The final objective is to contribute to the elaboration of specific tools to provide technical support for public administrations in the process of decision making.

In order to conduct the study of landscape dynamics a method of photographic observation and photo-comparison has been applied. It is based on the systematic classification of landscapes, which are monitored by a periodic follow-up of these photographs from the same perspective. The basic principles of this technique have been validated in a range of studies related to the monitoring of ecological, geomorphological and urban processes (Carré & Métailié 2008) and more recently to that of landscape evolution through the project OAPA (Observatorio y Archivo de los Paisajes de Andalucía/Landscape Observatory and Archive of Andalusia). OAPA, a project funded by the Government of Andalusia and developed during 2010 and 2011 by our research group, created a methodology which is the base for Landscape Observatory of the Sierra Nevada PA. This paper concentrates on the adaptation of the developed procedures of photographic observation to landscape analysis in the framework of PA.

The implementation of the Observatory consists of three main phases, preceded by a preliminary study. The last phase has a transversal character.

0. Preliminary study

The first part of the preliminary study aims at understanding the configuration and current characteristics of the landscapes of Sierra Nevada. It included a profound analysis of the bibliographical documentation of the historical evolution of the landscapes of the region (see Jimenez et al. 2010), and also the results of the processes of sectorization of the analyzed territory and of photointerpretation of two sets of aerial photographs: the series of 1999 and 2009.

The sectorization of the Protected Area has a triple functionality: it responds to the natural division of different types of landscape of the region, Yolanda Jimenez (1991); it structures the territory for subsequent configuration of the network of points for observation capturing the heterogeneity and richness of the region in terms of natural biodiversity and landscape; and, finally, it articulates the Sierra in a functional form, introducing already in this phase elements of the design of the processes of public participation.

The methodology of photointerpretation is not based in this case on a traditional individual reading of each of the series of aerial photographs and the subsequent extraction of statistics of the uses and land cover. It is based on the identification of changes. This process, using ArcGIS 9.3 of ESRI España, is conducted by superimposing the two sets of images. In this way we detect and mark on the most recent photo those areas that have been affected by transformations of land cover or of the elements of the landscape. This enables the identification of recent dynamic of change of the landscape of Sierra Nevada which took place throughout the last decade.

The last element of the preliminary study, which precedes the configuration of the network of fixed points for monitoring, is the analysis of the territorial planning documents. It enables the identification of possible changes and existing threats for the landscape assuring that the creation of the observation network is based on a solid knowledge of the past, present and future of our landscapes. It is, therefore, possible to make the first approximation to the places that should be considered as possible sites for the application of systematic monitoring by photography.

Thanks to this processes of the analysis of the characteristics of the landscape and the existing dynamics of change, it is possible to address the identification of issues to be monitored.

1. Data collection

The configuration of the network of monitoring points of the landscape is based on exhaustive fieldwork. With the support of the results of the preliminary study and through the implementation of public participation processes, which are described below, the final network of points is established. This network, covering all landscape types and taking into account the dynamics of change identified and the territorial actions planned, forms the base for regular and systematic monitoring.

For each point of observation an information file is elaborated. It is composed by an image taken in each campaign of photography, technical information of the point and the analysis of the characteristics and dynamics of the landscape. This enables future repetition of the exactly the same image. In each point's file the periodicity for rephotography recommended is indicated.

Examples of images from the network of points for monitoring (Autor: Andrés Caballero Calvo):

Foto 1: "Rinconada de Nigüelas"
Abandonment and recuperation of agricultural areas

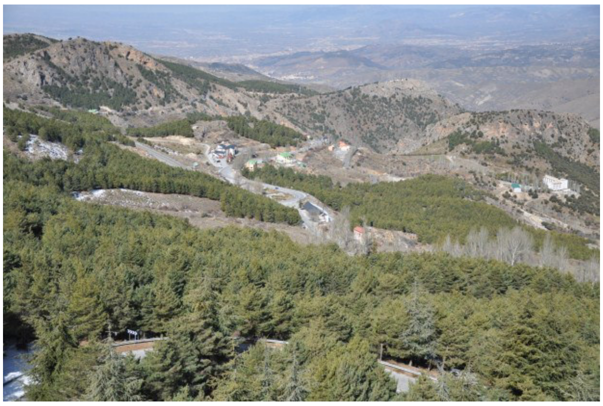

Foto 2: "Carretera de la Sierra"
Expansion of disperse constructions

Foto 3: "Siete Lagunas"
Landscape of exceptional natural values

Foto 4: Terraced slopes at Alpujarra
Landscape of exceptional antropical values

2. Interpretation

The analysis of the archives of images is conducted using the method of photointerpretation; comparing pairs or series of images.

The images from successive campaigns of rephotography form a database of landscapes. This database facilitates quantitative monitoring of landscape transformations and, above all, it allows qualitative analysis which is only possible through photos taken at ground level. In this sense, and in comparison to cartographic and aerial documents, photographs taken in the framework of the observatory will constitute a tool for the appreciation of landscape in terms of human perception (CARRÉ & MÉTAILIÉ 2008). It is this point which leads to the other branch of the Observatory: the Public Participation.

3. Public Participation

A series of different processes of Public Participation is transversal to the two previous phases. The Observatory is a tool for citizen participation through the creation of a space for dialogue on landscape values among key local actors such as the PA managers, researchers, professionals and general public (LAURIAN & SHAW 2009; NOGUÉ 2007; SGARD 2010). To ensure the participative character of the observatory, a specific methodology, which gathers information about the perception of the landscape for each of the areas of study, is designed. The selection of the specific techniques to be applied took place after the initial phase of fieldwork, once the preliminary study of the area in question was finalized.

The OAPA website should be highlighted as a tool and source of information for researchers and public administration, as well as for local communities, creating a base for the debate on the necessities and the models of management of PA.

The creation of conditions for the debate on the necessities and models of management of PA respond to one of the main aims of the project which is to ensure the participatory character the territorial planning.

Conclusions

The presented project is a methodological project, based on the design of a scientific process of observation and analysis of the landscape of Sierra Nevada. It enables us to monitor the landscape evolution, to detect the dynamics of change and, therefore, to undertake actions which corroborate or counter the causes of these transformations.

Given the nature of the design, the Observatory will fully reach its objectives once several campaigns of rephotography are conducted. However, it is equally important, that this methodology has been already implemented successfully in other areas of observation of the province of Granada, such as the *Vega de Granada*, the *Hoya de Guadix* and the *Costa*. In all of these regions we have already conducted several photographical campaigns obtaining excellent results in terms of the analysis of landscape evolution.

In Sierra Nevada, thanks to the configuration of a network of points according to the results of the public participation, the establishment of the observatory has been completed (see the previous four photos as examples of the network of points for monitoring). It is therefore already functioning and will be used to aliment the database and provide material for photocomparation.

The simultaneous application of various mechanisms of public participation enables us to identify the preferences of the society and include them in the *Landscape Quality Objectives*, which is the base of the landscape planning and management of landscape resources.

Finally, it should be noted that a key element which ensures the viability of the project in this National and Natural Park, is the collaboration with the authorities of the *Sierra Nevada Protected Area*. Only with the involvement of the governing body it is possible to guarantee the sustainability of the project as well as the effective implementation of its results in the documents of territorial planning.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 97 - 102

Effects of extreme weather events on Apennines grasslands productivity

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Abstract

Extreme weather events are expected to increase in frequency and magnitude due to climate change especially on Mediterranean chains, but their effect on ecosystem services and vegetation processes are widely unknown. Prediction of future impacts has become critical to conservation planning and management, particularly in protected areas.

Our research has been carried out in the Torricchio Nature Reserve (Central Apennines, Italy), 317 ha under strict protection since 1970, owned and managed by the University of Camerino.

Two contrasting grassland ecosystems under different environmental conditions (North and South facing slopes) were selected to simulate extreme events. The magnitude of a given recurrence interval (1000 year) were estimated by the application of extreme value distributions on climate data series covering 50 years.

In both slopes, the weather manipulations consisted of extreme drought (D), additional rainfall (R) and ambient conditions for control (C). The experiment covered 2 years (2011 and 2012). Once a year, at the end of the treatment period, the above-ground biomass was collected.

No significant differences between treatments were found in the productivity of the stony terrain of the S facing slope, while significant results were detected between the climatic extremes (D vs R) in the N facing slope with dense plant cover. In any case, the experimental treatments of the S facing slope, show a high level of biomass variability, demonstrating the importance of the fine-scale environmental heterogeneity.

The effects of climatic alteration on productivity of montane grasslands, underlines the crucial importance of future research on the outcome of climate change in these systems.

Keywords

Extreme weather events; Sub-Mediterranean grassland; Drought; Above-ground productivity; Torricchio Nature Reserve.

Introduction

Climatic and land use changes are considered to be major drivers of biodiversity loss in terrestrial ecosystems (Thomas et al. 2004; Fischer & Lindenmayer 2007). In particular, global climate change will likely cause profound effects shifting terrestrial ecosystems outside their historical range of climate variability. (Gordon et al. 1999; Thomey et al. 2011). In this context, prediction of future impacts has become critical to conservation planning and management (Suttle et al. 2007), particularly in protected areas.

Associated with a changing global climate, alterations in the distribution and abundance of animals and plants are already occurring (e.g. Penuelas & Filella 2001; Parmesan & Yohe 2003; Root et al. 2003; Thomas et al. 2004). This is due to changes in the mean and spatiotemporal patterns of temperatures and precipitation, as well as an increase in the frequency and magnitude of weather-related extreme events (IPCC 2007; Jentsch et al. 2007; Kreyling et al. 2008b).

The ecological effects of extreme events have been identified as one of the main gaps of knowledge in community ecology (Agrawal et al. 2007; Jentsch et al. 2007).

The Mediterranean area is characterized by a climate of transition between the temperate mid-latitude and tropical dry climate, therefore it is considered to be potentially very sensitive to climate change (Cubasch et al. 1996; Lavorel et al. 1998).

For Sala et al. (2000), Mediterranean grassland ecosystems likely will experience the greatest proportional change in biodiversity because of the substantial influence of all drivers of biodiversity change (land use change, climate change, biotic exchange, etc.). For instance, changes in timing and amounts of growing season precipitation and variations in temperature, are likely to cause long-term changes in grassland plant community composition and structure, with consequences on ecosystems functioning from the point of view of provision of habitat, biomass, water interception, nutrient cycling and carbon storage (GRIME et al. 2000; SANDEL et al. 2010).

Several studies of climate manipulation were recently carried out in Central and Northern Europe grasslands (GRIME et al. 2008; KREYLING et al. 2008a); however, experimental data on the effect of extreme weather events on montane sub-Mediterranean grasslands are lacking.

Here we evaluate the effects of certain induced extreme weather events (namely, drought and additional rainfall) on the above-ground biomass of two contrasting Apennines calcareous perennial grasslands, located in a protected area.

Methods

The Torricchio Nature Reserve (Central Apennines, Italy, Figure 1) provides areas of montane grasslands under different environmental conditions. The ones considered in this study are located at contrasting, north and south-facing slopes along a SW-NE orientated valley. Mean annual precipitation reaches 1250 mm and mean annual temperature is around 11 °C (HALASSY et al. 2005). Jurassic-Cretaceous limestone (scaglia rosata) prevails in the area. The Reserve, owned and managed by the University of Camerino, is under protection regime since 1970 and it is included in the Natura2000 and LTER networks.

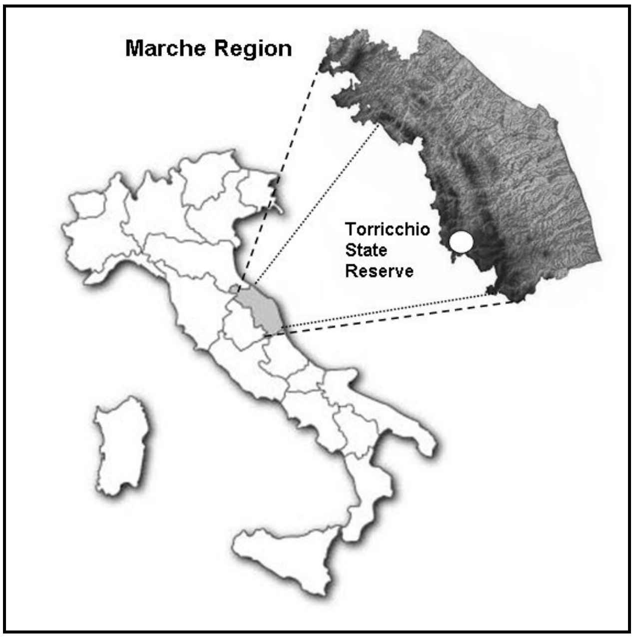


Figure 1: Location of Torricchio State Reserve in the Central Apennines, Marche Region. Italy

We selected two study sites with an area of about one hectare each, representing the contrasting environmental conditions of the north and south slope (Figure 2). The north-facing slope (site N) is covered with a dense grassland assigned to the association *Seslerio nitidae – Brometum erecti*, here a secondary community originated by the destruction of a former beech forest. The south-facing slope (site S) hosts an open grassland with a more scanty cover, assigned to *Asperulo purpureae – Brometum erecti*. Due to erosion associated with the presence of rocky outcrops, a poorly developed, shallow and skeletal soils occur which are characterized by strong instability (KWIATKOWSKI & VENANZONI 1994).

In both sites, the weather manipulations consisted of extreme drought (D), additional rainfall (R) and ambient conditions for control (C). Magnitudes of climatic extreme events of a given recurrence interval (1000 year event) were estimated by the application of extreme value distributions on climate data series (JENTSCH et al. 2007) covering 50 years. For Torricchio Nature Reserve, the 1000-year event resulted in 58,5 days of drought.

At each site, five plots were established with three 1x1m sub-plots: one sub-plot with a 4m² roof to simulate extreme drought, one sub-plot downstream the shelter to simulate additional rainfall and one control plot. Roofs were constructed with a steel frame and covered with transparent 3 mm plastic foil that permitted over 93% penetration of photosynthetically active radiation (PAR).

Soil temperature and soil relative humidity were measured each two hours (Maxim- Hygrochron Temperature/Humidity Logger – DS1923) during the entire period, in roofed and non-roofed plots, at two different soil depths: 0 and 10 cm. General meteorological data was provided by a local meteo station.

The experiment covered 2 years (2011 and 2012). Once a year, at the end of the treatment period, in each sub-plot, the above-ground biomass was collected.

Data from loggers were compared among treatments using the non parametric Mann-Whitney U-test.

Figure 2: Pictures of the North facing slope (Site N, on the left) with a dense and closed grassland, and South facing slope (Site S, on the right) characterized by an open grassland with poorly developed and shallow soils.

The effects of the treatments and time on mean above-ground biomass values for both sites, were tested used the univariate repeated measures ANOVA (test of within-subject effects). Therefore, per each site and year, the One-way ANOVA with "Bonferroni" post-hoc test was performed to check for significant differences on mean biomass values of the three treatments. Additionally, we used the coefficient of variation (CV; standard deviation divided by the mean) as a measure of above-ground biomass variability in each treatment for both sites and years.

Results

Soil moisture content measurements exhibited that the applied weather manipulations significantly differed from control conditions. As shown by table 1, for both sites and depths, drought treatments registered the lowest mean values of soil moisture, significantly different from the control; while the additional rain ones experienced the higher mean values, significantly different from the control only at the soil surface.

Table 1: Mean soil relative moisture (%) at both sites and depths (0 cm and 10 cm) for the three treatments. Different letters in the same line, indicate significant differences in mean values (Mann-Whitney U-test; $P \leq 0.05$).

		Control	Drought	Additional rain
Site N	0 cm	93.88 **a**	89.98 **b**	96.19 **c**
	10 cm	101.94 a	101.44 **b**	102.05 a
Site S	0 cm	90.03 **a**	83.84 **b**	93.21 **c**
	10 cm	97.98 a	96.74 **b**	99.13 c

As expected, significant effect of the shelters were noted also on soil temperature. The mean difference between roofed and non-roofed plots in the site N at 0 cm and 10 cm depth was respectively 0.66°C (4.1%, P = 0.009) and 0.95°C (7%, P = 0.000); while in the site S the mean difference was respectively 1.02°C (5%, P = 0.014) and 0.67 (3.6%, P =: 0.004).

In both sites the lowest values of total above-ground biomass were registered in the drought treatment, while the higher values in the additional rain one. This is true for both the vegetative seasons analysed.

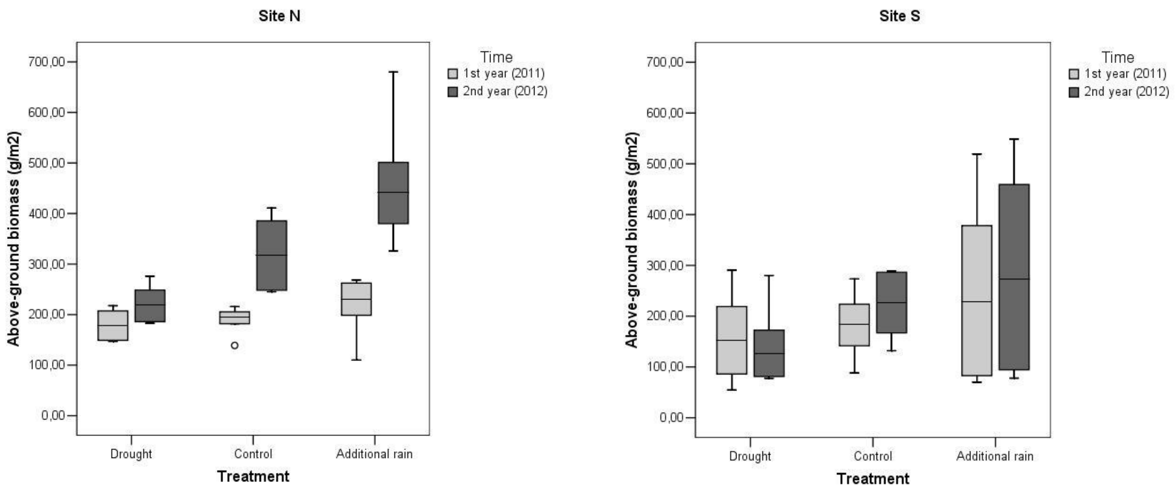
With respect of the effect of the treatments and time on mean above-ground biomass values, the repeated measures ANOVA shows for the site N a significant effect of the treatment (p: 0.003) and of treatment*time (p: 0.020). While, for the site S, not significant effects are registered.

Analysing separately each year, only the second one (year 2012) in the site N shows significant differences in mean values between the two experimental treatments (drought and additional rain) (Table 2, Figures 3a and 3b), but there are not significant differences between each experimental treatment and the control.

Table 2: Mean values of above-ground biomass (g/m²) per treatment and year. Different letters in the same line, indicate significant differences between means (p≤0.05).

		Mean values of above-ground biomass (g/m2)		
		D	**C**	**R**
Site N	1st year	182.00 a	189.25 a	215.25 a
	2nd year	226.25 **a**	332,00 **ab**	474.50 **b**
Site S	1st year	149.75 a	186.50 a	240.75 a
	2nd year	139.25 a	216.25 a	299.25 a

With respect of the biomass variability, the CVs indicate a surprisingly high variation in the experimental treatments (drought and additional rain) of the site S in both years; while the biomass variability in the three treatments of the site N is low (Table 3).



Figures 3a and 3b: Mean above-ground biomass values (g/m²) in both sites per treatment in each year (2011 in light grey, 2012 in dark grey).

Discussion

During the two seasons of weather manipulation, fixed shelters proved to be effective tools for altering the amount of rainfall. Anyway it is likely that, especially during the major rainfall events, a certain quantity of rain penetrated below the shelters due to the water runoff.

Grime et al. (2000) states that different plant communities, when exposed to changes in temperature and precipitation, will respond in different ways and, crucially, at different rates. Our results confirm this statement.

Table 3: Coefficient of variation (CV, standard deviation divided by the mean) as a measure of above-ground biomass variability.

		CV biomass	
Site	Treatment	1st year	2nd year
N	D	0.18	0.18
	C	0.16	0.24
	R	0.30	0.29
S	D	0.67	0.63
	C	0.39	0.33
	R	0.83	0.71

The stony south-facing slope (site S) shows no significant differences in above-ground biomass for treatment, indicating a certain resistance of this system. According to the exposition and soil features, this environment frequently experiences dry conditions in summer, and it is likely that this plant community is buffered to a certain degree of drought. In any case, for both years, the system shows a high level of biomass variability (CV) in experimental treatments (D and R) demonstrating the importance of the fine scale soil heterogeneity in the response to extreme events.

In the north-facing slope, after two years of recurrent extreme drought and increased rainfall, the biomass production differed significantly between the climatic extremes (D vs R). However, surprisingly, differences were not significant against the control. This means, that similar as in temperate grassland systems (GRIME et al., 2008; KREYLING et al., 2008b), sub-Mediterranean systems prove to be buffered to a certain degree.

In any case, we should consider that functional groups or individual plant species may differ in their responses to environmental change (KLANDERUD, 2005); changes in the performance of one species or a functional group may change any current relationship between positive and negative plant-plant interactions, i.e. changes in competition between co-occurring species or growth forms.

Conclusion

The results after two years of extreme event experiment, show that the climate change (i.e. rainfall variability) can have important implications for sub-Mediterranean grassland mountain communities. The effects of climatic alteration on productivity, and thus ecosystem services of grasslands, underlines the crucial importance of future research on the outcome of climate change in these systems.

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Conference Volume | 5th Symposium for Research in Protected Areas | pages 103 - 112
10 to 12 June 2013, Mittersill

Differences in development paths of tourism and agriculture within abruzzo region protected areas

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Abstract

The paper presents an analysis of some indicators in mountain areas of Abruzzo twenty years after the institution of the two National Parks of Majella and Gran Sasso-Laga. In order to understand the development paths, insights on tourism, demographic processes and agriculture have been highlighted. The data show a transforming reality and some possible propulsive effects linked to the protected areas in the inner territories of the region, from the point of view of both agriculture and tourist development.

Keywords

Protected areas, development paths, population, tourism, agriculture, multiple correspondence analysis

Introduction

In statistical terms, Abruzzo mountainous areas account for 65% of the regional surface. Mountain municipalities are 166 out of 305 in total, with a population of 380.000 inhabitants, corresponding to the 28% of the total on a regional level. If we add to these numbers the municipalities classified as inland hill, we reach the number of 232 units that cover an area of 8,705 sq km, corresponding to the 81% of the region, with a population of 587.000 inhabitants, 44% of the total.

Twenty years after the institution of the National parks of Majella and Gran Sasso-Laga and of the Regional Park of Sirente-Velino, the protected surface of Abruzzo has reached the degree of more than 30 % of the region, considering also the historical National Park of Abruzzo, Lazio and Molise. For this reason, the Authors have considered interesting to conduct an analysis of the dynamics, which interested the inner municipalities by highlighting the lines of development that protected areas have undertaken.

The protected areas of the region include both mountains and hills territories, thus creating the conditions to investigate similarities and differences between the development paths of areas within the parks and outside them.

By looking at the population long-term trends, the tourism and food industries, in the present work we have tried to identify the difference in development paths according to a local dimension. The analysis has aimed at identifying: the different models of development in mountain areas, the relations with agriculture and tourism and the presence of those original paths that can feature a paradigmatic value, particularly with regard to regional protected areas (HODGE & MIDMORE 2008; MARSDEN 2009).

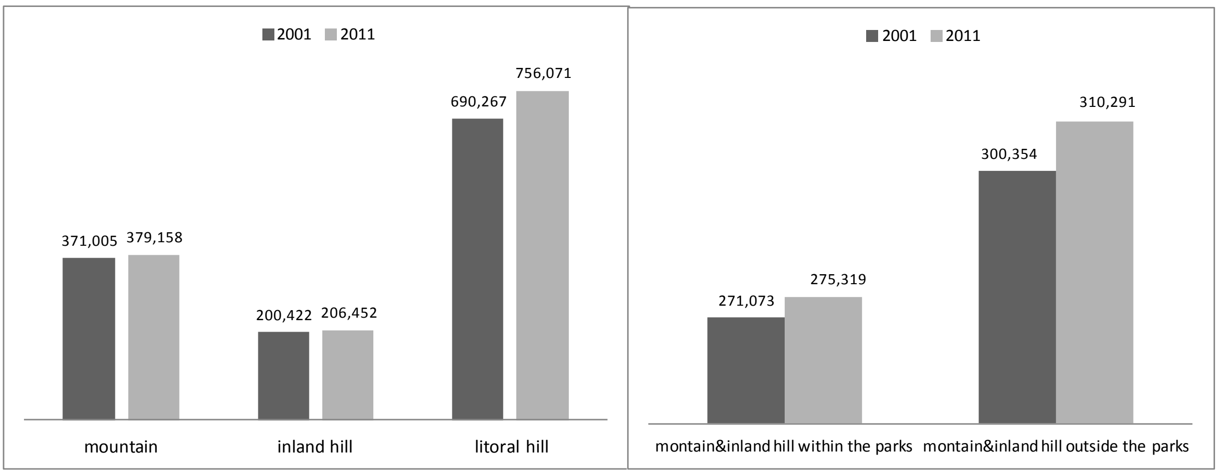

Figure 1: Population in the different altimetric areas, within and outside parks
(Source: Authors' elaboration on Italian National Institute of Statistics (Istat) data)

The interval time considered is the period 2000-2010 (except for the population data, referring to the period 2001-2011). It represents a period sufficiently large to ensure the full efficiency of protected areas in influencing local development dynamics. Through the use of a logistic regression model some factors have been extrapolated that characterize the socio-economic dynamics in mountainous villages, and that can be considered representative of the potential development of the region.

The trend of regional demography and territorial comparison

The analysis of the last decade reveals a relative impoverishment of the population in Abruzzo due to the falling of the birth rate, to the increase of elderly population and to migration. In 2011 the region records 1.342.000 inhabitants, with an increase in the decade (+6.3%) (Figure 1), albeit diversified among different geographical areas.

During the past decade, the mountain and inland hills municipalities outside the parks showed better demographic dynamics compared to those included in the parks. Furthermore, the dependency ratio (population aged 0-14 + population above 65 years / population 15-64 years) shows an improvement in mountain and inland hills municipalities, compared to the beginning of 2000, even if the ratio in litoral areas is much better (Figure 2).

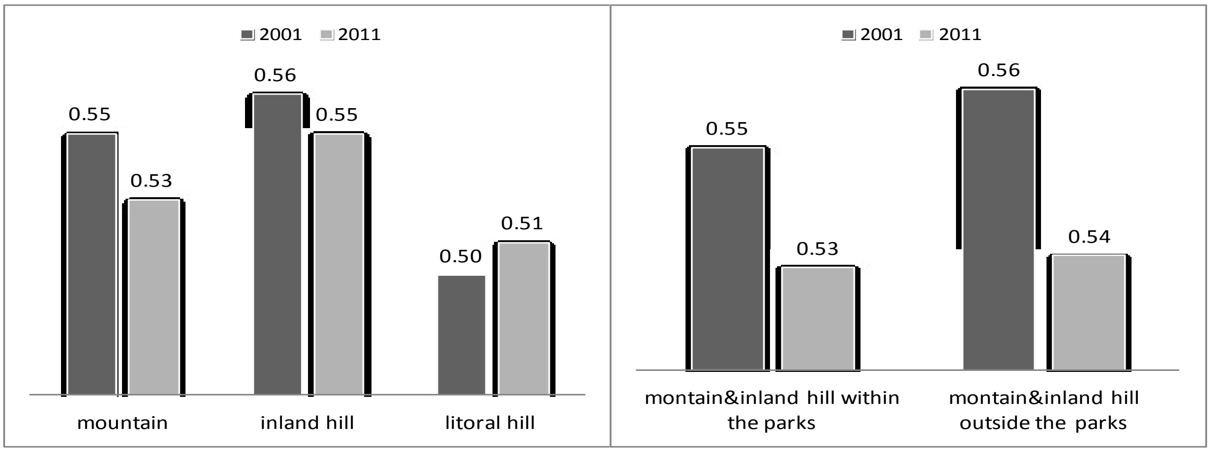

Figure 2: Dependency ratio in the different altimetric areas, within and outside parks
(Source: Authors' elaboration on Istat data)

The aging index (population over 65 / population 0-14 years) shows an extreme vulnerability of the mountain areas, especially in economical terms (Figure 3). Such a demographic structure - when combined with the lack of employment prospects as good as those existing in the coastal region - may constitute a risk to reduce the potential growth of productive fabric. But then, the aging index does not improve even in the municipalities within the parks.

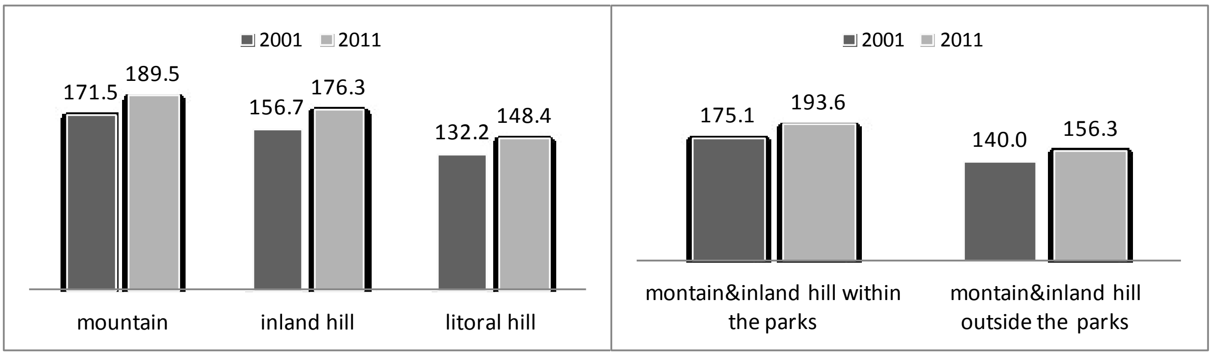

Figure 3: Aging index in municipalities divided per altimetric areas, within and outside the parks
(Source: Authors' elaboration on Istat data)

The analysis of the role of the natural increase and net migration rate reveals that the population growths outlined above are not generally attributable to natural growth but to the phenomenon of migration. In the referred period, there has been a large foreign immigration, especially in inland hills and mountain towns outside the parks (Figures 4 and 5).

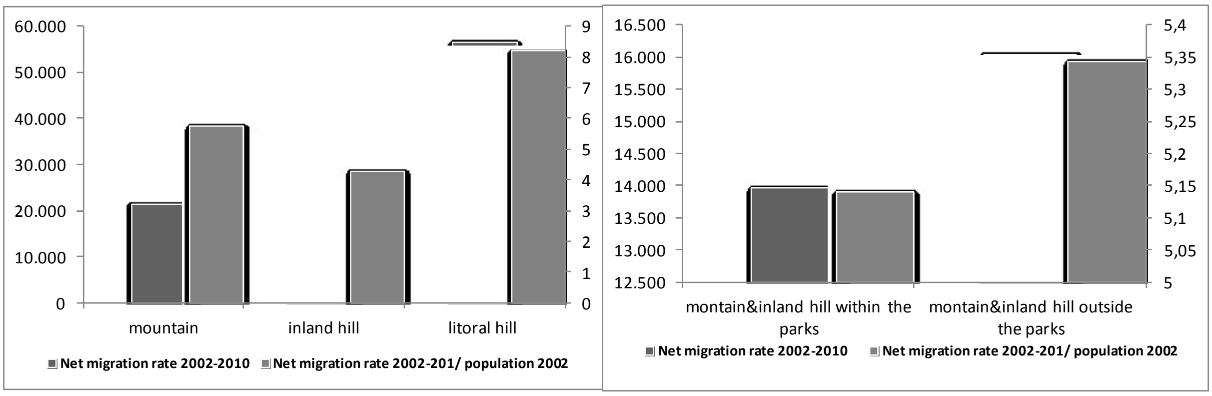

Figure 4: Net migration rate and migration rate over population
(Source: Authors' elaboration on Istat data)

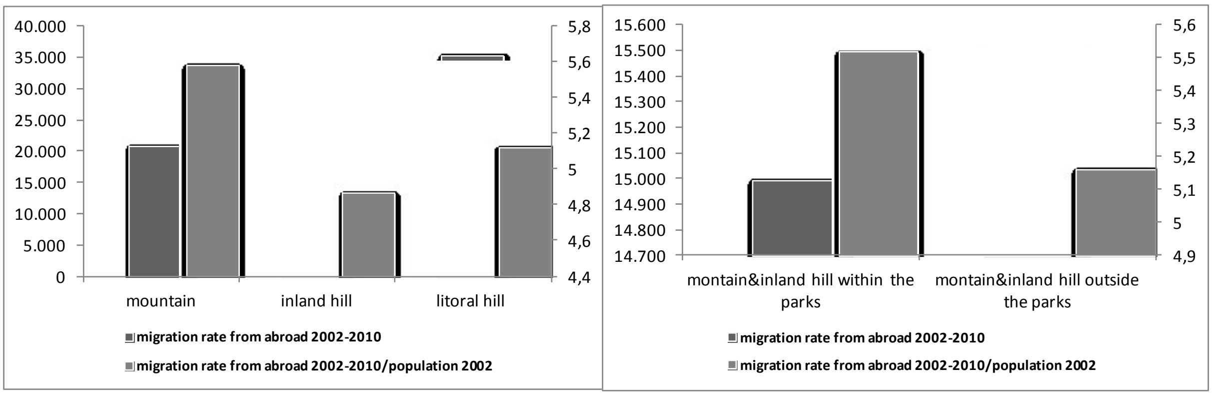

Figure 5: Migration rate from abroad and migration rate from abroad over population
(Source: Authors' elaboration on Istat data)

With special concern to the examination of the registry office movements, some meaningful migration fluxes from mountain areas toward the inland hills and the coastal cities can be highlighted. This is a phenomenon that should be monitored in future work to understand what the implications for local development asset might be (Barberis 2009). The changes occurred within the population show markedly negative balances. Mountain areas in general suffer a lot from this phenomenon, but and the areas included in the parks even more (Figure 6).

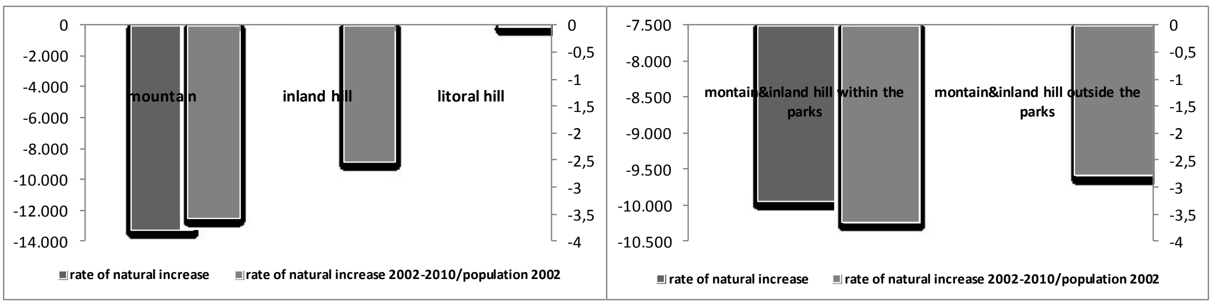

Figure 6: Rate of natural increase and rate of natural increase over population
(Source: Authors' elaboration on Istat data)

According to the analysis, the most important aspects to be mentioned are the progressive reduction of births and the persistence of negative natural balances, mainly in mountainous areas. The situation appears even more problematic in the parks areas. Because of that, they are also unlikely to reverse this trend on their own. The role of immigration in the process of development appears as a positive trait because is giving to mountain areas the possibility of acquiring new residents.

Analysis of mountain tourism in Abruzzo

In 2010, the municipalities in inner Abruzzo have accounted in terms of tourist supply, 1.224 accommodation establishments, corresponding to 54% of the region. The detail of bed places (numerically equal to 31% of the regional total) shows how the tourist facilities in these territories are have a smaller size compared to those in hillside and coastal areas.

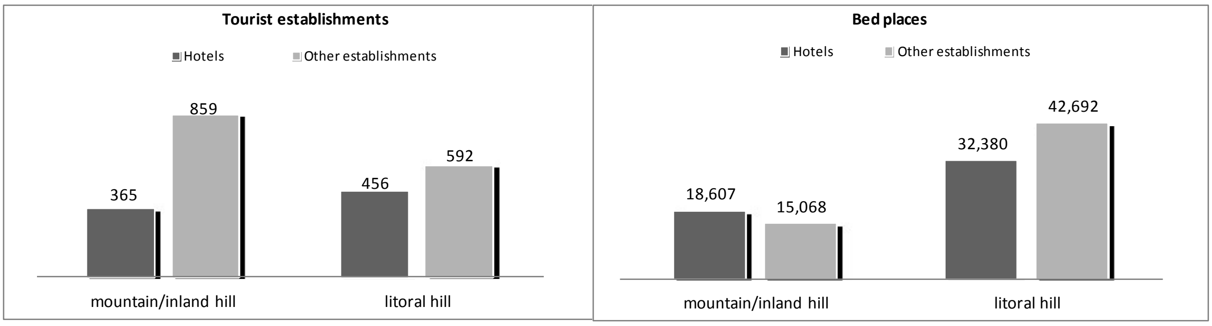

Figure 7: Comparison between different types of establishment and number of bed places, in 2010. Absolute values
(Source: Authors' elaboration on Abruzzo Region data)

At the special purposes of an analysis that proposes to evaluate the role of parks in tourism offer, it could be useful to read the data by focusing the attention upon agri-tourisms and B&B. Both types of facilities, in fact, compared to others, have a less impact in terms of architectural building and are more life-style oriented than hotels (CARLSEN et al. 2008). The territorial comparison shows that the agri-tourist facilities have a more meaningful incidence in inland areas, where they represent the 29% of the complementary offer in terms of number of establishments, even if both regional contexts the B&B is the most common type of accommodations in the non-hotel sector. The situation is completely different if the comparison is made on the basis of the distribution of bed places (Figure 9). In fact, both in the case of agri-tourisms and B&B, the incidence within the complementary sector is clearly lower compared to the numbers of the establishments. In the particular case of mountain and inland areas, instead, the data concerning the agritourist hospitality is quite significant because, in terms of beds, it represents the 19% of the total in the complementary sector.

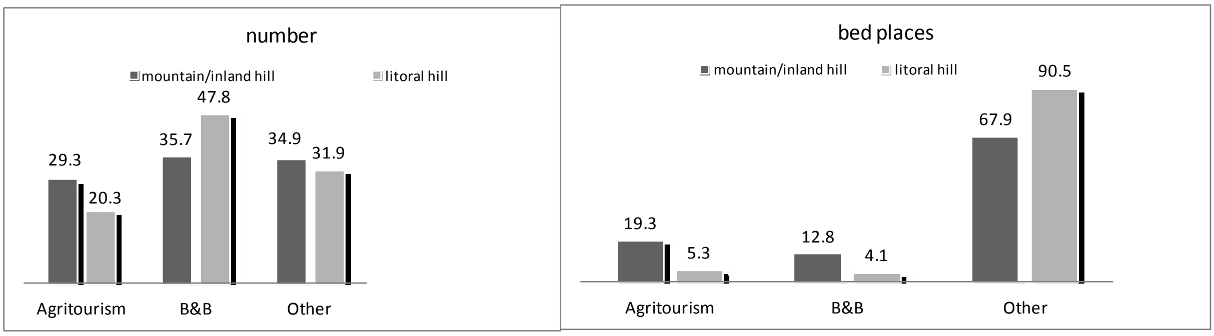

Figure 8: Comparison in the distribution of agritourisms and B&B, 2010 (%)
(Source: Authors' elaboration on Abruzzo Region data)

In order to analyse the dynamics in the development of these areas in terms of tourism, it could be useful to consider how the accommodation capacity has changed over the time (CST 2009). With reference to the period 2000-2010, the data record an overall increase (+89%) in the number of establishments in the context of mountains and inner hills, with an over 8% than in coastal territories.

Furthermore, the municipalities within the parks can exert a greater force in terms of attractiveness of tourist facilities. Among the 1.224 establishments existing in the mountain/internal hill areas, 66.7% of them is located in a protected area.

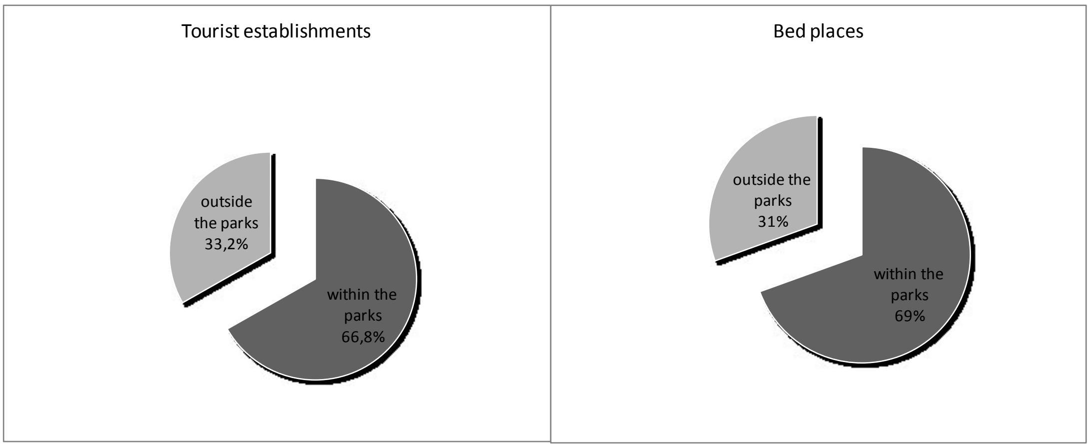

Figure 9: Distribution of accommodations and number of bed places, 2010
(Source: Authors' elaboration on Abruzzo Region data)

In percentage terms, being in or out of a park has led to a visibly differentiated increase of the accommodation capacity. In the protected areas the number of accommodation establishments increased of 96%, over 21% higher than the growth outside the park. The situation is similar, albeit with much lower rates for the beds, which increase more significantly outside the park (+36% compared to 21.8% of the beds in the park). The sector which has been most affected by this trend is the non-hotel, with an increase of the business equal to 227% within the park. Outside of a protected area, the number of non-hotel business generally tends to grow less.

Table 1: Accommodation capacity per type of accomodation in mountain/inner hill areas within a park and outside). 2000-2010 (absolute values and variation %; Source: Authors' elaboration on Abruzzo Region data)

	Type of accomodation	2000		2010		var. % 2000-2010	
		Number	Beds	Number	Beds	Number	Beds
Within a park	Hotels	250	13,378	273	14,171	9.2	5.9
	B&B			*201*	*1,239*		
	Agritourisms	*79*	*787*	*114*	*1,626*	*44.3*	*106.6*
	Other type of accomod.	*87*	*5,031*	*229*	*6,342*	*163.2*	*26.1*
	Non-hotels	166	5,818	544	9,207	227.7	58.3
	Total of establishments	416	19,196	817	23,378	96.4	21.8
Outside a park	Hotels	92	4,313	92	4,436	0.0	2.9
	B&B			*106*	*695*		
	Agritourisms	*120*	*881*	*138*	*1,277*	*15.0*	*44.9*
	Other type of accomod.	*20*	*2,375*	*71*	*3,889*	*255.0*	*63.7*
	Non-hotels	140	3,256	315	5,861	125.0	80.0
	Total of establishments	232	7,569	407	10,297	75.4	36.0

In order to integrate the analysis we have considered the rate of tourist function (the total number of beds available in a given area relative to the resident population) that can measure the density of accommodations in a specific area. From this emerges a better position of the coastal places, where beach tourism is a mature product.

Table 2: The rate of tourist function and variations (%), 2000-2010 (Source: Authors' elaboration on Abruzzo Region data)

	Mountain & inland hill	Litoral hill	Mountain & inland hill within the parks	Mountain & inland hill outside the parks	Regional total
2000	4.7	9.8	7.1	2.5	7.4
2010	5.7	10	8.5	3.3	8.1
var. %	1.1	0.2	1.4	0.8	0.7

The tourism intensity instead (indicating the accommodation potential of an area expressed in terms of places available per surface area), when detected at the different territorial contexts enables to measure the intensity of tourist movements. Even in this case the most attractive territory still remains the coastal one (Table 3). In the internal areas the decisive factor is represented, instead, by the presence of a park. To be a municipality of a protected area determines a shift toward the top of the index for more than three points.

Table 3: Rate of tourism intensity in different altimetric areas, 2010 (Source: Authors' elaboration on Abruzzo Region data)

	Inland areas	Litoral hill	Inland areas within the parks	Inland areas outside the parks	Region
Tourism intensity	2.95	7.41	4.63	1.45	5.46

The dynamic reading of the tourist flows shows an increase of hotel tourism, especially in the litoral hillside. In inland mountain/hill regions instead it seems to go down. It may be noted, however, an increase in extra-hotel accommodation, especially in protected areas (table 5). During the considered decade, the parks appear to have acted as a factor of attraction to tourists who seek an alternative to hotel accommodation. In this sector there has been an increase in arrivals equal to 145%.

Agriculture dynamics

According to provisional data of the Census 2010, the dynamics of agriculture show a reversal compared to previous decades. Against a decline of farms (-13% versus -32% on a national level) there is in fact an increase in both the Total Holding Land (THL) and the Utilized Agricultural Area (UAA), respectively of 3% and of 1.5%.

Such an increase, albeit slight, is in contrast with the national trend. Above all, it could represent a turning point related to the continuous loss of agricultural land that has occurred in the recent decades, and ultimately, a possible return to the importance of the agricultural sector compared to other economic sectors. This trend is accompanied from an increase in the average size of the enterprises (which have grown up to 20.2%) and from the concentration of farming in larger units (ABRUZZO REGION 2011). Precisely for this peculiar regional dynamics, it becomes important to verify the differences between the different geographical zones of the region.

Farms decrease in all altimetric areas but the contraction in inland mountain areas (-26%) is much higher than in other areas (respectively -9% and -10% in inner hills and in the litoral hills). There are significant differences between areas within the parks and areas outside the park, in their respective altimetric areas (Figure 10).

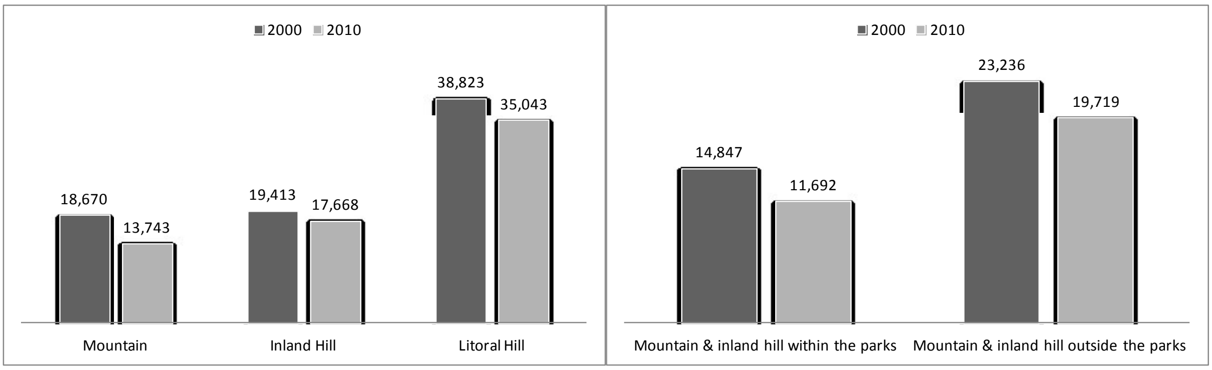

Figure 10: Variation number of farms 2000/10 per altimetric areas (Source: Authors' elaboration on Istat data)

The performances of the THL and UAA (Figures 11 and 12) are more complex. In these rates there is an increase in mountain areas (respectively of 6% and 4%), a stability in the inland areas and a decrease in hilly coastal areas (-3% for both). In mountain contexts, while the THL increases evenly both within the parks and outside them, the UAA increases of 1% in the municipalities within the protected areas and of 11% in the municipalities outside.

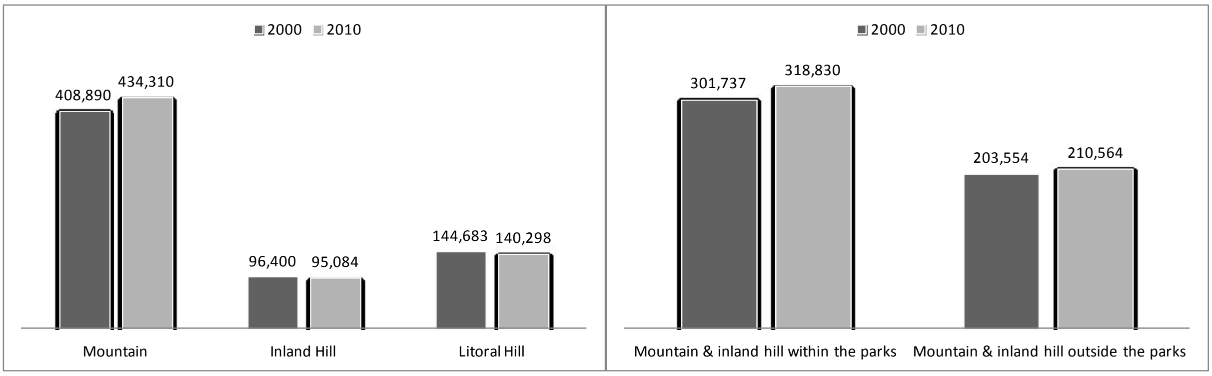

Figure 11: Variation of enterprises surface 2000/10 per altimetric areas (Source: Authors' elaboration on Istat data)

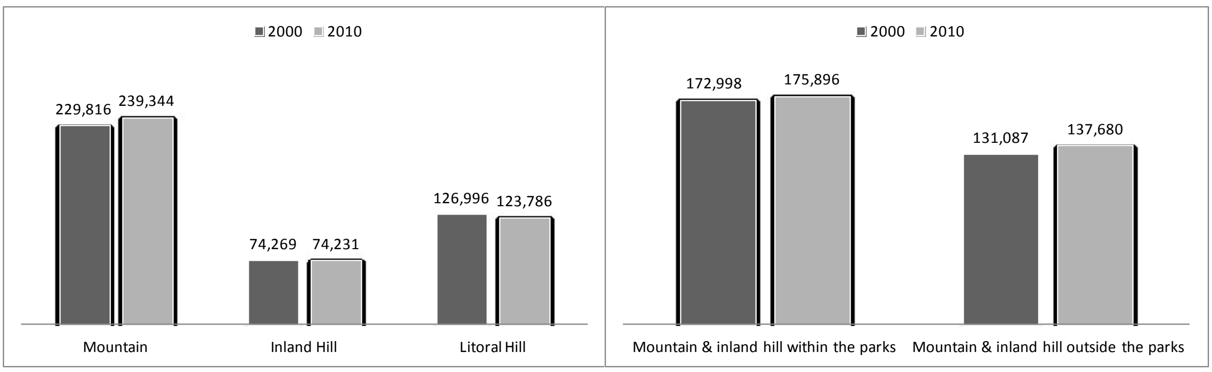

Figure 12: Variation of UAA 2000/10 per altimetric areas (Source: Authors' elaboration on Istat data)

Shortly, these developments show how both the use of land for non-agricultural purposes and the abandonment of agricultural land still remain - albeit in a limited way - in coastal and inland areas outside the protected areas. Instead, in the mountain and hilly areas of the parks, it seems evident an opposite trend. In the high mountain municipalities the number of farms is now so low that it is possible to assume that the cycle of economic conversion toward professional business has ended its course and that the remaining companies have reached a firm size sufficient to ensure farmers a certain profit.

The increase of agricultural area has also been characterized by a shift of the land availability, since the UAA property has reduced, the rent surfaces and free use ones have increased significantly, with different dynamics in different geographical areas (Figure 13).

This trend is related to the process of recomposition mentioned above, which highlights a limited number of companies in the mountain areas seeking by all means to reach that size production necessary to achieve an economical balance

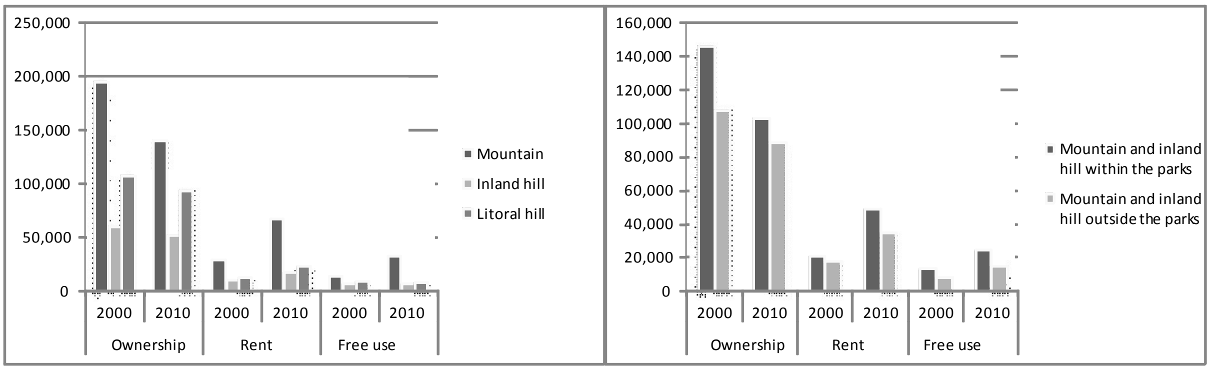

Figure 13: Variation of UAA in ownership, rent and free use
(Source: Authors' elaboration on Istat data)

With concern to the tenants, the proportion of people aged under 40 years is only 7% on a regional level, with a lower share than in 2000 (when they were 9%) and a decrease in absolute terms of almost 35%. The percentage has declined in all geographic areas except than in the mountain villages, where, instead, there has been a slight increase (from 9.2 to 9.8%). Once again, then there has been a specificity of mountain communities that have the relative share of young conductors larger than other regional areas.

Application of the logistic regression

The method of logistic regression has been chosen for its ability to define a model which shows the diversity of the context of mountains and inland hills with respect to the litoral hills one. The referred theoretical model is the one concerning the stochastic utility. Therefore, the observed phenomena allow us to go back, through their modelling, to the probability of the occurrence of a behaviour. Since we deal with an analysis of discrete choices, this family of econometric models is generally more suitable.

The data used for the application of logistic regression have been largely obtained from the official statistics and the 180 variables of the initial data-base have been reduced and, in part, transformed into dynamic variables, so obtaining a definitive data-base, consisting of twenty-three variables.

A first attempt to identify specific development paths of the park areas has had an unsatisfactory outcome from the statistical point of view and few possibilities of interpretation. The logistic regression model in this case has had a capacity of correct classification between municipalities within the parks and outside them of about 73%, using the following five variables, all statistically significant, listed in order of importance for the correct classification and the correlation sign into parentheses:

Table 4: Logistic regression. List of most significant variables

D_A_3 (+)	variation % UAA 2000/2010
D_T_20 (+)	absolute variation no-hotel tourist establishments 2000/2010
D_T_24 (+)	tourist intensity (overnights and population ratio)
D_T_25 (-)	tourist density (available bed places and surface area ratio) 2010
DIN_A_7 (-)	variation farms specialized in sheep and goats 2000/2010

Shortly, the interpretation of these results indicates that the municipalities located in the parks of Abruzzo, between 2000 and 2010, have distinguished themselves from the rest of the region for a more dynamic agricultural land used, for a better tourist performance and for a greater contraction in sheep and goats livestock.

A second attempt - through the use of the binary variable to verify the differentiation of mountain and inland hill communities from the coastal hill ones - has enabled us to obtain more satisfactory results, (Table 6) both from the point of view of the capacity of correct classification (representing 83% of the cases), and from the point of view of statistical significance of the seven variables present in Equation final, listed below in order of importance for the purposes of correct classification and with the sign of the correlation in parentheses:

Table 5: Logistic regression. List of most significant variables

DIN_A_8 (+)	variation farms 2000/2010 (source: CCIAA data)
D_A_3 (+)	variation % UAA 2000/2010
D_A_5 (-)	variation % farm women managers 2000/2010
D_A_6 (-)	variation % younger than 40 farm managers 2000/2010
D_A_7 (-)	variation farms specialized in sheep and goats 2000/2010
D_A_18 (-)	variation number of agritourisms 2000/2010
DIN_P_12 (-)	variation dependency ratio 2002/2010
DIN_P_13 BIS (-)	population natural increase rate 2002/2010 on population in 2002

This model is able to classify the 83% of the Abruzzo municipalities correctly. In particular, the positive dynamics of farms and the utilized agricultural area show a contrast of inland areas compared to the coastal ones. The demographic variables, though not particularly relevant for the correct classification made by the model, instead indicate signs of further aging and declining population of mountain communities and inland hills than coastal ones. Finally, the development of rural tourism seems to have more positive performance in coastal rather than in mountains. The same happens for innovative dynamics in the management of farms, such as the increase of the corporate management by young people and women.

Table 6 – Results of the logistic regression model

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	206,661[a]	,345	,517

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than ,001.

Classification Table[a]

Observed			Predicted MONT_COL ,00	Predicted MONT_COL 1,00	Predicted Percentage Correct
Step 1	MONT_COL	,00	42	31	57,5
		1,00	20	212	91,4
	Overall Percentage				83,3

a. The cut value is ,500

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	D_A_3	1,469	,545	7,251	1	,007	4,344
	D_A_5	-,046	,022	4,405	1	,036	,955
	D_A_6	-,078	,027	8,325	1	,004	,925
	D_A_7	-,301	,124	5,865	1	,015	,740
	DIN_A_8	2,920	1,334	4,788	1	,029	18,541
	DIN_P_12	-7,841	3,193	6,032	1	,014	,000
	DIN_P_13BIS	-37,023	5,914	39,184	1	,000	,000
	D_A_18	-,295	,146	4,096	1	,043	,745
	Constant	,724	,412	3,093	1	,079	2,063

a. Variable(s) entered on step 1: D_A_3, D_A_5, D_A_6, D_A_7, DIN_A_8, DIN_P_12, DIN_P_13BIS, D_A_18.

Through the comparison of these results with those obtained from the model applied to municipalities within the park / outside the park, though not statistically significant, we can notice that in general the context of internal mountains and hills is less differentiated in terms of tourist dynamics, compared to the coastal hillside, than the context underlined by the difference between municipalities within the park and outside the park. Thus, tourism seems to play a positive role in the path of virtuous development undertaken by the park areas, rather than in the general framework of internal mountain and hillside, especially if it will enhance synergies with a modern and renewed management of agricultural businesses.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 113 - 118

World Natural Heritage Sites – Triggers for Sustainable Development Processes?

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Abstract

World Heritage (WH) sites enjoy high popularity and their numbers are continuously increasing. Currently, WH status attribution raises diverse expectations in addition to conservation, particularly with regard to tourism or regional development. By means of a global survey on 128 of the 211 natural and mixed WH sites listed in 2011, this paper highlights these changing expectations towards WH status and the associated influence on sustainable regional development. The survey results show that WH sites do in fact contribute to sustainable regional development on different levels, especially if the concept is understood in its broader sense as a process that equally contributes to the advancement of social, economic and environmental goals on a regional level.

Keywords

World Heritage, conservation, tourism, sustainable regional development

Introduction

World Heritage (WH) sites enjoy increasing popularity, spearhead global conservation efforts, and are bound to a broad range of development expectations. This particularly holds true for the 211 World Natural Heritage sites, of which 28 are mixed natural and cultural sites (UNESCO WHC 2011). Although protected area labels (which include World Heritage) are discussed as a promising strategy to promote sustainable regional development (SIEGRIST et al. 2009; MOSE 2007; HAMMER 2003), these interrelations have received little attention in research on WH sites. In addition, most published work on WH sites and their effects are single case studies or commissioned studies (e.g. REBANKS CONSULTING & TBR 2009; HAMBREY 2007), meaning that consistent and comparative research on the effects and impacts of WH status attribution is largely missing.

For natural WH sites, being part of this "heritage of humankind" is no longer only about preserving natural and cultural values for future generations. Indeed, inclusion in "the list" raises various expectations in terms of promotion, marketing, tourism, and regional development (LI et al. 2008; SCHERER et al. 2005). This paper traces these changing motivations and compares them to the reality on the ground by drawing on the results of one of the first global and comparative surveys on WH sites and sustainable regional development.

Method

Based on a sustainability framework within the conservation-use context, a comprehensive set of questions with regard to WH sites, sustainable development, tourism and conservation was developed. This online questionnaire also integrated findings from the project "Benchmarking World Heritage & Tourism" which assessed the interrelationships between WH sites and tourism development (CLIVAZ et al. 2013).

The online questionnaire was available in six languages and sent to all 211 site managers of the natural and mixed WH sites listed at that time. The questions addressed the current state (also drawing on statistical data), the respective development trends, and the influence of the WH site listing.

The survey featured a very high response rate of over 60% – possibly an indication that there is an increasing interest in how WH site status can influence sustainable regional development processes. The following table (Figure 1) provides an overview of the data collected in the WH survey.

Building on the quantitative data, 12 in-depth interviews were carried out and complemented with 22 interviews from the aforementioned benchmarking study. Detailed analysis was performed with SPSS 21 for the quantitative data and Atlas.TI for the qualitative data.

		Survey	Listed Sites (2011)	Percentage
	Total Number	**128**	**211**	**61%**
Participating WH sites	Completed	123	183	58%
	Partially completed	5	28	2%
Geographical distribution	Africa	28	38	74%
	Arab States	4	5	80%
	Asia & the Pacific	27	61	44%
	Europe & North America	45	69	65%
	Latin America & the Caribbean	24	38	63%
Site types	Natural WH sites	113	183	61%
	Mixed WH sites	15	28	53%

Figure 1: Overview of data (own table)

Changing motivations for WH status

The WH convention was established in 1972 with the consciousness that natural and cultural heritage were increasingly threatened, that the disappearance of heritage was a loss to all the nations of the world, and that hence, increasing efforts to conserve outstanding universal heritage were necessary (UNESCO 1972).

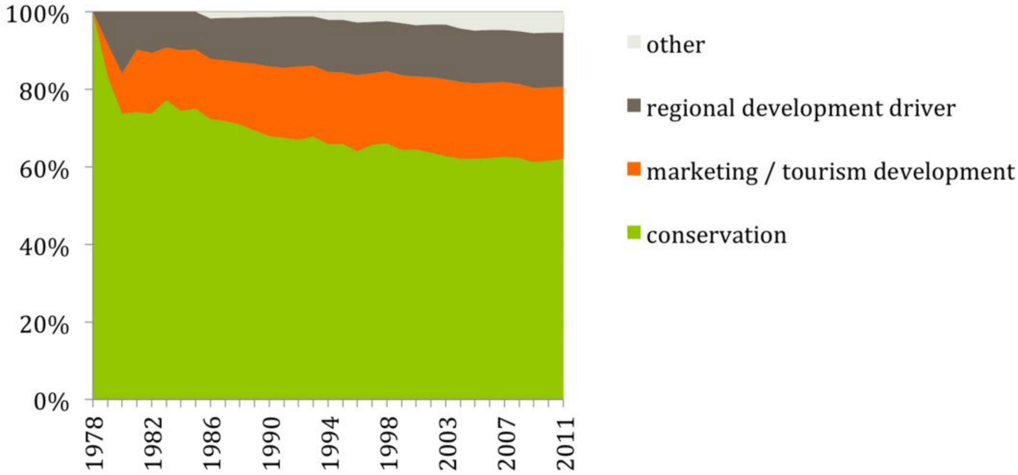

Figure 2: Main motivation for WH status application (by the main applying party preparing the candidature), own figure, n = 127, multiple answers possible

While conservation was the single most important reason when the WH status was created, additional expectations have emerged over time, such as the hope that the WH status will improve site attractiveness, promote tourism, or boost regional development in general (see Figure 2) (see also Conradin 2013). Results of the global survey indicate that the inscription of 63% of the participating WH sites was motivated mainly by conservation, whereas 37% had concrete expectations with regard to regional development and/or tourism development.

These changes in motivation for WH status from "pure conservation" to "conservation and development" can be seen as the reflection of a fundamental paradigm shift in the meaning and management of protected areas that took place in the course of the 20th century. In the light of progressing industrialisation and exacerbating environmental pollution in the early 20th century, "static-conservatory" approaches (Weixlbaumer 2005) were for a long time the gold standard of environmental conservation. However, such approaches are exclusive not only in terms of human interventions, but also in terms of participation and decision-making (Henderson 1992). The subsequent increase in protected area designations in the first half of the 20th century, as well as the emerging sustainability debate some decades later, eventually led to a paradigm shift that allowed more inclusionary concepts to thrive ("dynamic innovation approach", Weixlbaumer 2005). These concepts pay tribute to the fact that particularly in populated areas – which are, specifically because of the proximity of natural and cultural landscapes, often rich in habitats and biodiversity – exclusionary concepts were not only unrealistic, but would often not lead to a fulfilment of conservation goals. Today, it is widely recognized that conservation and development are mutually dependent (see e.g. Siegrist et al. 2009; Mose & Weixlbaumer 2006; Hammer 2003). Berghöfer (2010) even argues that "[...] calls for strict protection are not only misleading – they are unhelpful in delicate political processes of innovating conservation."

With regard to WH site designation, this paradigm shift does not only manifest in changing motivations – as shown in Figure 2 – but is also reflected in the increasing number of natural WH sites that constitute buffer zones: Of all natural and mixed sites inscribed between 1978 and 2000, only 6% had a buffer zone; from 2001 to 2011, the percentage had increased considerably, and 29 of the 51 newly inscribed WH sites were created with a buffer zone. On a WH policy level, these developments are partially reflected in the Durban accord or the Budapest declaration, which seek to equitably integrate the interests of affected populations into conservation goals and create synergies between conservation, the maintenance of life support systems and sustainable development

(UNESCO WHC 2007; WPC 2003). The WH Convention, as well as UNESCO's operational guidelines, remains unchanged.

Effects of WH status with regard to regional development

Certainly, these debates influenced the motivations of state parties to apply for an inclusion of natural heritage sites on the list. But can WH status really trigger sustainable regional development? It is important to remember at this point that regional development cannot only be understood as economic development, but as all processes and developments that contribute to an advancement of the environmental, economic and social issues within a defined region.

Participation and cooperation

With the changing paradigms in conservation approaches, participation of involved stakeholders with regard to protected areas management has increased in importance. Participatory and trans-sectoral decision-making processes that ensure that development needs and conservation goals are balanced are the foundation for sustainable regional development.

The attribution of the WH status has a significant influence on participatory processes. Of all participating sites, 56% found that participation had increased as a result of WH status attribution, specifically in areas such as management plan development, conservation, monitoring or conflict resolution, and had also led to greater international cooperation in conservation. Managers frequently mentioned the involvement of indigenous population groups and key industries in decision-making processes. With regard to cooperation, more than 75% of all participating sites felt the level of cooperation had increased as a result of WH listing. The ability of the site management to bring different stakeholders together so as to foster new forms of cooperation is probably one of the key factors promoting sustainable regional development.

These results are important, because only approaches that manage human utilisation instead of simply excluding it stand a chance of linking conservation and regional development goals. Despite the fact that from the quantitative data alone, no conclusion can be drawn about the quality of participation (i.e., whether stakeholders were primarily consulted, or whether they were really given a chance to play a part in developing a common vision and management approach, see also WALLNER & WIESMANN 2009), these figures still highlight how WH status can lay the foundations for broadly supported sustainable regional development processes.

Institutional management

Related to participation and cooperation are institutional management processes. Two thirds of all sites were of the opinion that the management of the site had improved due to WH status attribution. This is certainly a tangible effect of the operational guidelines of UNESCO that demand that each WH site develop a management plan and has a management body with clearly defined responsibilities. Clearly defined site management, as well as a management plan that takes into consideration both the conservation of the site as well as sustainable development is – just as participatory decision-making – a crucial basis to induce sustainable development processes.

Tourism and visitor numbers

WH status can have a significant influence on visitor numbers. More than 60% of all participating sites indicated that WH status attribution had resulted in more visitors. This effect has been extensively described in literature (LI et al. 2008; HAMBREY 2007; SCHERER et al. 2005; TISDELL & WILSON 2001). However, as SCHERER (2005) notes, these effects differ substantially according to whether a WH site is already an established "brand name" (such as, for e.g. the Galapagos Islands or Mt. Kilimanjaro) or whether it is a rather unknown site. In the latter case, the effect of WH status attribution is naturally more perceptible, as international recognition grows. Yet, apart from a quantitative growth, participating WH sites also indicated that the quality and range of tourism offers had improved as a side-effect of WH status, and that many tourism offers had become more sustainable (e.g. increased compliance with sustainability standards, improved tourism policies, eco-tourism offers). In addition, almost a third indicated that the attribution of WH status had a mitigating influence on the environmental pressures caused by tourism.

Environmental conservation

As mentioned, regional development is more than economic advancement. The specific landscape, local biodiversity or intact scenery are key resources of many of the inscribed sites. As such, conservation is a significant aspect of regional development. Despite the various meanings that WH status has for site managers, more than 80% of all sites are of the opinion that WH status contributes to the conservation of the outstanding universal values for which the site has been inscribed and just as many indicate that the condition of the site has remained stable or improved. Interviewees frequently commented that the importance of conserving a site increases with its inscription in the WH list, as the conservation of the specific values has now become a global concern (see also MATYSEK et al. 2006; SCHERER et al. 2005; WIESMANN & LIECHTI 2004).

Overall contributions to sustainable regional development

Participating site managers indicated numerous areas where WH status directly contributed to regional development and displayed a broad understanding of this concept in the sense of the definition aforementioned (see Figure 3).

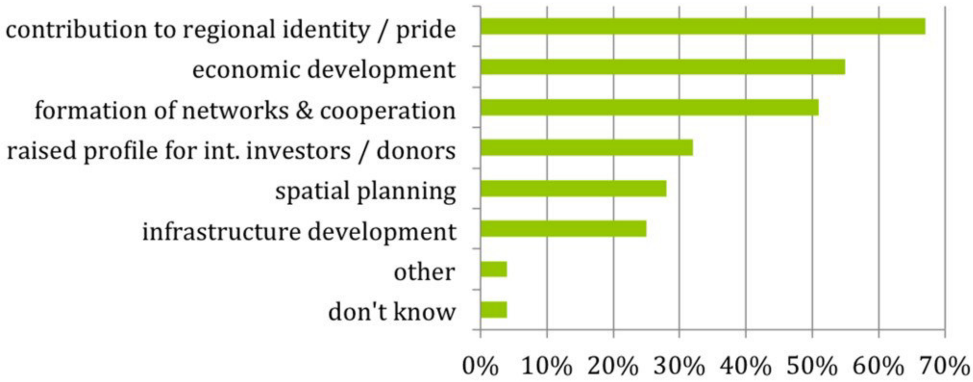

Figure 3: Contributions of WH status attribution to regional development in a broader sense, own figure, n = 118, multiple answers possible

Many stressed the contribution to the formation of a regional identity or of instilling regional pride (which is conducive both to social cohesion and participation/cooperation), but also suggested the raised profile for international donors and investors was a notable effect. The meaning of this contribution is perceived to be significant: A quarter of the involved site managers felt that WH status had "strongly fostered" and another 41% felt it had "generally fostered" sustainable regional development processes (for case studies see also CLIVAZ et al. 2013).

Discussion

The effects generated by WH status attribution are neither obvious nor generic. Apart from external factors such as specific context and socio-economic setting, the effects delivered by WH status are a result of clear goals, an effective involvement of and cooperation between different stakeholders, as well as a strong and capable management and the support of the local population.

However, results of the survey also clearly show that establishing a natural WH site can have a notable influence on regional development in a broader sense. In particular, the contributions of establishing a consolidated management, increasing cooperation (also international), and involving stakeholders are promising signs. Yet, WH sites do not automatically deliver benefits. Positive results are, as REBANKS CONSULTING & TBR (2009) conclude, "overwhelmingly the result of coordinated and well thought through efforts to achieve targeted change". Sites that do achieve benefits with regard to regional development had carefully planned the application process and the management plan, and had also identified issues at stake and how they could be addressed with WH status denomination.

Conclusion

WH status is, first of all, an opportunity that can – if well used – be instrumental in achieving defined targets with regard to sustainable regional development. However, the aforementioned survey has also shown that WH status attribution can and does result in perceptible benefits with regard to regional development. Though some of the effects induced do not directly result in net profits, to say that WH status attribution only results in "soft changes" falls short in many respects. First of all, it does not suffice to narrow down regional development as economic development. Sustainable regional development must imperatively be seen as a much larger process that encompasses social, institutional, and environmental aspects in addition to economic advancement. Yet all too often, the "missing link" between WH status and regional development is considered to be tourism.

Under the precondition that WH status is attributed following comprehensive guidelines that take into account today's reality (which is, that WH sites can in most cases no longer serve pure conservation goals), WH status attributions can act as a powerful catalyst for sustainable development in a broader understanding: be it in allowing stakeholders to take their fate into their own hands, by contributing to conserving essential means of livelihood or be it by actually contributing to making tourism more sustainable. WH status is no panacea – but it can be an important piece of the puzzle on the way to sustainable development.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 119 - 120

Effects of wildlife management in national parks on its populations - Where to go?

Dominik Dachs

Keywords

Wildlife Management, National Park, Kalkalpen, Ungulate Management, Disturbance, Natural Process, Predation

Introduction

Wildlife management, especially of wild ungulates, is a key aspect of national park management in Europe. The lack of natural densities of large carnivores in Austrian National Parks, leads to a substantial need for population control, as long as natural processes ought to be protected.

The interpretation of simulating natural population size limitations is very diverse in national parks throughout Europe and even within Austria. It ranges from a „no-control strategy" to very intensive culling including the use of bait. However most of the national park administrations are striving for a 75% core zone where no management is operated. While this "hands off" strategy suits perfectly for the management of more stationary parts of the ecosystem such as plants (e.g. zoning of phytosanitary management), it might not meet the demands of protecting wild ungulate populations from unnatural influence.

The wildlife management goals in national parks

<u>The IUCN Guidelines</u>

In the "Guidelines for Applying Protected Area Management Categories" published by the IUCN (DUDLEY 2008) we find a very clear definition on the goals in the various categories. For the category II, as all Austrian national parks are declared we find the following:

> *"Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities."*

With the primary objective:

> *"To protect natural biodiversity along with its underlying ecological structure and supporting environmental processes, and to promote education and recreation."*

And other objectives (1-3 out of 6):

> *-To manage the area in order to perpetuate, in as natural a state as possible, representative examples of physiographic regions, biotic communities, genetic resources and unimpaired natural processes*
>
> *-To maintain viable and ecologically functional populations and assemblages of native species at densities sufficient to conserve ecosystem integrity and resilience in the long term*
>
> *-To contribute in particular to conservation of wide-ranging species, regional ecological processes and migration routes;*

What does this mean for a population of red deer

At first we need to define the natural processes that need to be protected, according to the IUCN guidelines.

Red deer are the largest herbivores, present in Austrian national parks, and are capable of influencing the vegetation composition (AMMER 1996; VAN HEES et al. 1996; SCOTT et al. 2000). A prominent example of the interaction between deer (in this case *Cervus canadensis*), vegetation and even other mammals like beavers is documented for the Yellowstone ecosystem (FORTIN et al. 2008). Thus it is important to know how the quantity and the quality of the ecological impact is shaped.

<u>Environmental factors</u>

It is widely accepted, that environmental factors influence the behavior of deer. This is mainly due to the quantitative and qualitative availability of forage (KUIJPER 2011).

In Austrian alpine national parks these environmental factors can be considered as "natural" during summer months, whereas in winter artificial feed is provided in summer habitat, thus prohibiting seasonal migration. The seasonal migration is a natural behavior. Even if winter habitats are not available, the widely used strategy of well distributed artificial feeding sites, does not meet the objectives of a national park.

<u>Predation</u>

In northern ecosystems large predators limit the densities of herbivores (RIPPLE & BESCHTA 2012), although this effect varies with the productivity of the ecosystem (MELIS et al. 2009). Also the combination of large predators has different effects on its prey species compared to situations where species of predators are missing (RIPPLE & BESCHTA 2012).

Austrian national parks lack the existence of large carnivore species inventory in sufficient densities, necessary to keep up the natural process of limiting the numbers of wild ungulates. Every national park in Austria controls the population of red deer (where the species is present) artificially, because overpopulation is expected to cause various problems (ANONYMUS 2011).

The density of ungulates alone is not the only factor influencing their impact on vegetation. Indirect effects of predation are key drivers of the spatio-temporal behavior in many prey species (BUSKIRK et al. 2002; SCHMITZ et al. 1997) by creating a "landscape of fear" (LAUNDRÉ et al. 2010). In response to this, prey species alter their behavior and thus their impact on the vegetation changes.

The "landscape of fear" is widely ignored as a key natural process in our ecosystems. Without anti-predation behavior, ungulate species are kept in a system that is far from being natural.

For protecting the natural processes in national parks without predators, the question is not if population control is maintained, but rather how it is done (CROMSIGT et al. 2013).

Regular hunting is a very poor substitute for imitating the "landscape of fear" normally created by large carnivores (PROFFITT et al. 2009) and contains great risks to the objectives of the national parks. Human hunters can select by unnatural behavioral criteria (MILNER et al. 2007) or have negative genetic effects (COLTMAN et al. 2003).

Conclusion

The future challenge for national park administrations will be to set up a high quality program to ensure the natural process of predation, as long as there are not enough natural predators present. Wildlife managers in national parks should be strongly encouraged to keep an eye on how population control is carried out in their areas regarding the objectives of the IUCN category.

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Conference Volume | 5th Symposium for Research in Protected Areas, 10 to 12 June 2013, Mittersill | pages 121 - 124

Mercantour-Alpi Marittime Generalised Biological Inventory: An Example of Successful Collaboration between Protected Areas Managers and Taxonomist

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Abstract

This article aims to highlight the strong collaboration built between protected areas managers and taxonomists, in the framework of the Mercantour/Alpi Marittime Generalised Biological Inventory.

Keywords

ATBI, Generalised Biological Inventory, Inventory, Biodiversity, Taxonomy, Protected Areas, National Park, Natural Park, Mercantour, Alpi Marittime.

Introduction

Since 2007, the Mercantour National Park (MNP) and the Alpi Marittime Natural Park (AMNP) have been endeavouring to enhance their knowledge of their natural heritage through the first exhaustive inventory of the biodiversity on their territories : the Mercantour-Alpi Marittime Generalised Biological Inventory (formerly ATBI+M: Mercantour-Alpi Marittime All Taxa Biodiversity Inventory+Monitoring) (DE BIAGGI et al.2010).

Due to its geographical location, varied geology and altitudinal gradient, our territory includes great diversity of habitat. It is thus home to an exceptionally high number of species and is considered to be a biodiversity hotspot on a planetary scale (MÉDAIL & QUÉZEL 1997). The scientific community therefore finds it extremely attractive.

D'après Médail F. & Quézel P., 1997. *Annals of the Missouri Botanical Garden*, 84.

However, a substantial part of its biodiversity remains to be discovered and listed, notably in groups that are less studied such as insects, bryophytes and lichens, etc...

It is to this end that our two parks decided to implement a joint Generalised Biological Inventory, the first inventory on such a large scale in Europe and the second one in the world.

The National Natural History Museum of Paris has been striving to improve knowledge of the Mercantour - Alpi Marittime territory since 2001, harnessing the parks expertise to carry out inventories of spiders and molluscs in the MNP. When the European Distributed Institute of Taxonomy (network of excellence in taxonomy) was created in 2006, and offered to help set up exhaustive biodiversity inventories (then called ATBI+M (All Taxa Biodiversity

Inventory + Monitoring)), the National Natural History Museum backed parks' application to become the site for the first European ATBI+M.

Thanks to this scientific guarantor, and to the reputation of our structures and our territories, our application was accepted. From as early as December2006, we could therefore rely on the scientific community linked to EDIT (i.e. a network of over 250 taxonomists from all over Europe), with the network growing as the project advanced, notably thanks to non-professional taxonomists who joined in along the way, and the involvement of local networks of naturalists. Today, almost 350 taxonomists work hand in hand with us to take our inventory forward.

Methods

We decided to concentrate on the least known taxa (i.e. invertebrates and non-vascular flora), but without neglecting other better studied taxa (such as herpetofauna, mammals and vascular flora). Many prospection campaigns were carried out in the least investigated natural environments (cavities, hyporheic zones, etc).

Prospection campaigns take place between May and October, weather permitting, and take two forms:

- Either the scientists come individually and decide themselves where they will prospect, heeding recommendations from the parks. They are only authorised to collect taxa they can identify or must provide us with the list of the taxa they wish to collect and of the competent individuals to whom they wish to send them. The travel and accommodation costs of these researchers are reimbursed.
- Or scientists come in teams. In this case, prospection sites are co-determined with the parks for a programme lasting from 2 to 4 years. These prospection campaigns frequently involve a high number of taxa, with the specimens shared out among the team. These scientists benefit from an agreement with the parks covering their travel and accommodation expenses plus certain other costs related to the inventory (collection equipment, sample sorting, etc).

Research carried out by the teams is relatively easier to monitor and organise than individual research, although the two types of prospection are complementary.

Setting up an interception trap (photo: Elise Minssieux)

Results

After the specimens have been collected, the identification phase can take from a few weeks to several months, depending on taxonomic group and the quantity of material collected. We then ask each researcher (or team of researchers) to provide us with a list of species collected (which is then entered into the National Natural Heritage Inventory (INPN) (http://inpn.mnhn.fr)) plus a report commenting on the list (What extrapolations can be made based on the species collected? Which are rare species? Endemic species? etc).

Currently, 61.000 data concerning more than 10.000 species have been integrated in the INPN; all these data are shared with the MNP and AMNP managers, but the imprecise data are also available for consultation by the public (communal scale).

Collected specimens are kept by the collectors, apart from one specimen per species that is sent to the National Natural History Museum if collected in France, or to the Regional Natural Sciences Museum in Turin if collected in Italy.

Our project also incorporates the option of carrying out molecular studies (barcoding) on collected taxa, to find out more about their systematics and/or phylogeny. These studies are carried out either by the Molecular Systematics Department at the National Natural History Museum, or by the CBGP (Centre for Biology and Management of Populations).Over 2,000 sequences of the gene CO1, concerning at least 434 species, have already been published. This work is already starting to bear fruit, advancing taxonomy (species divided into a species complex, etc).

Discussion

As we expected, no major discoveries have been made in the field of vertebrae. Apart from better knowledge about its spread, vascular flora did not bring any huge surprises either, apart from one species that is new to France (*Moehringia argenteria*). On the other hand, however, the inventory has considerably increased our knowledge of the invertebrate world: in six years of prospection, the number of listed species in our parks has tripled, and many families have not yet even had the opportunity to be prospected! Another example is lichens. The inventory of lichens in several valleys of the MNP produced a list of 1,277 species of lichen compared to 426 before the inventory. 16 are new species for science, 1 new for Europe, and 53 are new for metropolitan France. Similarly, in the AMNP, 193 species were listed. This represents an increase of almost 60% in the number of species known for that zone. Our knowledge about bryophytes (taxonomic group including mosses and non-vascular plants) has been considerably enriched, too. 183 species have been listed, including 39 that are rare and interesting from a conservation point of view, plus 7 that have never seen before in the Piemonte region.

Most of the discoveries pertained to the arthropod group. Several hundred species were observed for the first time in the two parks; dozens are new fauna for France and Italy, and approximately thirty are waiting to be described (i.e. new for science). As an example, we can mention the description of the coleopter sub-species *Duvalius magdelainei tordjmani*, harvested in 2010 in a cavity in the Roya Valley by the Terrestrial Biospeleology Group. At the Parco Naturale Alpi Marittime, a species of troglobite arachnid that lives exclusively in caves and is new for science has been described under the name *Troglocheles lanai*.

Conclusion

In the long run, this inventory will enable us not only to learn more about our natural heritage, but also to understand better how our ecosystems function. We are currently setting up a number of monitoring projects to help assess the impact of human activities on our territory, so that it can be managed optimally. The impact of climate change will also be studied when monitoring the spread of certain alpine species.

The Generalised Biological Inventory did not focus exclusively on the scientific and technical aspects of the survey of biodiversity in the Marittime-Mercantour sector. It also addressed the fields of education, science teaching and communication in an effort to heighten the awareness of a broad audience about environmental dynamics and the role man and his activities play. Taxonomy Summer Schools were organised for students and academics, and educational activities and naturalist excursions for schoolchildren. Finally, photo exhibitions entitled "Taxon" and "Inventaires sans Frontières" (Inventories without Borders") were organised jointly with the museums in Turin (Regional Natural Sciences Museum) and Paris (National Natural History Museum), exposing this inventory project and, more generally, taxonomy andits role in understanding biodiversity, to large numbers of people.

Our initiative has encouraged other European protected areas to start their own Generalised Biological Inventory: Muranska Planina National Park (Slovakia) in 2008, and Spreewald Biosphere Reserve (Germany) in 2010.

Our project has been funded by France's Ministry of Ecology, EDIT, the Albert II of Monaco Foundation, the Monegasque government, and the European Regional Development Fund - Alcotra 2007-2013 programme.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 125 - 130

Natural floodplain dynamics shape grasshopper assemblages of meadows in the Donau-Auen National Park (Austria)

Agnes Demetz, Konrad Fiedler, Tobias Dreschke & Christian H. Schulze

Abstract

Flooding events are an important factor shaping arthropod communities on riverine meadows. We investigated to what extent species diversity and species composition of grasshopper assemblages on meadows in the Donau-Auen National Park (Lower Austria) are affected by annual floods. Grasshoppers were sampled between June and September 2012 on 12 meadows prone to yearly summer inundations, and 13 meadows protected from such floods by a levee. All acoustically and visually detected individuals were counted. Excluding one stray species not associated to meadows and representatives of the genus *Tetrix*, which cannot be recorded reliably with our sampling method, a total of 24 grasshopper species were recorded. Species richness was nearly identical on both meadow types. However, species composition differed prominently between regularly flooded and non-flooded meadows. Furthermore, we compared local incidence of all 24 species (quantified as percentage of colonized meadows) with their regional occurrence (quantified as percentage of 6250 m x 5550 m grids with records in Eastern Austria). Accordingly, hygrophilous species are more prevalent in the Donau-Auen National Park than expected from their regional occurrence. Our study provides strong evidence that natural floodplain dynamics still have a significant impact on species composition of meadow grasshopper assemblages in the Donau-Auen National Park. Hence, maintaining high hydrological dynamics (e.g. by river restoration measures) will be a precondition to successfully protect the characteristic fauna of floodplain meadows.

Keywords

Caelifera, Ensifera, species richness, species composition, habitat preferences, Danube floodplain, Eastern Austria

Introduction

Hydrological dynamics are important to shape the community structure of aquatic and terrestrial plant and animal communities of floodplain ecosystems (Ballinger et al. 2005, van Diggelen et al. 2006, Reckendorfer et al. 2006; but: Truxa & Fiedler 2012). So far only few studies have addressed potential effects of flood events on richness and composition of grasshopper communities (Fischer & Witsack 2009, Dziock et al. 2011). In the present study, conducted in one of Europe's largest remaining floodplain ecosystems located in the Donau-Auen National Park (Lower Austria, east of Vienna), we investigated whether grasshopper communities on meadows prone to summer inundations differ from those on meadows that are no longer subject to natural river dynamics.

Particularly, we addressed the two following questions:

(1) *To what extent are local grasshopper assemblages shaped by flooding events?* We expect that regularly flooded meadows show a lower species richness than non-flooded meadows and are characterized by a different species composition due to a higher dominance of hygrophilous flood-resistant habitat specialists.

(2) *Are hygrophilous grasshopper species more prevalent on a local scale (Donau-Auen National Park) compared to their incidence on a regional scale (Eastern Austria)?* Local abundance of species is often correlated with their regional occupancy (Gaston et al. 2000). Due to flooding of large areas at high water levels of the river Danube, we expect that hygrophilous species are relatively more abundant in the national park than xerophilous species, when compared to their regional incidence in Eastern Austria.

Methods

Study area and study sites

This study was conducted in the Donau-Auen National Park north of the river Danube between the villages Schönau and Stopfenreuth (Fig. 1). The river-floodplain system of the national park has been constrained due to major river regulation measures since 1875 (Reckendorfer et al. 2006). However, it is still influenced by the dynamics of the river Danube due to water level fluctuations of up to 7 m amplitude throughout the year, which cause periodic and aperiodic overbank flows. Periodic floods occur from late spring to high summer due to the snowmelt in the Alps. Aperiodic floods can be caused by heavy rainfall (Nationalpark Donau-Auen 2013).

The study area is divided by a levee which protects the area situated to the north against flooding during periods of high water level. In contrast, meadows south of the levee are still flooded almost every year. Twelve meadows were selected south of the levee, and 13 meadows north of it. Mean size (± SD) of the selected meadows was 2.97 ± 1.54 ha (north of the levee) and 2.67 ± 1.61 ha (south), respectively, and did not differ significantly (t-test: $t = 0.46$, $p = 0.648$) between both groups of meadows.

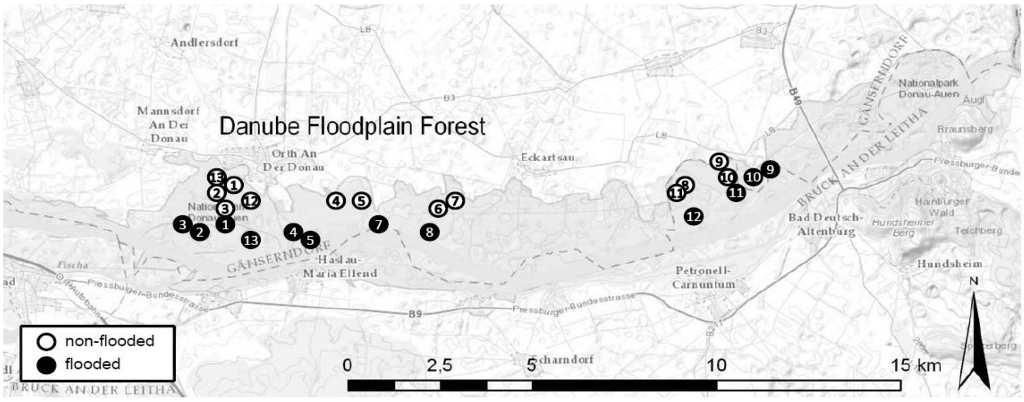

Figure 1: Map of the study area indicating regularly flooded and non-flooded meadows.

<u>Grasshopper sampling</u>

On each meadow grasshoppers were sampled once during each of the five sampling rounds: 18-22 June (sampling round A), 2-6 July (B), 23-27 July (C), 2-6 August (D) and 10-17 September 2012 (E). During sampling rounds A and C, grasshoppers were surveyed visually and acoustically for 15-30 minutes depending on meadow size by a group of 4 recorders who walked the entire meadow area. During the other three sampling rounds the first author counted all visually and acoustically detected grasshoppers along transects (50 m transect length per ha meadow area). All visually detected grasshoppers were caught for identification with a sweep net. Identification was facilitated by available field guides (BELLMANN 2006, BAUR et al. 2006) and song recordings (ROESTI & KEIST 2009). For each meadow, data from all five sampling rounds were combined as units of analysis. We excluded one stray species not associated with meadows (*Phaneroptera falcata,* one single recorded nymph) and all *Tetrix* species which cannot be reliably surveyed with our sampling method.

Table 1: Classification of habitat preferences of recorded grasshopper species and their Red List status in Austria (RL Austria) (BERG et al. 2005).

Habitat preferences	Species	RL Austria
hygrophilous	*Chorthippus albomarginatus*	NT
	Chrysochraon dispar	NT
	Mecostethus parapleurus	NT
	Ruspolia nitidula	NT
	Stethophyma grossum	VU
xerophilous	*Calliptamus italicus*	VU
	Chorthippus apricarius	
	Chorthippus biguttulus	
	Chorthippus brunneus	
	Euchorthippus declivus	
	Gryllus campestris	
	Leptophyes albovittata	NT
	Metrioptera bicolor	NT
	Omocestus haemorrhoidalis	VU
	Platycleis albopunctata grisea	NT
	Stenobothrus lineatus	
indifferent	*Chorthippus dorsatus*	
	Chorthippus mollis	NT
	Chorthippus parallelus	
	Conocephalus fuscus	NT
	Euthystira brachyptera	
	Metrioptera roeselii	
	Pholidoptera griseoaptera	
	Tettigonia viridissima	

<u>Data analysis</u>

To compare species richness of grasshopper assemblages, randomized species accumulation curves were calculated for regularly flooded and non-flooded meadows using the software EstimateS (COLWELL 2013).

Similarities between species assemblages were quantified by Bray-Curtis similarities (calculated using square-root transformed abundances) for all combinations of meadows. Then, similarity relationships between grasshopper assemblages of sampled meadows were visualized in a non-metric twodimensional scaling (NMDS) ordination (CLARKE 1993). To test for differences in species composition of grasshopper assemblages between flooded and non-flooded meadows, an analysis of similarity (ANOSIM; with 999 permutations) was calculated with the program Primer (CLARKE & GORLEY 2001).

Regional occupancy of grasshopper species was quantified as the percentage of occupied grids (6250 m x 5550 m) from the distribution atlas for Eastern Austria (ZUNA-KRATKY et al. 2009). Local occupancy of species was quantified by our surveys as the percentage of meadows in the Donau-Auen National Park, where the respective species had been recorded. Then, local occupancy of species was plotted against their regional incidence. Subsequently, for each species the deviation of its local occupancy from the expected value if local occupancy were equal to regional occupancy was measured. Positive deviations indicate a higher local occupancy than expected by chance, and negative values a lower local occupancy compared to the species' regional occupancy. Finally, we calculated a Kruskal-Wallis ANOVA to test for differences in these deviations of local from regional occupancy across three classes of grasshopper species: hygrophilous species, xerophilous species, and species with no clear habitat preference relative to humidity ("indifferent species"). Classification of species according to their habitat preferences was based on the information provided by ZUNA-KRATKY et al. (2009) (Table 1).

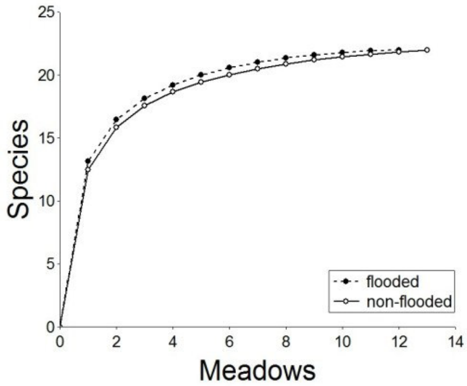

Figure 2: Randomized species accumulation curves for grasshopper assemblages on flooded and non-flooded meadows.

Results

<u>Species richness and species composition on flooded vs. non-flooded meadows</u>

A total of 24 grasshopper species (excluding *Phaneroptera falcata* and *Tetrix* species) were recorded (Table 1): 22 species on flood-prone and non-flooded meadows, respectively. Species accumulation curves calculated for regularly flooded and non-flooded meadows also indicate near identical species richness (Fig. 2). Species composition, however, differed markedly between flooded and non-flooded meadows (one-way ANOSIM: R = 0.34, p < 0.001). Distinct grasshopper assemblages on both meadow types were also indicated by the NMDS ordination based on Bray-Curtis similarities. Grasshopper assemblages of flooded meadows aggregate in the left half, those of non-flooded meadows in the right half of the ordination plot (Fig. 3).

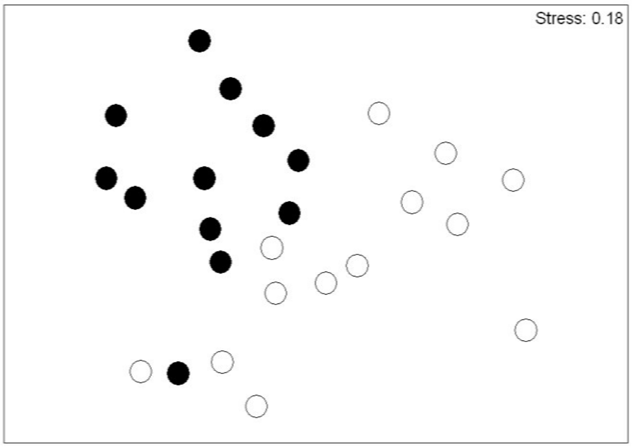

Figure 3: Similarity relationships between grasshopper assemblages sampled on flooded (filled circles) and non-flooded meadows (empty circles), visualized in a non-metric twodimensional scaling ordination. Similarities between species assemblages were quantified by Bray-Curtis similarities calculated using square-root transformed abundances. The low stress value (<0.20) indicates acceptable representation of the similarity relationships in the two-dimensional ordination.

<u>Local vs. regional incidence of species</u>

Deviations between species' local occupancy and regional incidence (Fig. 4) differed significantly between grasshopper species with contrasting habitat preferences (Kruskal-Wallis ANOVA, $H_{2\mathrm{df}}$ = 9.09, p = 0.011). Hygrophilous species were characterized by a higher local occupancy than expected, whereas species classified as xerophilous or indifferent had a lower occupancy than predicted (Fig. 5). The only xerophilous species which occurred on a higher fraction of meadows than predicted was *Stenobothrus lineatus* with a regional occupancy of 55% and a local incidence of 97% (Fig. 5).

Discussion

Remarkably, regular flood events did not prove to affect species richness of grasshopper assemblages on meadows in the Donau-Auen National Park. Also FISCHER & WITSACK (2009) found a high similarity of grasshopper assemblages on flooded and non-flooded meadows of the Elbe floodplains (Germany). However, in our study inundation had a strong effect on the species composition of grasshopper assemblages. Some hygrophilous species were more abundant or exclusively occurred on regularly flooded meadows, while the opposite was true for several xerophilous species. For example, the two xerophilous species *Chorthippus apricarius* (recorded on one meadow) and *Platycleis albopunctata grisea* (four meadows) were only found on non-flooded meadows. Examples for hygrophilous grasshopper species exclusively observed on flooded meadows were *Euchorthippus declivus* (2 meadows) and *Stethophyma grossum* (3 meadows). In contrast to our study area, where flood events typically occur in early summer, the Elbe floodplains are usually flooded in spring, when the majority of grasshopper larvae still have not hatched from the eggs. The egg phase is the only life-history stage for most grasshoppers to survive flood events (FISCHER & WITSACK 2009). Hence, summer floods as typical for the Danube floodplains have a much higher potential in shaping the composition of grasshopper assemblages, resulting in a higher prevalence of hygrophilous species on flooded meadows.

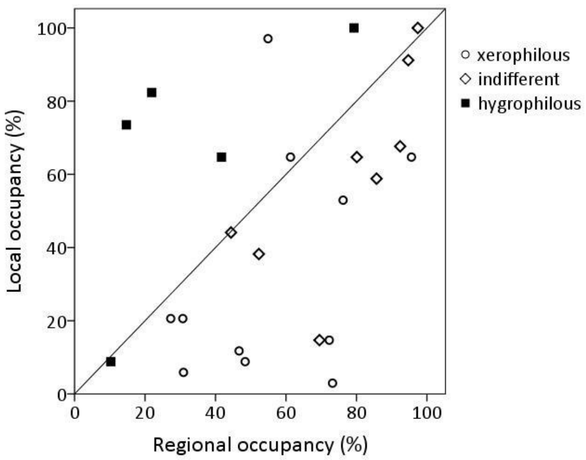

Figure 4: Relationship between local and regional occupancy of 24 grasshopper species, classified into three types of habitat affiliation. Local occupancy was quantified as the percentage of colonized meadows in the Donau-Auen National Park (own data), regional occupancy in Eastern Austria was quantified as percentage of 6250 m × 5550 m grids, from which the species had been recorded (ZUNA-KRATKY et al. 2009). An identical local and regional occupancy is indicated by the line.

The importance of the Danube floodplains for hygrophilous species was confirmed by the comparison of local to regional occupancy. Hygrophilous species proved to show a higher local incidence on meadows in the Donau-Auen National Park, compared to their regional occupancy in Eastern Austria. In contrast, xerophilous and indifferent species were less abundant in comparison to their representation on a regional scale.

The high conservation value of meadows in the Donau-Auen National Park is highlighted by the large number of recorded species which are classified as near threatened (9 species) or vulnerable (3 species) according to the Red List for grasshoppers in Austria (BERG et al. 2005). Of the five hygrophilous species recorded in this study, all are near threatened or vulnerable on a national scale; *Stethophyma grossum* was the only species classified as vulnerable (Table 1). Crucial habitat requirements for *S. grossum* are high humidity near the ground and in the soil and a heterogeneous vertical vegetation structure (SONNECK et al. 2008). The eggs are laid near the ground and require high soil humidity (INGRISCH 1983, MARZELLI 1997). The larvae hatch from June until September in the following year. First adults appear at the end of June (INGRISCH & KÖHLER 1998). The species' dispersal capacity is very low with median male and female dispersal distances of 37 and 27 m, respectively (BÖNSEL & SONNECK 2011). In our study area, the species was only recorded on three annually flooded meadows. Like many other grasshopper species also *S. grossum* may face a severely increased mortality during summer floods. However, some larvae hatch very late in summer ensuring that at least a fraction of the population will be able to survive summer floods in the egg stage. Nevertheless, the small number of only 8 recorded individuals may indicate a relatively low habitat quality for this threatened species.

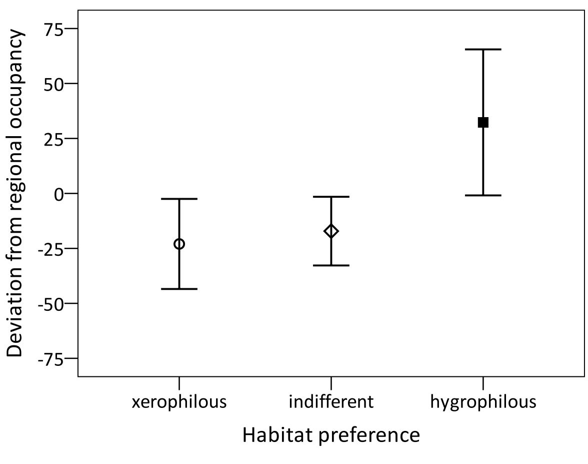

Figure 5: Deviation (mean ± 95% CI) of species' local occupancies (Donau-Auen National Park) from their regional occupancies (Eastern Austria), grouped according to habitat preferences of grasshopper species. Positive values indicate over-representation, negative values under-representation at the local habitat scale.

Conclusion

Our study provides strong evidence that natural floodplain dynamics still have a significant impact on the grasshopper fauna of meadows in the Donau-Auen National Park. Hence, maintaining high hydrological dynamics (e.g. by river restoration measures) will be a precondition to successfully protect the fauna of floodplain meadows, characterized by a high proportion of regionally threatened hygrophilous species.

Acknowledgements

We thank the Donau-Auen National Park and the University of Vienna for logistic and financial support of our research project. In particular, we are grateful to Christian Baumgartner and Christian Fraissl for fruitful discussions and help with the selection of study sites. Helene Holzweber, Ulrich Kurrle and Karin Neunteufl assisted with field surveys.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 131 - 136

Strategies of wetland restoration in the Waasen/Hanság (northern Burgenland)

Barbara Dillinger

Abstract

Severe human impact has led to a massive degradation of former vast fens in the Hanság. Economic considerations are decisive as well for the necessity of an ecological restoration of that area. As scientifically profound basic knowledge is essential for its planning and successful development, the paper at hand, on the basis of vegetation ecological studies, seeks to name the components of that ecosystem and explain the causes and consequences of degradation. Two central issues result from that: A description of the ecological restoration potential of the Hanság and the assignments and tasks derived from that.

As components of the ecosystem, operable vegetation types and their conservation status were surveyed in representative landscape plots in the area of interest. The species composition of the types reflects the consequences of the massive drainage measures and agricultural use in that area.

The environmental variables collected in the course of biotope mapping and GIS analysis were studied with regard to their effect on the vegetation types with the help of various statistical methods. The findings indicate that there is an equally distributed, high nitrogen concentration in the soil and a much too low groundwater level. That explains the strong decrease or complete extinction respectively of fen-specific vegetation types.

Moreover, a *Morphological Spatial Pattern Analysis* of the mapped biotopes was performed in order to illustrate the differences between the landscape plots with regard to their landscape structure and their low connectivity.

Finally, possible restoration activities could be derived from the results. Pushing back of competitive species and nutrient removal from eutrophic soils by means of a spatio-temporally coordinated grazing and mowing regime in combination with topsoil removal have proved to be promising measures. Degradation of several vegetation types by drainage could be reversed by rewetting. Furthermore, measures for establishing a biotope network system were discussed.

In addition to that strongly practice-oriented approach, selected concepts of restoration ecology were presented and elaborated with regard to their importance for the Hanság. The area with all its conflicting priorities of the most diversified interests in which this cultural landscape is situated was described and the importance of a broad-based agreement in society for its positive development was emphasized.

Keywords

Hanság; Fens; Vegetation; Wetlands; Restoration ecology; MSPA; TWINSPAN; Landscape structure; Biotope network system

Introduction

The Hanság is a fen of really vast proportions resulting from siltation of one part of Lake Neusiedl. By massive human impact, this natural landscape has undergone transformation from an open forest landscape to an intensively used agricultural landscape (Löffler 1982). Judging from the remnants of former fen vegetation the potential for the recovery of wetlands in the Hanság can be estimated and ecological restoration can be taken into consideration.

The fact that profound ecological studies are essential for the success of restoration activities was motivation for this diploma paper. The central question of this paper was: How can the ecological restoration potential of the Hanságbe described? A comprehensive survey of the vegetation and of environmental factors was the consequence. On the basis of those findings, concrete restoration activities were to be formulated and discussed. The intention of applying selected concepts of restoration ecology to the Hanság was to provide a prospect on the effects of different restoration goals and objectives. That is of particular interest with regard to the central and isolated position of the national park section and its embedding in the agricultural landscape.

Methods

In the area of interest, 5 plots with an area of 1 km² each were investigated and the essential abiotic and biotic factors collected. The available geodata provided all information with regard to types of soil, groundwater levels and landforms. Land cover and land use regime were surveyed in the course of selective biotope mapping and sampling of vegetation using the relevé-method according to Braun-Blanquet.

Vegetation classification was performed on the basis of the *Two Way Indicator Species Analysis*(TWINSPAN, Hill 1979). In addition to that, the average ecological indicator values according to Ellenberg (Ellenberg 1974ff) were calculated for nutrient and moisture as well as diversity indices for each relevé.

In order to illustrate that diversity in the relevés depended on indicator values and diversity indices, linear regression analyses were performed. In the course of the indicator value analysis, the distribution of vegetation types along the moisture and nutrient gradients was shown. The Constrained Correspondence Analysis (CCA) was supposed to show the distribution of vegetation relevés in multidimensional ecological space. Furthermore, vegetation maps were created in GIS.

Subsequent statistical evaluation included the presentation of absolute frequencies of dominant vegetation types per landscape plot in graphs. By means of logic regression it was attempted to measure the dependency of stands of vegetation types on the environmental variables surveyed. In order to present the spatial patterns of the wetlands and woodlots in the individual landscape plots, a MSPA (*Morphological Spatial Pattern Analysis*) was performed. This segmentation process subdivided the geodata as binary image into seven MSPA classes (e.g. Core, Islet and Bridge) (Vogt 2010).

Results

The syntaxonomic classification of 80 relevés resulted in 34 plant communities, which were arranged in a synoptic table. The analysis of absolute frequency of the dominant vegetation types (fig. 1) allowed for conclusions on the landscape structure of the individual landscape plots and on the moisture gradient prevailing in the area.

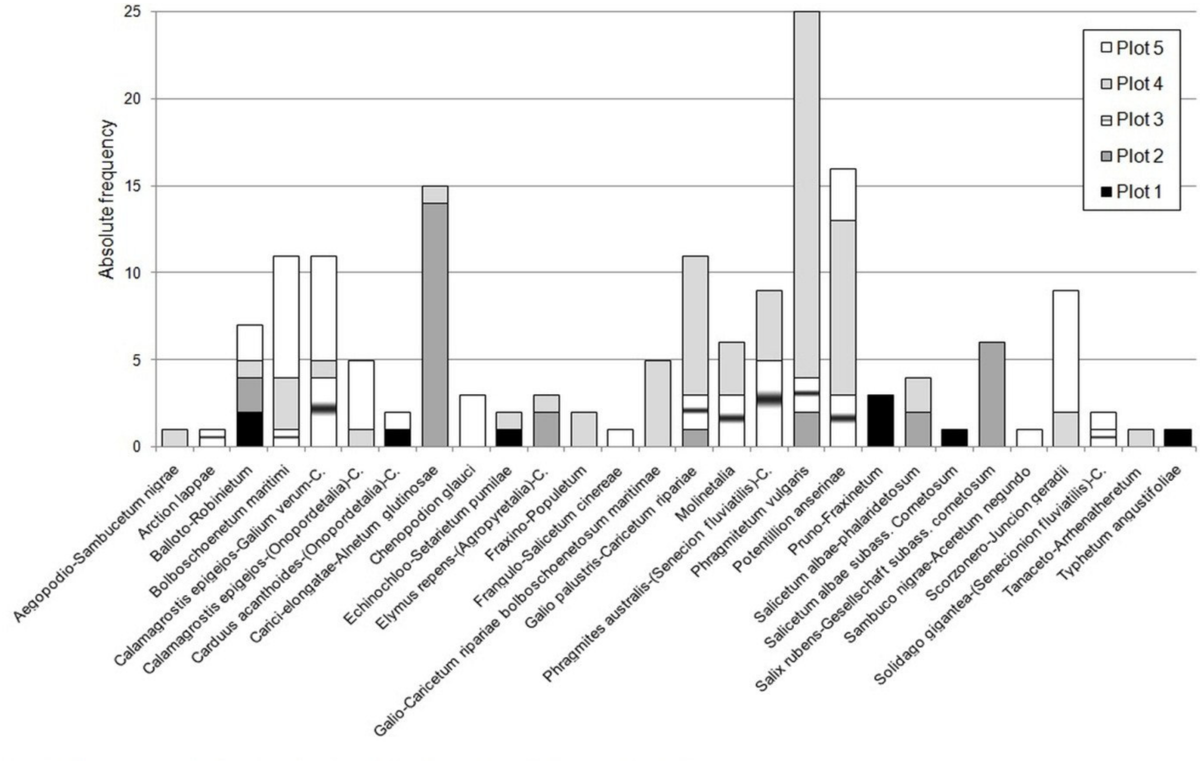

Fig. 1. Absolute frequency of dominant vegetation types per plot. C. = Community.

The CCA triplot of the woodlots showed that the moisture gradient explains the highest ratio of variance in species composition of the relevés. In the triplots of biotopes without woodlots, the division of the relevés was clearly visible because of the intensity of use.

The indicator value analysis of the average moisture values (fig. 2) showed the high ratio of dry site indicators, which significantly reduced the moisture values of wet soils. A comparison of the average nutrient values of the vegetation types revealed a focus in the sites of intermediate fertility to richly fertile places.

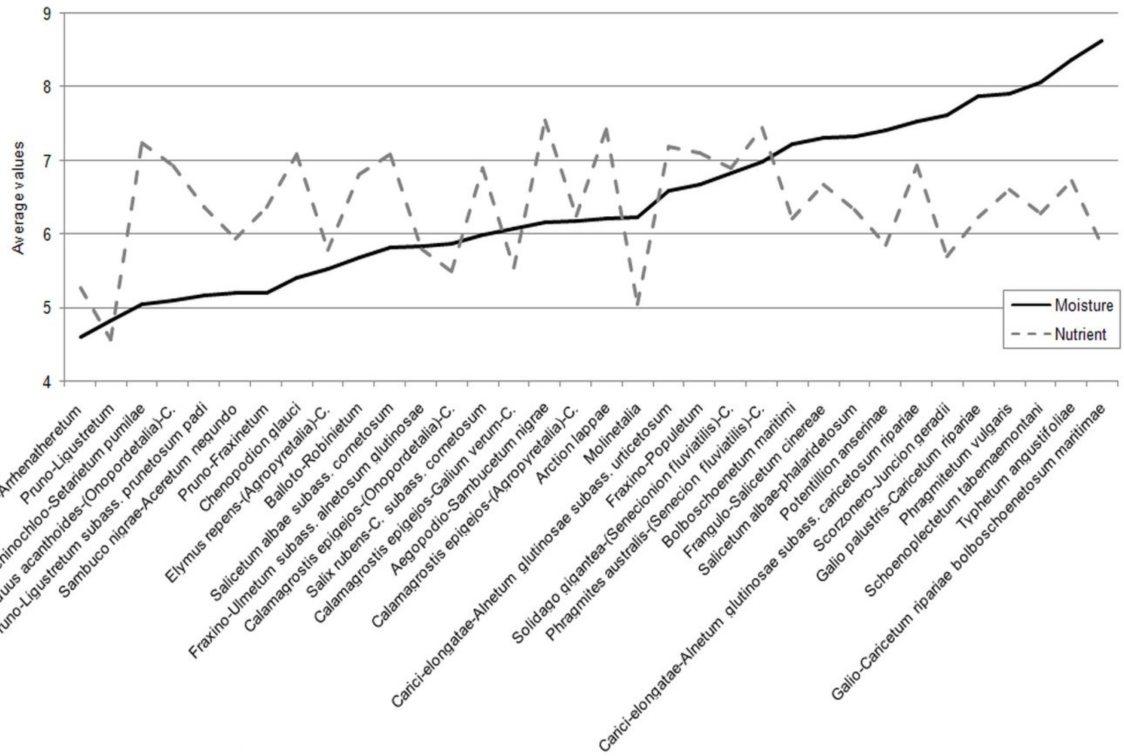

Fig. 2. Average moisture and nutrient values according to Ellenberg (2001) of vegetation types. C. = Community.

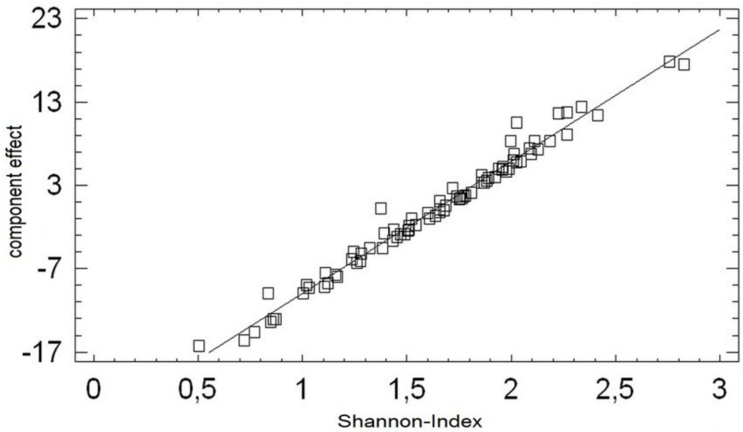

Fig. 3. Multiple Regression: Effect of number of species on diversity indices e.g. Shannon-Index (Linear model: N_species=10,9321+15,8109*Shannon 2,59266*Simpson-39,5309*Evenness. n=80. r^2=94,31%. p=0,0000).

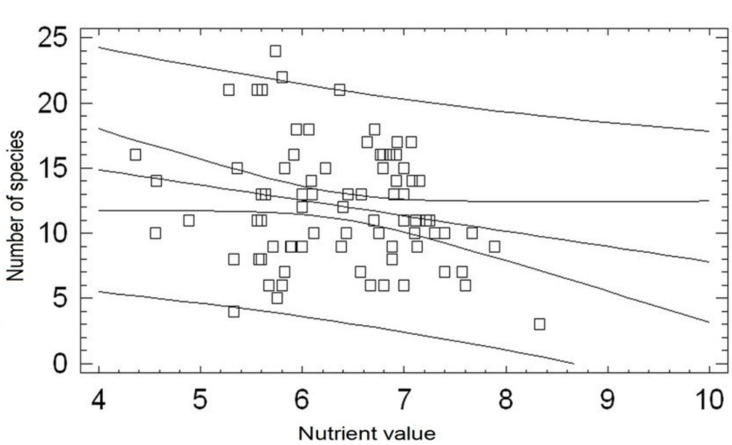

Fig. 4. Simple Regression: Effect of nutrient indicator values (Ellenberg 2001) on number of species (Linear model: No_species=19,5953-1,17917*nutrient. n=80. r^2=4,3 %. p=0,0649).

The effect of diversity indices on the number of species (fig.3) that was investigated in the course of a multiple linear regression, as expected, showed a close correlation. No effect of the nutrient values according to Ellenberg on the number of species could, however, be proven by linear regression (fig. 4), which suggests an equal nutrient distribution in the area of interest. Furthermore, a weak relationship could be found between the moisture values according to Ellenberg and diversity (fig. 5). Both regression lines showed a tendency of decreasing species diversity with regard to increasing moisture and nutrient content.

Logic regression illustrated that the occurrence of vegetation types can be explained by extremely different combinations of environmental variables. This is mainly the result of incomplete data material in particular with regard to groundwater levels.

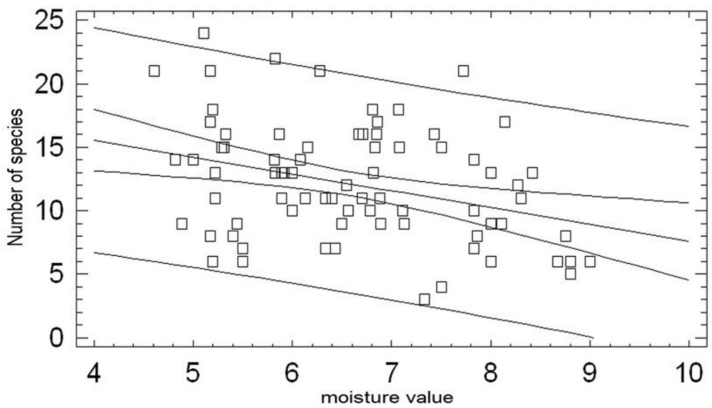

Fig. 5. Simple Regression: Effect of moisture indicator values (Ellenberg 2001) on number of species (Linear model: No_species=20,8927-1,33241 *moisture. n=80. r^2=11,05 %. p=0,0026).

The MSPA of woodlots demonstrated their minor expansion and fragmentation in the area of interest. The analysis for plot 3, for the national park section, was omitted as there were no woodlots in that part. The spatial patterns of the fens and fen meadows revealed big differences between the plots with regard to their landscape structure. Whereas in plots dominated by agriculture they only occurred as linear corridors or small patches, they formed the matrix in others.

Discussion

The survey of vegetation types revealed a strong expansion of problematic species such as *Calamagrostis epigejos, Phragmites australis and Solidago gigantea*, which have a diversity decreasing effect. In many projects extensive grazing in combination with mowing has proven to be an appropriate measure for regulating those species (KORNER et al. 2008).

The obvious changes in species composition of the vegetation relevés are consequences of long-term drainage and would be reversible by rewetting of the area. Since restoring the hydrological regime in the whole surrounding catchment area would lead to conflicts of various use claims, locally restricted measures with regard to drainage ditches have proven feasible (ANDEL 2006).

Another diversity decreasing effect is caused by the invasive species *Robinia pseudacacia*, *Acer negundo* and *Elaeagnus angustifolia*. Their removal and planting of site-adequate tree species would be desirable.

High nitrogen concentration in the soil and the reduced groundwater level explain the almost complete extinction of fen-specific *Molinion* communities. An appropriate measure for their advancement would be a removal of biomass by mowing according to adapted time schedules (KORNER et al. 2008). In this connection, sod cutting and/or topsoil removal have/has proven successful (ANDEL 2006).

In landscapes characterized by agriculture, the establishment of landscape elements and extensification of use in the sense of a biotope network system would make sense (JEDICKE 1994). Furthermore, the creation of buffer zones for wetlands and forest edge development would be advisable.

When dealing with concepts of restoration ecology it became clear how important it is that restoration activities are subject to a well-defined restoration goal. The latter should be derived from the respective concept of nature, the level of ambition, an appropriate reference ecosystem and from the definition of restoration ecological targets (ANDEL 2006).

Conclusion

Summing up, it can be stated that an elaborate vegetation survey is essential for the planning and monitoring of restoration projects. Logic regression for establishing habitat models could be a useful tool that helps to predict the effect of different restoration activities on the occurrence of target species and communities. Prerequisite for that is a solid basis of data material which, however, was unfortunately not available when preparing this paper. For the restoration of groundwater-fed vegetation types, precise measuring of the groundwater levels would be indispensable in case of future studies. As this diploma paper can be seen as a preliminary study, a continuation of these scientific investigations on a larger scale and inclusion of zoological expertise might be possible since the operable vegetation types and the methodology are already available.

The restoration activities derived from the findings may be contradictory to each other or might not be feasible for a number of reasons. A successful restoration project would require a fundamental decision which restoration goals to be realized in which spatial and temporal dimension. This would, of course, require broad-based agreement among nature conservation organizations, land users, population and the public authorities. This is the background with all its conflicting priorities against which the national park section Waasen-Hanság has to be seen. For the restoration of site-adequate fen vegetation, large-scale changes in the hydrological regime and in the nutrient balance would be necessary that by far exceed the boundaries of the protected area.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 137 - 142

Long-term ecosystem monitoring and research at LTER Zöbelboden – 20 year anniversary

Thomas Dirnböck, Maria-Theresia Grabner, Johannes Kobler, Andrea Stocker-Kiss, Michael Mirtl

Abstract

The long-term monitoring and research site "LTER Zöbelboden" has been used for two decades to record trends in several hundreds of environmental parameters. The montane site of 90 hectares size in the Northern Limestone Alps has become the best examined karst forest ecosystem in Austria. Based on the measurements from Zöbelboden, the effects of air pollution and the consequences of climate change for ecosystems are analysed. Findings show that excessive nitrogen deposition disrupts the ecological balance of forest ecosystems leading to a loss in biodiversity and putting their protective function at risk. More frequent disturbances by windthrow and bark beetle infestation as a consequence of climate change are likely to reduce the carbon sink function of forest stands. Even though the deposition of lead and cadmium has decreased by 70 – 80 % due to emission abatement measures in the 1990s, heavy metal pollution in ecosystems is still an environmental problem today. As transport or leaching of heavy metals into deeper soil layers happens much more quickly than assumed, the high inputs from the 1980s may pollute the groundwater, water ecosystems and finally our drinking water after only a few decades. Half of the Austrian population is supplied with drinking water from karst areas. The results of karst-hydrological measurement and modelling at the Zöbelboden allow estimations of changes in water quality and water supply, thus enabling scientists and water suppliers to develop adaptation strategies. Long-term data collected at the Zöbelboden, in combination with research projects and models, provide an ideal basis for the interdisciplinary development of perspectives and solutions to a variety of environmental problems on national as well as on international level. LTER Zöbelboden is one of 35 sites in the national network "LTER-Austria" and therefore also part of "LTER-Europe", which involves more than 400 research sites, 100 institutions and thousands of research projects within 21 national networks.

Keywords

Forest, nitrogen deposition, heavy metals, carbon budget, biodiversity

Introduction

The Zöbelboden site in the "Reichraminger Hintergebirge" mountains is the core element of long-term ecological monitoring and research (LTEM/LTER) in Austria. This ideally equipped site has been used for two decades to record trends in several hundreds of environmental parameters (Figure 1). Based on these parameters, the Umweltbundesamt analyses the consequences of climate change and the effects of air pollutants on whole ecosystems. Within 20 years of continuous measurement and evaluation, and supported by substantial contributions from the Kalkalpen National Park and the Austrian Federal Forests, the site has become the best examined karst forest ecosystem in Austria. The Zöbelboden site is Austria's contribution to the Integrated Monitoring programme of the United Nations which is aimed at a better understanding of cause-and-effect relationships in ecosystems. It is part of a close-knit network of research projects and monitoring programmes. These include LTER-Europe, Global LTER, ALTER-Net, ESFRI/LifeWatch, EBONE, EXPEER und Life+ EnvEurope. Harmonised Europe-wide measuring methods and standards allow trans-boundary environmental monitoring, which provides the basis for effective air pollution policies and the development of adaptation measures to climate change (www.umweltbundesamt.at/oekosystem_monitoring).

Site description

LTER Zöbelboden has a size of 90 hectares and is situated in the northern part of the Kalkalpen National Park (Northern Limestone Alps), approximately 50 km south of Linz (N 47°50'30", E 14°26'30"; www.umweltbundesamt.at/im). The altitude ranges from 550 m to 956 m a.s.l. The main rock type is Norian dolomite (Hauptdolomit), which is partly overlain by limestone (Plattenkalk). Due to the dominating dolomite, the watershed is not as heavily karstified as limestone karst systems, but showing typical karst features, such as conduits and sink holes. These conduits and sink holes provide pathways for rapid water flow and quick response times to water input at the soil-bedrock interface. The long-term average annual temperature is 7.2 °C. The coldest monthly temperature at 900 m a.s.l. is -1 °C in January, the highest is 15.5 °C in August. Annual rainfall ranges from 1500 to 1800 mm. Monthly precipitation ranges from 75 mm (February) to 182 mm (July). Snowfall occurs between October and May with an average duration of snow cover of about 4 months.

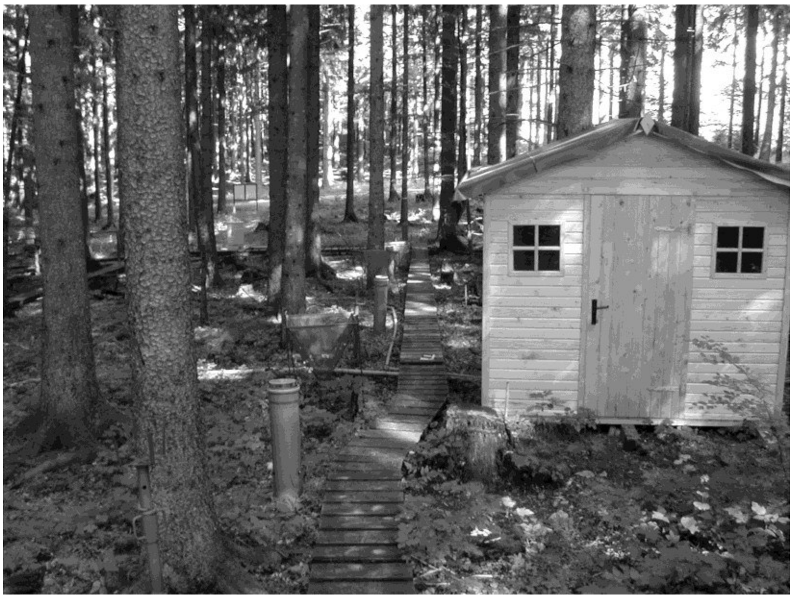

Figure 1: Forest ecosystem processes and element cycling are continuously measured at three intensive plots (Foto: Umweltbundesamt)

The watershed can be divided into two distinct sites: A very steep (30 – 70°) slope from 550 – 850 m a.s.l. and an almost flat plateau (850 - 956 m a.s.l.) on the top of the mountain. The areal coverage of each site is 50 % of the watershed. At each site, intensive plots have been selected for comprehensive measurements of hydro-chemical variables. Intensive plot I (IP I) is located on the plateau where Chromic Cambisols and Hydromorphic Stagnosols are found. Intensive plot II (IP II) is located on the slope and dominated by Lithic and Rendzic Leptosols. The mean slopes are 14° at IP I and 36° at IP II. IP I is dominated by a Norway spruce (*Picea abies*) following plantation after a clear cut around the year 1910, whereas a mixed mountain forest with beech (*Fagus sylvatica*) as the dominant species, Norway spruce (*Picea abies*), maple (*Acer pseudoplatanus*), and ash (*Fraxinus excelsior*) covers IP II. After wind and bark beetle damage at IP I a third intensive plot (IP III) has been established in the year 2008 representing the plateau ecosystem. IP I is still used for studying the effects of disturbance on these ecosystems.

Selected Results

Excessive nitrogen disrupts the ecological balance of forests

The natural ecosystems of today are exposed to nitrogen levels which are 5 - 10 times higher than in preindustrial times. The causes of these elevated nitrogen levels lie in the use of fossil energy sources, animal husbandry and the fertilisation of agricultural land. At the LTER site Zöbelboden, total nitrogen deposition in the forest amounts to about 30 - 40 kg/ha/year. As a rule, forest ecosystems tend to be more exposed to air pollutants than other land use forms. At the LTER site for example, the site-specific limit value for eutrophication, measured on the basis of open field deposition according to the Critical Loads of the UNECE, is complied with – whereas the same limit value is considerably exceeded in the forest. Forests respond to excessive amounts of nitrogen in different ways: While the spruce stand at the Zöbelboden site deposits large amounts of nitrate in the groundwater in some years, efficient nitrogen fixation is achieved in the mixed beech forests (Jost et.al 2011). Nitrate losses are a certain sign of excessive inputs of nitrogen in forest ecosystems. Apart from disruptions of the nutrient cycle, there is also a negative impact on biodiversity. Loss of lichen, moss and vascular plant diversity will occur in the long term. In addition the protective function of the forest will be impaired (Zechmeister et al. 2007, Hülber et al. 2008, Dirnböck & Mirtl 2009, Diwold et al. 2010, Pröll et al. 2011). Epiphytic lichens growing on trees are a particularly good indicator of nitrogen effects (Figure 2). While the lichens have been recovering slowly when the acid rain has subsided in the 1990s and 2000s, many species are lost today as a result of nutrient accumulation. At the Zöbelboden site, epiphytic lichen diversity declined dramatically since 2005. This was caused by an exceedance of limit values for nitrogen inputs for many years. Excessive nitrogen levels putting the protective function of ecosystems at risk are a Europe-wide issue. Based on measurements at monitoring sites the UNECE working groups prepare the principles and methods of emission reduction policies.

The impact of storms and bark beetle on forests which are CO2 sinks

Disturbances such as windthrow and bark beetle infestation are part of the natural development and dynamics of forest ecosystems. As a consequence of global climate change, however, the negative effects from such disturbances are accumulating and leading to an increasing damage frequency worldwide. How disturbances from small-scale windthrow events and bark beetle infestation affect the carbon balance of a montane forest has been investigated at the LTER site Zöbelboden. A disturbed old-growth forest stand was compared with an adjoining undisturbed forest. The carbon balances show that both forest stands are carbon sinks. However, the carbon budget for the disturbed forest is almost balanced. If the disturbance intensifies, which can be assumed, the forest stand will become a carbon source. This is due to the decreasing carbon sequestration of the forest stand, combined with an increased decomposition of organic soil matter caused by higher soil temperatures. The results show that more frequent small-scale disturbances from windthrow and/or bark beetle infestation in the investigated area are likely to reduce the carbon sink function of the forest. The further development of the carbon balance depends on many factors and is the subject of a variety of research projects.

Figure 2: Finger cup lichen (*Cladonia digitata*) at Zöbelboden (Foto Roman Türk).

Heavy metal deposition on the decrease since the 1980s

The Industrial Revolution and especially the economic boom after World War 2 resulted in a dramatic rise in heavy metal emissions in Europe. Thus, heavy metals were increasingly deposited via (long-range) transport even in remote ecosystems such as the LTER site Zöbelboden. The higher the concentrations, the higher became the potential threat to fauna, flora and to ground and drinking water. Against this background, the Protocol on Heavy Metals to the 1979 Convention on Long-range Transboundary Air Pollution (CLRTAP) was adopted in Aarhus (Denmark) in 1998. One of its most important aims is the reduction of the three heavy metals lead, cadmium and mercury below their levels in 1990. This target has been successfully achieved in the case of lead and cadmium due to emission abatement measures such as eliminating lead from gasoline. Checking the effectiveness of such measures is one of the tasks of the international cooperation project „Integrated Monitoring" of the UNECE. The data measured at Zöbelboden show that the amounts of heavy metals from long-range transport ending up in Austrian forests are much smaller today than only a few years ago (Figure 3). Loads of particularly harmful heavy metals (cadmium, lead) remain far below the applicable guidance and limit values and are much lower than the values measured in forest ecosystems in the 1980s. Lead and cadmium concentrations have decreased by 70 - 80 % (UMWELTBUNDESAMT 2009). At the same time, it has been shown that cadmium and lead pollution in ecosystems is still an environmental problem today. Transport or leaching of heavy metals into deeper soil layers happens much more quickly than initially assumed. Up to now, experts had expected heavy metals to remain bound up in the soil for a period of 100 up to 200 years. Data collected at the Zöbelboden site have proved this hypothesis wrong. They provide information about reaction times in different soil types (KOBLER et al. 2010). Thus, the high heavy metal inputs from the 1980s may be leached into the groundwater, pollute water ecosystems and finally our drinking water after only a few decades.

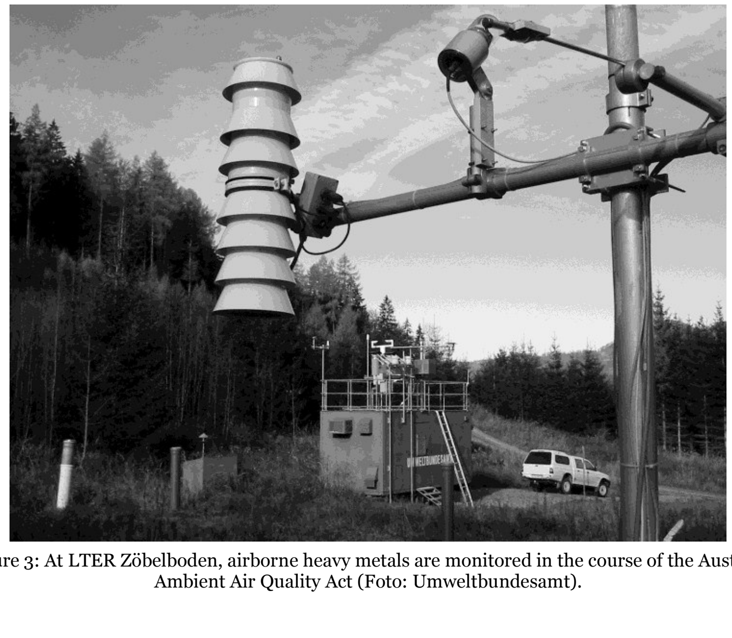

Figure 3: At LTER Zöbelboden, airborne heavy metals are monitored in the course of the Austrian Ambient Air Quality Act (Foto: Umweltbundesamt).

Hydro-geochemical monitoring and research

In Austria 50 % of the population is supplied with drinking water from the karst areas of the Northern and Southern Limestone Alps. Pollutant inputs and climate change disturb the functionality of the ecosystems in these catchments. Extensive karst-hydrological measurement and modelling activities at the Zöbelboden allow estimations of how the water supply for the population will change and how the water suppliers can adapt to the new conditions (Figure 4; HUMER & KRALIK 2008, HARTMANN et al. 2011). In tracer experiments was shown how precipitation seeps into deeper-lying systems and reaches the surrounding watercourses through the springs. It was also shown how the water moves at different speeds through the rock fissure system. While the tracer substance could be detected within a day at some of the springs, traces of the same substance were still found at another spot four years after the experiment. Age detection with CFCs, tritium and helium has shown mean residence times of 20 years or more at some of the springs in the area (KRALIK et al. 2009). Special sampling and analytical methods reveal how pollutants pass through the mountain massif during heavy rainfall events. Based on the analysis of data collected at the Zöbelboden a hydrological prediction model shall allow a scientifically sound assessment of changes in environmental conditions. Coupling long-term assessment and model development makes it possible to place the findings in a larger context. One example is the EU ORIENTGATE project, which investigates how climate change affects nitrate leaching. Measurements at the Zöbelboden have shown that during the snow melting period and during thundery summer showers increased levels of nitrate are found in the spring water. Researchers intend to find out whether increased nitrate concentrations will occur more often in future and how water suppliers can prepare themselves for this situation. Here not only climate change plays an important role but also forest management, since excessive timber harvesting and soil damage lead to additional nitrate loss. The long-term data collected at the Zöbelboden, in combination with individual research-oriented projects and models, provide an ideal basis for the interdisciplinary development of perspectives and solutions to a variety of environmental problems.

Figure 4: At LTER Zöbelboden, long-term physical and chemical runoff data is collected at measurement weirs (Foto: Umweltbundesamt).

The future: LTER Zöbelboden as part of the European Long-term Ecosystem Research Network

Since 2012 LTER has been part of the International Programmes of the Austrian Academy of Sciences. This ensures that the results from the Zöbelboden site are linked to other research projects and strategies, bringing Austria one decisive step closer to the early detection of environmental problems, the precautionary principle and sustainable development. Since the 1970s sites of long-term ecosystem research have mostly been defined in terms of their natural characteristics (e.g. catchments of small water bodies). They were limited in size (10 – 1000 hectares) and, preferably, they were semi-natural areas with protection status. At the beginning of the 21st century intensive discussions started about the future orientation of existing and planned LTER networks. Sustainable preservation of essential ecosystem services against a background of global change had been the central political goal formulated prior to the discussions. In Austria, the available LTER infrastructure was consolidated, too. The national network “LTER-Austria” involves 35 LTER sites including the Zöbelboden (http://www.lter-austria.at). With their group („Trägerverbund”) of highly instrumented forest sites, the University of Natural Resources and Life Sciences, the Federal Research Centre for Forests and the Environment Agency Austria demonstrate their commitment to cooperation and to the maintenance of their LTER sites. LTER Austria is part of LTER Europe, which combines more than 400 research sites, 100 institutions and thousands of research projects within 21 national networks, covering the full range of European ecosystems from the Arctic and alpine sites to Mediterranean ecosystems (http://www.lter-europe.net). By aligning these sites with European standards it becomes possible to identify long-term ecological changes on different scales – from local to continental – and to interpret them. To meet the requirements of modern ecosystem research the ecosystem concept was broadened by integrating social, economic as well as demoscopic aspects and aspects of historical use. LTSER symbolises traditional ecosystem research with the added human factor. LTSER platforms are selected regions with sophisticated research networks combining several scientific disciplines and working in close interaction with local communities, regional developers and decision makers. In Austria, two LTSER platforms are being implemented: „Tyrolean Alps” in the Ötztaler and Stubaier Alps and „Eisenwurzen” in the Northern Limestone Alps (http://www.plattform-eisenwurzen.at). The Zöbelboden and other classic LTER sites represent important ecosystem types of the Eisenwurzen area. With the integrative LTSER approach it is possible to deal with issues from the region in an interdisciplinary manner and to provide results relevant to society and facilitating decision-making in favor of sustainable development at local, regional and national level.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 143 - 146

Monitoring dormice (Gliridae) populations as a method of evaluating the efficiency of biodiversity management tools in Grădiştea Muncelului – Cioclovina Nature Park

Cătălina-Ioana Drăgoi & Mihaela Faur

Abstract

Dormouse (Gliridae) populations in Romania are so far insufficiently studied, with very little data available. Four types of forest habitat were selected in Grădiştea Muncelului – Cioclovina Nature Park for the instalment of nest boxes in 2010, mostly in areas covered by virgin and cvasivirgin forests. During the following period, more nest boxes were installed in rural areas, in habitats with high human interaction. *Muscardinus avellanarius* and *Glis glis* were the most common species found and their population density is proven higher in areas with sustainable forest management.

Keywords

Dormice, monitoring, biodiversity, forest management, stakeholders, local communities

Introduction

Grădiştea Muncelului – Cioclovina Nature Park is located within the Southern Carpathians (Şureanu Mountains) and represents a protected landscape (category V IUCN). More than half of its 38.184 ha are covered in forest vegetation, thus creating the premises for high biodiversity, especially in the less accessible virgin and cvasivirgin forests.

Grădiştea Muncelului-Cioclovina Nature Park includes large forested areas as well as pastures, cultivated land, carstic areas, historic monuments, archaeological sites and villages. The landscape is characterised by hills and mountains with steep slopes, ranging between 600-1700 m.

Dormice are a peculiar group among mammals, set aside by the fact that their population densities are smaller compared to that of other rodents of same size and their reproductive success is considerably lower. Dormice are sensitive to climate change or any disturbances of their natural habitat, which makes them excellent bio-indicators for forested or shrubby areas.

In the context of recent financial difficulties, we decided to test a method of evaluating the efficiency of biodiversity management tools by monitoring dormice (Gliridae), which implies low costs and minimal equipment. The method consists of installing nestboxes and live-traps in a few key areas, covering an array of different forest types, including those with high naturality as well as areas with high human interaction.

At certain steps of the monitoring process, stakeholders (reticent at first towards the concept of forest management) have been involved in installing the nestboxes and monitoring their status (reporting missing or damaged ones). Meetings have been organized in order to explain the importance of forest habitats, of dead and decaying wood, and of maintaining ecological corridors open. A better collaboration with the park administration has been achieved.

Methods

In order to make any determinations regarding the biology and ecology of dormouse species, nest boxes were installed in several areas in Grădiştea Muncelului-Cioclovina Nature Park. These nest boxes are made of wood, shaped like a cube with a 15 cm side. The top of the boxes can be removed to allow the investigation of its contents. Each box has an entrance on the side, no more than 5 cm in diameter. The boxes are always installed with the entrance facing the trunk of the tree as to avoid being used by birds. Above and beneath the entrance, wooden elements allow enough space between the trunk of the trees and the box to facilitate access of the individuals.

Nest boxes were placed in trees in linear transects about 15 m apart from each other, with 10 boxes for each transect. The height at which the boxes were places varies between 1,5 m and 2,5 m (JUSKAITIS 2006).

In addition to these boxes, artificial shelters were made from plastic bottles in order to supplement possible nesting sites. The plastic bottles were cut at both ends resulting in a tube which is then painted black. Plywood is then used to make a small platform on which the nests will be installed. Another piece of plywood is used to seal off one end of the tube. The platform is always a bit longer than the tube, to allow easier access. These structures were also placed in linear transects, in the same manner as the nest boxes.

The nest boxes and shelters were first installed in April 2010, just before the active season and were checked once every two weeks to avoid disturbing the nests. A total of 80 nest boxes and plastic tubes were installed by 2012. Captured individuals were marked by tattooing the ear and released. During the study, the degree of occupancy for the nest boxes was noted as well as the degree of capture and recapture. For each captured individual biometrical data was recorded (body length, tail length, weight).

In addition to these, live-traps were used for the capture of dormice. At every given location, twice a year, 10 live-traps were used for 3 nights in a row, baited with apple, peanut butter and sunflower seeds. This led to a better understanding of dormice dynamics in the study area.

The study began in areas with high degrees of naturality and was later extended to include areas with high human interaction. The virgin and cvasi-virgin forests that we first studied became the control group. Low reproductive success or other significant changes that would occur in both groups at the same time would be considered natural and thus not an influence of management. The habitats included in the study consists only of beech forests (pure or mixed with hornbeam) with *Corylus avellana* or *Crataegus monogyna*.

A very important aspect of management in protected areas is insuring a good communication with the local communities and stakeholders. In order to guarantee that biodiversity management tools have a lasting effect, the local communities have to understand the importance of sustainability and support the endeavours of the park administration. Meetings were organised in order to explain the importance of dead wood, of keeping ecological corridors open and of sustainable forest management. Denizens were also involved in the research as they were asked to participate during the instalment of the nest boxes and throughout the monitoring period.

A first meeting in 2010, brought together local communities and stakeholders. The importance of dead wood was underline, practices that encourage natural forest regeneration were promoted and the importance of preserving the understorey and shrubs was explained. Presentations and films were made and shared at this meeting as well as during events that involved local schools. Some solutions were suggested as an alternative to removing dead wood or cutting down shrubs from private property land.

In 2011, more meetings were organized. Besides explaining the concepts and the need of sustainable forest management, dormice were introduced to the locals. Volunteers were recruited for the instalment of nest-boxes, and the monitoring method was explained. Volunteers were asked to check the nest-boxes for damage at least once a week. During 2011 5 meeting were organised with members of the local communities, as well as schools in the park's surrounding area.

In 2012 other areas were included. Besides the usual talks regarding forest management, results from the previous years were presented, demonstrating the potential for a sustainable use of forest resources.

Results

Three species of dormouse were found using the nest boxes:

Muscardinus avellanarius (hazel dormouse), the smallest dormouse species in Romania, forms round nests made of branches, leaves and grasses (ZAYTSEVA 2006).

Glis glis (edible dormouse) usually builds nests from leaves and mosses (GRZIMEK 2003). Nests are usually found higher in the trees, in hollows of at the bifurcation of branches. This species sometimes uses deserted birds' nests (JUSKAITIS 2006).

Dryomys nitedula forms round nests, about 15 – 25 cm across, with the entry on the side or at the top. Rough materials are used at the outside, such as branches, and the interior is padded with grasses, moss, feathers or hair. It sometimes uses empty bird nests that it modifies to fit its needs (ADAMIK & KRAL 2008). Several nests can be found on a single tree, yet only one is functional (MURARIU & POPESCU 2001).

All the nest boxes were installed during April, at the start of the active season for dormice. However, during the first two months there was very little evidence that the boxes were being used. This situation was common throughout the study. In any given location, about one month after the instalment of the shelters, hardly any results were recorded. After the first month, droppings, leaves and nests began to gradually appear in the nest boxes.

In the first season, in 2010, when only virgin and cvasi-virgin forests were considered for the study, 53.8% of the nest boxes were occupied. The following year the rate of occupancy rose to 71.3%, and remained relatively stable throughout the study period (70-80%). The other nest boxes, not inhabited by dormice, also recorded signs of activity (dormouse droppings, leaves fragments) and in several cases, *Apodemus sylvaticus* and *Apodemus flavicollis* individuals as well as birds' nests were found in the boxes.

During the three years, 144 *Muscardinus avellanarius*, 89 *Glis glis* and 23 *Dryomys nitedula* were captured.

Most *Muscardinus avellanarius* (96 individuals) individuals were captured in areas with dense understorey or shrubs, rich in *Coryllus avellana* or *Crataegus monogyna* (JUSKAITIS 2008). In contrast, most *Glis glis* (61 individuals) were found in forests with tall trees (MILAZZO et al. 2003) and little understorey. The species is known to prefer such habitats (JURCZYSZYN 1995) and its presence in the area has been confirmed for many years, since it began nesting in cabins and other buildings nearby.

Dryomys nitedula was proven the most elusive, with a scarce 27 individuals over a 3 year period.

The rate of recapture is relatively high, with 65% of individuals being recaptured at least once. This is a result of the nest-box method we used, since dormice build their nests during the first year and for the most part will return the following spring. Some individuals we captured and marked were not found during subsequent verifications. They were most likely killed by predators.

The number of captured individuals varies from month to month, reaching a maximum in August, after weaning. Starting with October, the average number of captures begins to decline until the second half of November, when all activity stops in the nest-boxes. Not a single artificial shelter was used during winter. Dormice prefer hibernating in nests built on the ground.

The average number of captured individuals for all three years is presented below.

Table 1: Average captures for every month of the active season

Species	April	May	June	July	August	September	October	November
Muscardinus	2	4	10	19	29	32	19	6
Glis	0	1	4	9	13	14	7	2
Dryomys	0	1	1	4	3	3	2	0

Each year, in every new location, given the novelty of the shelters, very little activity was recorded in the nest-boxes during April. For the second season, however, activity begins about 3 weeks sooner.

Though the number of dormice using the nest-boxes remained relatively stable in the virgin and cvasi-virgin forests, a rise in numbers was recorded in forests with high human interaction after 2011. If the populations in the virgin forests rose by only 2-3 dormice, in the other areas, 7-9 more individuals were recorded during 2012. Since the rise in number was one-sided, we correlate this population growth to the success of management measures and effective implementation.

Local communities, though reticent at first towards dormice, considering them to be pests, finally came to understand the importance of these species. Once confused with mice and rats or considered pests because of their resemblance to other rodents, are now viewed as charismatic species, with children being most involved in the monitoring process. However, there are still areas where the task of implementing this monitoring scheme is just beginning. Of course, the purpose of the meetings we organized is not to change the attitude towards these species, but rather to raise awareness to the fragility of the ecosystems and the need to protect all species.

Weight was recorded for every captured individual (g). The results are shown in the figure below.

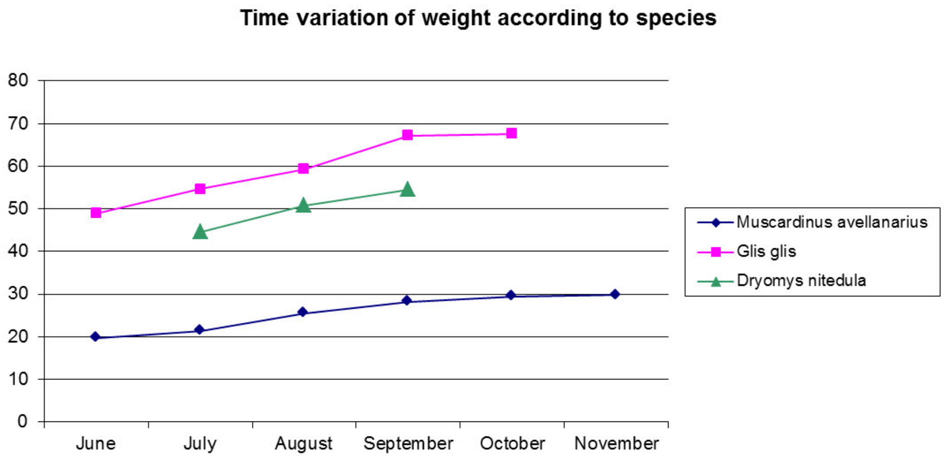

Figure 1: Time variation of weight according to species

The average value for the biometrical data recorded is listed in table 2. There are no notable differences when compared to other European populations (PUCEK 1981).

Table 2: Average values for biometrical data for each species

Species	*Muscardinus avellanarius*	*Glis glis*	*Dryomys nitedula*
Body length	73.3	165.4	97.7
Tail length	69.4	127.5	84.5
Weight	25.6	59.2	50.0

Discussion

Dormice monitoring schemes have been implemented before in Romania, but this was never used in Romania as a means of monitoring the effectiveness of forest management. We chose this novel method because dormice are good bioindicators, very sensitive to changes in their habitat.

However, this is merely being tested. Given the short period of time for the study, it is possible that in time, this method will be proven unsuccessful. Further data and a comparison with other methods of evaluating forest management are required.

On the other hand, low costs of implementation, and the accessibility of it (dormice are easily handled), make this method ideal for biologists or other protected area specialists who do not specialize in small mammal biology.

Conclusion

As a conclusion to our study, we could notice positive correlation between dormice population growth and stakeholders' understanding of forest management needs, with the trend being maintained to this day. Even so, some areas with a long history of human interaction, still need to be closely observed and the management tools, proven successful so far, widely accepted by all stakeholders.

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Conference Volume | 5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill | pages 147 - 154

Mountain Biking in Protected Areas in Case of Triglav National Park

Urška Drofenik & Mojca Golobič

Photo 1: Mountain biking in Julian Alps

Abstract

Mountain biking is becoming an increasingly popular way of recreation and leisure, as well as professional sport. But in the moment when mountain bikers turn off the road, they find themselves in conflict with other users as well as with law. Existing legal provisions in Slovenia deny access to natural environment, including hiking trails and forest roads for bikers, unless explicitly designated as bike trail. Such provision is based on the assumption that riding a bike in nature poses greater threat to the environment than the impact of any other similar form of recreation (for example: hiking or mountaineering). Legislator is particularly worried for safety of participants, conflicts between them and overcrowding of the area with different users, as well as for shrinking of the natural environment. This situation applies to the entire country but this presentation focuses on the most protected area in Slovenia, Triglav National Park. In order to protect the park, park authorities are preparing a management plan which will include the trails, explicitly allowed for mountain biking. Based on opinion surveys, analysis of bike internet forums, reviews of cases from abroad and cooperation with various biking and hiking clubs, representatives of the Triglav National Park and others, we prepared an indicative proposal of bike trails that would be suitable for mountain bikers and could be included in the park management plan.

Keywords

Protected area/Triglav National Park/Slovenia/mountainbiking/recreation

Introduction

Biking is one of the most popular sports in Slovenia. There are regulated cycling connections between towns, but mountain biking is still without proper legal basis and no one really knows, where mountain bikers are allowed to ride their bikes and where not. The law prohibits riding bikes in the natural environment, except where it is explicitly permitted. So bikers are not welcome on trails in natural environment and if they are not warned by signs, they are told so by passersby or locals. With this theme we focused on the most protected area in Slovenia, Triglav National Park, where throughout the park signs warn that biking off the categorized roads is strictly prohibited. But the park administration is aware that mountain bikers are using the park also off the roads, and they are willing to try to find answers to the question – where to ride with mountain bikes? Triglav National Park is preparing a management plan for the park, which should also include mountain bike trails, hoping that this will preserve and protect other natural areas.

As a result of increased popularity of mountain biking, bikers became common users of the natural areas, especially in protected areas, such as Triglav National Park. Problems we are dealing with in this article are:

- Conflicts between different users of the same area (hikers, bikers, loggers, farmers, hunters ...)
- Mountain biking as untapped potential for recreation and tourism

We try to find common language between the people who are all using the same area for their sport, recreation or work, we are looking for solution which will satisfy needs and desires of all users.

Main goals of this article are:

- Based on the research we will identify the most visited or popular places for mountain bikers and other users
- To establish the actual extent of conflicts between different users of the same space
- To proposal methodology for planning mountain biking trails that take account of specific features of protected areas of nature
- To proposal of mountain biking trails in the area of Triglav National Park

Methods

<u>Theoretical part</u>

- Analysis of the Triglav National Park (literature review),
- A review of research on the impact of mountain biking on the environment,
- Review of best practice examples,
- Critical review and synthesis of the information

<u>Planning-management part</u>

- Identification and description of existing hiking and walking trails used by mountain bikers
- Analysis of the existing regime for users
- Field visits (interviewing users, field trip to certain areas)
- Expert opinions (interviews with the management of Triglav National Park, hiking and biking clubs)
- Opinion survey for mountain bikers (web)

Results

<u>Survey</u>

The survey was completed by more than 500 mountain bikers, and resulted in the following main findings:

- Age of respondents ranged between 20 and 40, but there are also younger generations engaging mountain biking
- mostly respondents are experienced bikers using to difficult trails, followed by a fairly large percentage of those who believe that their technical mountain biking skills are good enough to cope with off road ride, quite a few riders believe that their knowledge is advanced and are managed demanding descents and jumps
- They mostly bike in small groups (3-5 bikers)
- Biking season runs from April to October. Most of them bike in May, June and September, but many are biking throughout the year
- They bike on weekdays and weekends, but more often on weekends
- The most popular uphill type of terrain are gravel roads or country lanes and forest tracks, the least paved roads
- For descent more than half of the respondents prefer more demanding trails with technical challenges, followed by a quarter who like dynamic, not very demanding track. Surprisingly many (18%) want very challenging trails with many technical challenges.
- Important factors for choosing the trail are: circular route (downhill another trail than uphill), away from the motor traffic and trails with nice views.
- Least important factors are: availability of car parking, hut on the goal and cultural attractions.

Answering the question about the conflict, a quarter of respondents said that they had already had an unpleasant experience with other users of trails. Conflicts are mostly verbal. Most serious conflicts are with hunters, where threats with guns were also mentioned. Conflicts with hikers usually happen on most popular trails. Conflicts with farmers are rare and are limited to particular places in Slovenia.

Most of respondents have never been in the Triglav National Park by bikes, the main reason is that they know that biking on trails is forbidden.

The survey also included an open question, which are the most popular trails As expected, the most of the described trails were in the Bohinj and Posočje; the traditional attractive biking areas. Based on these answers we made a trail table. Trails are divided by region. The table describes the technical, as well as ambiental elements. Technical part describes: length of the trail, the altitude between the start and the end of the trail, type of path on the trail. The ambiental path elements synthesize the information from the survey, why a specific trail is attractive and what are its weaknesses or why a specific trail is conflicting.

Table 1: Comparative table of trails within the Triglav National Park sorted by area

AREA	TRAIL	TRAIL LENGHT (km)	ALTI-TUDE (m)	TRAIL TIP (asphalt, gravel, forest trail, mule track, hiking trail)	TRAIL ATTRACTIONS	DISADVANTAGES OF TRAIL
BOHINJ	Planina pri jezeru	18,5	1.300	asphalt - gravel – mule track	View on the mountains, good food, lake.	Congestion in the summer months, concierge of the hut by the lake is not a fan of mountainbikers.
	Komna	11,6	1.550	mule track – hiking trail	Waterfall Savica, flat mule track, hut at the top, the starting point for crossing Julian Alps to Tolmin or Lepena.	Congestion in the summer month.
	Vogel	/	1.000	gondola – forest trail – ski slope	Gondola leads to the top, a trail for downhill lovers, through Žagarjev graben.	Habitat of capercaillie, hikers in summer time.
	Planina Uskovnica	12,2	690	asphalt - gravel – hiking trail	Good traditional mountain food in the huts, possibility of continuing trip to Pokljuka.	Congestion in the summer months.
POKLJUKA	Pokljuška krožna pot	18,6	830	asphalt - gravel – forest trail – hiking trail	Good traditional mountain food in the huts, beautiful nature.	Forest trails are not marked, so we need good skils in orientation and knowing the maps.
	Galetovec	5,2	250	asphalt – forest trail-hiking trail	Beautiful view of the glacier, moraine and lake Bohinj. Can be a short afternoon trip, or full-day tour.	Occasional meetings with hunters, but otherwise quite uninhabited excursion.
KR. GORA	Vršič	22,3	2.370	asphalt – hiking trail	Mountain hurs on the way, nice views, many cultural attractions: Russian chapel, Ajdovska girl, window on mountain Prisank, remnants of the old road Vrišič.	Busy road on weekends, many people on trails in the summer.
SOČA VALLEY	Berebica	12,2	1.860	mule track – hiking trail	Nice views.	Returning by the same rute.
	Dobrenjščica	50	10.190	asphalt - gravel – mule track	Mountain hut on mountain Razor, nice views, spring Tolminka.	Hunters.
	Tolminske ravne	44	10.370	asphalt - gravel – mule track	Mountain hut on mountain Razor, nice views, spring Tolminka.	Hunters.
	Sleme	30,3	2.500	asphalt - gravel – mule track	Beautiful views, more options for going downhill, mountain hut on the top.	Steep ascent.
	Planina Zaprikraj	16,1	980	asphalt - gravel – mule track	One of the few almost entirely unpaved access routs to the top, beutiful views, cottage on the top	Returning by the same rute.

Analysis of selected trails

From table we have chosen three trails for detailed analysis. The first two trails represent a specific problem in the eyes of trail users and managers of Triglav National Park. The third trail is described as an example of good practice in cooperation between the municipality and local sports organization.

Photo 2: Dobrenjscica

Dobrenjščica

Leon Leban, author of mountain biking guide of Soča valley, describes Dobrenjščica trail is as the most attractive way to cross the Soča valley. The trail almost entirely consists of the remains of mule tracks. Trail is not interesting for hikers, because it climbs slowly, which is exactly what mountain bikers want. But also at this point a new problem appears, since the slopes of Dobrenjščica are also an attractive hunting area. Hunters accuse mountain bikers that their presence frightens deer and other wild animals. This problem was mentioned by Triglav National Park management, survey respondents and various online portals.

Photo 3: Planina pri jezeru

Planina pri jezeru

Planina pri Jezeru is a very popular hiking trail, since a high starting point, accessible by car makes it an easy mountain destination. Despite 10 Euro of environmental tax, the parking area at the trail beginning is full most of the hiking season. For mountain bikers the trail is also interesting and challenging., but at the same time one of the most hostile places, since hikers, rangers from Triglav National Park, mountain hut owners etc. all believe that bike does not belong there.

Photo 4: Vrsic

Vršič

Climb to Vrišč is a challenge for many, as it is the highest road pass (1661 m) in the Eastern Julian Alps. For mountain bikers, the most attractive way to climb the Vršič pass is by the old Vršiška road, thus avoiding the busy main road. The descent from the Poštarska hut to the Krnica place goes by a marked path, which is, compared to surrounding mountain trails, a little less popular. We chose Vršič as an example of good practice in cooperation between municipalities and local sport organization, which runs mountain bike park Fun Bike Park Kranjska Gora. Local authorities agreed that Fun Bike Park takes care of a trail that runs from Vršič to Kranjska Gora, and is used for the purpose of learning the right techniques and behavior of bikers in the mountains.

Proposals to solve the problems

Finding common solutions is always difficult, because at least one, if not all involved need to take a step back in their principles and beliefs. Mountain biking is a typical example, where in the end everyone needs to accept certain compromises. Bikers will have to possibly change something, perhaps in the way of driving, perhaps behavior, or maybe just a little more respectful view of nature. As an example of such “soft approach” we present “the rules of the game” provided by Eco Farm Koroš in Koroška for all bikers who visit them. (Mountainbike Nomad website)

1. **Drive on open roads** – respect road/trail closures, do not cross private land without permission.
2. **Do not leave traces** – watch the ground beneath your bike, wet and muddy trails are more vulnerable than dry. If the trail is not dry, consider other riding options, stay on existing trails and do not make new trails, even on sharp turns.
3. **Control your bike** – just a moment of lack of concentration could endanger you and the people around you, observe all bicycle speed limits and recommendations and ride within your abilities.
4. **Respect others** – Do everything in your power to warn other trail users (friendly greeting or bell is a good method), when driving through bends, consider that others can use this trail as well. Try to anticipate the possibility of meeting. The rider must respect and give way to all other road users, unless the trail is designed specifically for mountain bikers. Each meeting should be safe and respectful.
5. **Never frighten animals** –animals are easily distracted, may be due to a sudden meeting, quick moves or loud sound. Give animals enough room and time to get used to you. Persecution of cattle and disturbing wildlife is a serious offense.
6. **Plan ahead** – know your equipment, skills and area in which you ride, and act appropriately.

These rules could be guidance to all riders for how to behave. But this will not solve all the problems that bikers face on their paths.

The following sections present solutions for two selected examples of conflict trails and proposal for a new road around Pokljuka.

Dobrenjščica

Conflict with hunters is going to be tough, because the hunters have to fulfill certain quotas, which may be more difficult if other users scare animals away. The proposal to solve the conflict in Dobrenjščica is primarily to reconcile the hunting association with the local mountain biking community, as the problem repeats for many years. Together they need to specify the periods during which bikers can ride their bikes and the period when biking in this area is prohibited (mating season, hunting season. Perhaps it would make sense for this area to train mountain bike guides who would have permission to guide the group. Guides should have accurate information about when and where to drive and when not. Information about riding restriction should also be available via online forums, Facebook, the local tourist website. The point of access to Dobrenjščica, Planina Razor, should be equipped with an info board, which would inform bikers if the path is open of not. If it is closed, riders could be advised to continue their trip towards the mountain Lom and Stador, which also applies to a nice trail.

Planina pri jezeru

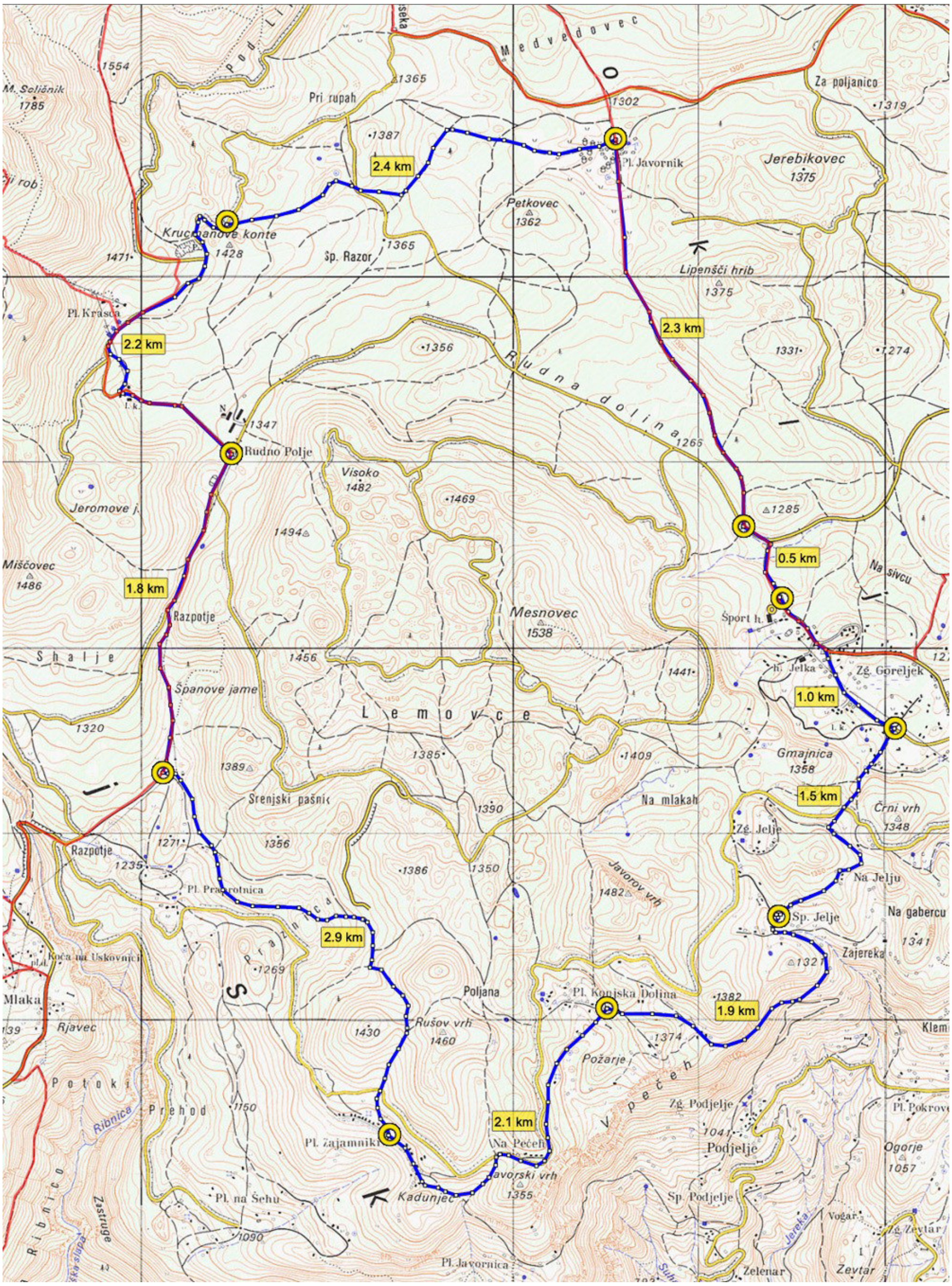
Conflict on the trail to the Planina pri jezeru again needs to be resolved between the users. Since the path is a dirt road, occasionally even used by motorized vehicles, it should be in the first place marked also as a bike trail. Tags could serve as signposts for bikers, hikers would be informed that bikers are also likely to be on the road. A suitable information (info boards, web information) should also be used to inform bikers which months, weekends, days of the year the trail is most visited by hikers and when they should try to avoid it.

Photo 5: Pokljuka

Pokljuka – proposal of a new trail

Some conflicts between the different groups of users will always be difficult to solve. One way of mitigation is to try to separate them, or at least reduce the number of users – by for example providing a new trail in less conflicting area. As an example we present one such proposal within Triglav national park. Pokljuka is surrounded by many mountains and magnificent forests. There are many existing forest roads, desolate paths, which are not very attractive for hikers due to long distances and moderate climbs. As suchm they are ideal for mountain bikers, only difficult for orientation since there are very little signs.

We present a proposal of a circular route, intended for a wide group of bikers – from less to more experienced.



Map 1: Pokljuka trail

Discussion

Hypothesis stating that the cycling opportunities in the Triglav National Park are very limited, due to legal ban on riding offroad can be partially confirmed. With the survey among mountain bikers, literature review and interviews with representatives of various user groups, I compiled an extensive list of the paths, used by mountain bikers within the Park. This, proves that the mountain bikers visit the Park area despite the ban.

The second hypothesis is related to the contact a mountain biker has with the environment and other users of the area. It says that mountain bikers are attributed to various destructive effects on the environment, causing frustration of other users of the area and frightening the animals. The hypothesis also notes that most conflicts are perceived beyond actual dimensions and occur mostly in summer time and on weekends. Mainly, they are related to the marked footpaths that are also used by mountain bikers. Based on review and analysis of the literature on the effects mountain bikers have on the environment, survey among mountain bikers, interviews with hikers, hunters and representatives of the areas, I can confirm that mountain bikers cause much less impact on the environment than for instance hikers and foresters do. Mountain bikers strictly stick to existing paths, creating shortcuts is more an exception than a rule. I can also confirm that it conflicts cummulate in summer months and on weekends, when number of all users raise to maximum.

The survey succeeded to reach the target audience; active mountain bikers. Age group and dominant male gender were expected characteristics of the sample. Dilemmas we encountered at composing the survey were that we did not know how to get as much information as possible from mountain bikers about the trails they use within the park. Those who drive there know that they are violating the law and that it is not the best idea to talk about it. Despite our doubts we got quite many information about the trails within the park.

Due to late snow cover in the research area the field work extended into late summer. This proved useful, since we have the opportunity to experience the conflicts between bikers and hikers and bikers and landowners Nevertheless these were not very serious, and together with the reports from the survey and the interviews we can conclude that these conflicts are exaggerated in media and forums which also distorts the real situation in public opinion.

Conclusion

Mountain biking, is becoming more popular every year. The literature does not confirm a serious impact of bikers on the environment. On the other hand, these impact are often perceived as detrimental for natural environment in (Slovenian) public opinion. Such perception also led the legislator to ban off road biking in natural environment in Slovenia.

Based on the findings from the field visits, survey and interview with different users we can conclude that the main cause of the problem is conflicts between the users. Therefore we propose the establishment of paths where cycling can be implemented, and paths and areas where the implementation of these activities due to certain reasons (congestion area by hikers, the area with wild animals etc.) would be prohibited or limited.

Such restrictions and rules of use should be reached in agreement. Thus, the representatives of users must first agree to sit together and discuss the problem. The Triglav national park management could have the mediating role in the process.

As a complementary solution we propose marking and promoting a new trail which would relieve some of the most crowded (and conflicting) trails in the area. Pokljuka forests represent great potential for mountain bikers, but at present there are no marked bike routes off road. The proposed route runs along forest trails and connects Pokljuka highlands. In order to gain simpler orientation, the path would be marked with the signs and markings on trees.

The results of this study could be used by Triglav national park in their management program to designate the biking trails and the rules for their use. Mountain bikers are at present an important group of visitors in the wider park area. If effectively managed this type of tourism could become even more important to the satisfaction of bikers, other users of protected area and local economy.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 155 - 158

Living forests and dead wood
Saproxylic beetle communities in two suspected virgin forest areas in the Nationalpark Kalkalpen (Upper Austria)

Nationalparks Austria Science Award 2013

Andreas Eckelt

Abstract

The saproxylic beetle fauna of two forest areas ("Kohlersgraben" and "Zwielauf") was studied during the vegetation period 2010. Both investigation sites are dominated by mixed beech-fir-spruce forest. The results obtained were used for an ecological- and faunistic evaluation of the two investigation sites. Approximately 3500 individual specimens were collected. They all belong to 438 different beetle species, of which 242 are saproxylic beetle species. Among those there are thirteen relict species of virgin forests. These thirteen species present a strong indication for a long habitat tradition in the two forest areas. All xylobiont beetles are divided into substratum-guilds (SCHMIDL&BUßLER2004) to enable a comparison with different natural forest reserves.

Keywords

saproxylic beetles, xylobiont beetles, relict species, virgin forests, National Park Kalkalpen, Upper Austria

Introduction

Xylobiont* (or saproxylic) species are one of the most critically endangered organism groups (STOKLAND et al. 2012). Xylobiont and phytophagous organisms play a very important role in the structural development of forest areas. Xylobiont beetles are very crucial for wood decomposition and thereby also in soil development processes (MÖLLER 2009).For such enormous meaningful species natural habitats or at least habitats without nearly any visible anthropogenic influence, are in Austria minimised to only a few thousand hectares (probably less than 1% of the nation area). There are very limited sites left where it is possible to study the original native fauna as it once used to be way back .A large part of the forests in the national park area experienced a huge silvicultural utilisation during the last centuries and only a hand full of small places remained almost untouched. These few places are one of the last regions in Upper Austria where it is possible to study a potentially natural xylobiont beetle community.

The main goals of the study has been to carry out an enquiry of the deadwood dependent beetle community composition in order to conduct a faunistic-ecological evaluation of the study areas applying xylobiont beetles as indicator group. Furthermore to perform an endangerment analysis of the encountered beetle community and providing well founded fundamental data for future comparative studies.

Study Areas

The supposed primeval forest areas of Zwielauf (54,6ha) and Kohlersgraben (30,6 ha) are both dominated by mixed beech-fir-spruce forest. In Zwielauf the dispersal of conifers and broadleaf trees are more or less equal. In the area Kohlersgraben the broadleaf trees are more abundant. Both areas show a great amount of dead wood in divers structural stages (Fig. 1). The area Kohlersgraben is situated between the upper collin and lower montane stage (600-800m), whilst Zwielauf lays in the upper montane region (1200-1400m).

Methods

To give a good overview of the range of the species, additional trap methods (window-, pitfall- and light traps) as well as the traditional manual sampling techniques were used during the vegetation period in 2010. All beetles were determinated to specie's level using the standard literature of Freude, Harde & Lohse –"Die Käfer Mitteleuropas". To provide a good quality of the determined material, all species which were tough to identify, also got checked up by using the great beetle collections of the natural science departments of the Tyrolean State Museum and the University of Innsbruck.

*The definition for xylobiont beetles follows SCHMIDL & BUßLER (2004): xylobiont are all species which reproduce and spend the most of their lifespan obligatorily in and on any kind of wood in all various kind of decay stages, including wood inhabiting fungis.

Figure 1: Habitat pictures of the two study areas. Zwielauf (left) andKohlersgraben (right). (Photos A. Eckelt)

Results

Approximately 3500 individual specimens were caught, all belonging to 438 different beetle species out of 60 families overall, of which 242 are xylobiont beetle species (Fig. 2). Among these 242 beetle species there are thirteen relict species (MÜLLER et al. 2005) of virgin forests (Kohlersgraben 10 spp. and Zwielauf 7 spp.). These thirteen species (Tab. 2) present a strong indication for a long habitat tradition in the two forest areas. All xylobiont beetles are divided into substrate guilds (see SCHMIDL & BUßLER 2004) to enable a comparison with different natural forest reserves. The substrate guild composition of the two sites differ in the guilds of the inhabitants of fresh dead wood (f - guild) and the inhabitants fungi on deadwood or fungi-infested deadwood (p–guild). In Zwielauf the f–species are stronger represented, whereas in Kohlersgraben the p–species show a higher representation rate. The other guilds hardly show any difference in the frequence of appearance (Tab. 1).

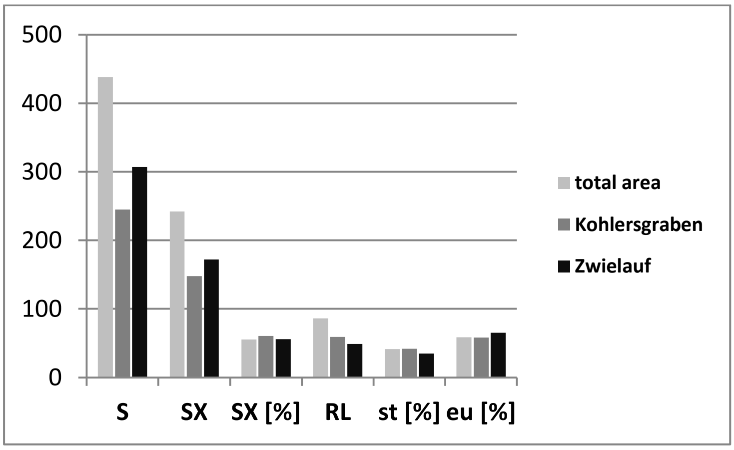

Figure 2: Overview to the results of the study.S = Species, SX = xylobiont Beetles, SX [%] = percentage xylobiont Beetles, RL = Red List Species, st [%] = percentage stenotopxylobiont Species, eu [%] = percentage eurytopxylobiont Species

Both sites share shortly 25% of the species range. This result shows a great difference in the beetle community structure of the investigation areas. Additionally, 86 red list species were identified and mapped, indicating that around 20% of the entire species assemblage is in some way endangered. Among saproxylic beetles, 24 % are considered red list species. In the investigation area Zwielauf, 49 red list species, and in the site Kohlersgraben, 59 red list species, have been recorded.

All detected xylobiont beetles are analyzed for their potential as appropriate indicators of natural forests. There were 126 species identified as potential indicators for natural forests. Among them, 70 are weak indicators, 41 are good indicators and 15 are considered strong indicators for potential natural forests without any anthropogenic influence (Fig. 4). As Figure 3 shows, the amount of high and good indicators for nativeness is slightly higher in the research area Kohlersgraben than in the one of Zwielauf.

Another highlight for the so far for the park unknown FFH – Species *Cucujuscinnaberinus* (Scopoli, 1763)(Code: 1086; Annex II & IV of the FFH-Directive), was located in both study areas. Together with *Rosaliaalpina* (Linnaeus 1758) and *Stephanopachyssubstriatus* (Paykull, 1800), as well a FFH-Directive species, there are now three known FFH-Species in the national park.

Table 1: Percentages of substrate guilds composition overall and within the red list species. a = inhabitants of old rotten deadwood in a variety of conditions, f = inhabitants of fresh dead wood, m = inhabitants of rot-holes, p = inhabitants fungi on deadwood or fungi-infested deadwood, s = species using deadwood in other ways, n = species number, RL% = percentage of red list species within the xylobiont spectrum. (following SCHMIDL & BUßLER 2004)

Substrate - Guilds			
	ZWI [%]	KOH [%]	GF [%]
a	39,5	37,2	39,5
f	33,1	27,7	29
m	0,6	0,7	1
p	25,6	31,1	27,5
s	1,2	3,4	3
n	172	148	242
Red List Species			
a	35,9	37,3	37,1
f	15,4	9,8	12,9
m	0	2,0	1,4
p	48,7	43,1	42,9
s	0	7,8	5,7
n	39	51	70
RL %	22,7	34,5	28,9

Discussion

Surprisingly the two investigation areas only share 25% of the detected species range. This fact could be based on the different altitudes of the sites as well as on the higher rate of conifers and the more open forest structure in Zwielauf. Within the substrate guilds the percentage of freshwood inhabiting species (f) is higher in Zwielauf as in the area Kohlersgraben. The situation within the inhabitants of xylobiont fungi (p) is reverse. These matters of facts could be explained with the following reasons: a.) In Zwielauf, a few years ago, a storm caused several wind thrown trees as well as damages on still standing trees in the area. This means more potential habitats for fresh dead wood inhabiting species. b.) The highly closed canopy structure in the area Kohlersgraben generates a more balanced humidity within the stock. A constant humid microclimate provides a perfect habitat for many different wood and tree inhabiting fungi species. This might be the most likely reason for the higher percentage of p-guild members in the area. The very short survey period of only one summer season is enough for a first small insight, but it is not adequate for a reasonably entirely enquiry of the real xylobiont beetle community. Therefore one would need at least two or better several years of fieldwork to establish more precise study results. Nevertheless it was possible to highlight the meaning of those forest areas in nature conservation efforts for the national park as well as for entire Upper Austria.

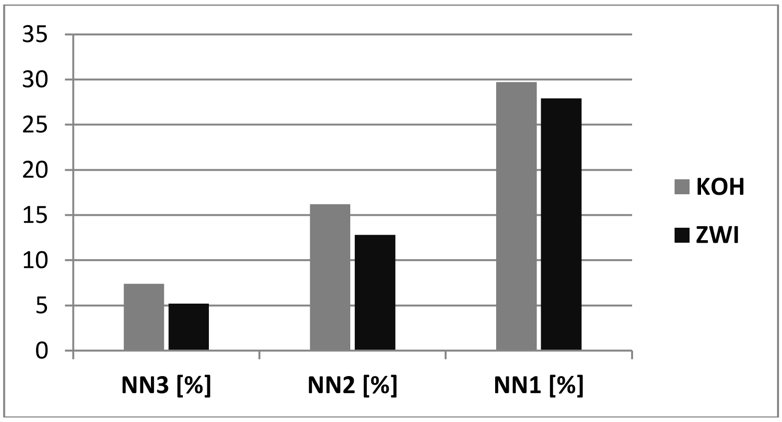

Figure 3: NN = indicator of nativeness, NN3 = high indication, NN2, good indication, NN1 low indication, KOH = study area Kohlersgraben, ZWI = study area Zwielauf
Table 2:Urwaldrelict species and their occurrence in the investigation sites Kohlersgraben (KOH) and Zwielauf (ZWI).

Conclusion

The examined potential virgin forest areas are from crucial importance - both local and nationwide - for nature conservation. The results of the study prove the largely nativeness of the study areas as well as their potentials as dispensing fields for a resettlement of the surrounding areas with the aboriginal beetle fauna. The highly specialized way of living and their very sensitive reaction of environmental changes in their habitats, makes xylobiont beetles an ecological key group for several different queries in the context of forest ecosystem research and conservation.

Table 2: Urwald relict species and their occurrence in the investigation sites Kohlersgraben (KOH) and Zwielauf (ZWI).

Urwald relictspecies	KOH	ZWI
Peltisgrossa	+	-
Calitysscabra	+	-
Ampedusauripes	-	+
Nematodesfilum	+	-
Pediacusdermestoides	+	+
Synchitaseparanda	+	-
Xestobiumaustriacum	-	+
Dolotarsuslividus	+	+
Neomidahaemorrhoidalis	+	+
Ceruchuschrysomelinus	+	+
Tragosomadepsarium	+	-
Rosalia alpina	+	-
Rhyncolussculpturatus	-	+

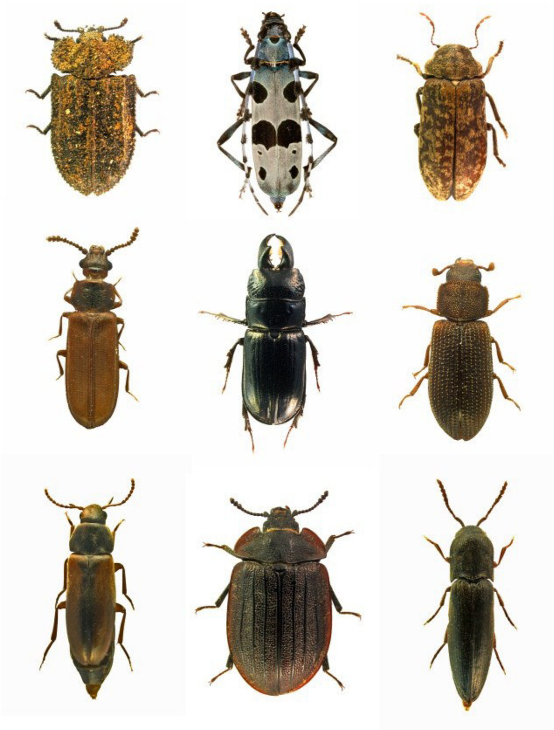

Figure 4: A small selection of characteristic species of natural forests. *Calitysscabra, Rosaliaalpina, Xestobiumaustriacum, Pediacusdermestoides, Ceruchuschrysomelinus, Synchitaseparanda, Dolotarsuslividus, Peltisgrossa* and *Nematodes filum* (f.l.t.r).

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 159 - 166

Analysis of Natura 2000 habitats and species in the Hohe Tauern National Park Carinthia and Salzburg

Gregory Egger, Nadja Merkač, Susanne Aigner, Christian Komposch, Brigitte Komposch, Paul Schreilechner, Robert Lindner

Abstract

The Hohe Tauern National Park Salzburg and Carinthia hosts a Natura 2000 site which covers more than 1000 km². Protection objectives of this Natura 2000 site are habitats (32 types), animal species (10 spp.) and plant species (7 spp.). Its purpose is to maintain or restore habitats and species to an appropriate level and to monitor their status.

Spatial data collection over such a large area is a complicated and resource demanding task. In particular, at the Hohe Tauern, many datasets – at least for certain special fields – were available but with different quality and resolution. The project goal was the development of a GIS based dataset encompassing and harmonizing the existing data sources describing the FFH habitats and their conservation status.

The content of the project "Analysis of Natura 2000 habitats and species in the Hohe Tauern National Park Carinthia and Salzburg" is the proliferation of FFH habitats, animals and plant species; the determination of their conservation status, the storage of all available data and information in a database, the identification of measures and projects to maintain or restore nature-favourable conservation status and the identification of possible shortcomings in the data for the National Park of Salzburg and Carinthia.

Based on the available data, it was assessed the sensitivity and degree of endangerment of the protected areas in respect to the interference given by mountain farming, forestry and tourism. Sensitivity to the different criteria were finally assigned to each of the spatial units making up the spatial dataset. The resulting maps and quality of the work together with the cost effectiveness rate of the whole work demonstrate the suitability of the technique as a viable cost effective tool applicable also to other large protected areas. Furthermore the Standard Data Form of the Natura 2000 sites has been updated.

Keywords

FFH habitat directive, conservation status, management alpine pastures, Austrian and Eastern (Central) Alps

Introduction

The Hohe Tauern National Park Salzburg and Carinthia hosts a Natura 2000 site which covers more than 1000 km². Protection objectives of this Natura 2000 site are habitats (32 types), animal species (10 spp.) and plant species (7 spp.). Its purpose is to maintain or restore habitats and species to an appropriate level and to monitor their status. For such protected areas generic management plans are not sufficient because critical aspects need to be accurately located, therefore they require a detailed and high quality spatial information. At the same time, the collection of spatial data over such large area is a complicated and resource demanding task. In particular, at the Hohe Tauern, many datasets to some degree of extent were already available but they exibhit different quality and spatial resolution. The objectives of the project "Analysis of Natura 2000 habitats and species in the Hohe Tauern National Park Carinthia and Salzburg" are

- development of a GIS based dataset encompassing and harmonizing the existing data sources describing the FFH habitats and their conservation status
- identification of the current status of all FFH habitats (Annex I, habitats directive), animals and plants species listed in Annex II; additionally, extensive research, expert interviews, literature and database evaluations for selected animal key-species of FFH habitats has to be performed
- determination of all FFH habitats, animals and plants species listed in Annex II conservation status
- documention of the spatial arrangement of FFH-habitats and species and their conservation status by maps
- identification of measures and projects to maintain or restore the favourable conservation status
- identification of possible data deficits of the National Park of Salzburg and Carinthia
- documention of all base data and results in a relational database

The results of the project are the basic for a spatially inclusive and comprehensive management plan of the Hohe Tauern National Park.

The project (Egger et al. 2013) was funded by Salzburger and Känrtner Nationalparkfonds (Mittersill, Großkirchheim) and Amt der Kärntner Landesregierung (Klagenfurt).

Study area

The study area is defined by the border of the Hohe Tauern National Park Salzburg and Carinthia (Außen- & Kernzone). All research data are related to this area. The analysis of the conservation status is related to the Natura 2000 area, which covers the peripheral- and core zone of the Hohe Tauern National Park Salzburg and the core zone of the Hohe Tauern National Park Carinthia.

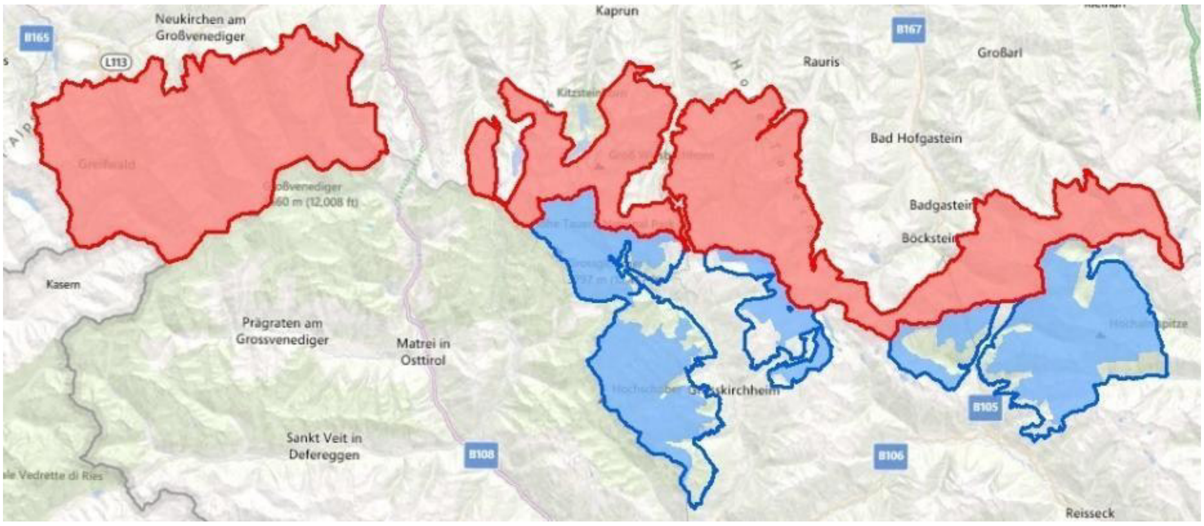

Figure 1: Natura 2000 site Hohe Tauern Salzburg (red area) and Carinthia (blue area:) and Hohe Tauern National Park Salzburg (red border line) and Carinthia (blue border line)

Methods

The existing data sources were available for the whole National Park or at least for large parts of it. The overall data analysis procedure was made up by following steps:

1. localization of FFH-natural habitat types (Annex I), FFH plant species (Annex II) and FFH animal species (Annex II and selected indicator species)
2. evaluation of the conservation status of FFH natural habitat types and species
3. definition of measures

Localization of the FFH-habitat types

The FFH habitats were derived from the combination of the information stored in ArcGIS® thematic layers such as aerial photographs (Habitalp), geology, habitat mapping, forestry inventory and existing maps. The layers data quality and their heterogeneic resolution required the development of an innovative data classification lineage based on multivariate regression statistics and expert knowledge judgment. Thematic layers considered in the analyss were:

- CIR-areal photo interpretatin
- mapping of moor and alpine wet lands from Wittmann
- geology
- digital elevation model (10 m)
- habitat mapping Salzburg
- mapping of mountain and deciduous forest

Localization of FFH-plant species Annex I

The source of information of bryophytes (coordinates of places) are from Mag. Köckinger. The places of lady's-slipper orchid *(Cypripedium calceolus)* are from Dr. Helmut Wittmann.

Determining the conservation status of the Habitats Directive habitat types

For the classification of the site's conservation status, the concept of hemeroby is applied. It takes into account the intensity of the intended and unintended effects of human intervention on ecosystems. The hemeroby concept (Blume & Sukopp, 1976) assumes that in the absence or very low impact of the site's conservation status is "favourable" (A), with a greater degree of influence the conservation status is "unfavourable-inadequate" (B) and with a higher degree of influence the conservation status is "unfavourable-bad"(C). Figure 3 shows an overview of the determination of the site's conservation status for Habitats habitats is given.

The sensitivity of the protected areas in respect to the interference given by mountain farming, forestry, tourism, game pressure and water uses was assessed. Sensitivity to the different criteria were finally assigned to each of the spatial units making up the spatial dataset.

The FFH-Habitat types show different sensitivity to the individual impact factors which were individually determined. By linking the impact intensity and sensitivity of each FFH-habitat type we obtain the impact relevance of each FFH-Habitat type. In accordance with ELLMAUER (2005) the total area of the impact relevance of each FFH-Habitat type per impact factor is determined. For the two FFH-Habitat types (7140 Transition mires and quaking bogs and 7240* Alpine pioneer formations of Caricion bicoloris-atrofuscae) the results of WITTMANN et al. (2007a, 2007b) are transferred directly.

The last step is the sum all impact relevances (meant as the combination of the impact relevances of all individual impact factors) and the determination of the site's conservation status in categories A, B and C for each type FFH-habitat type.

Animals

The identification and the monitoring of zoological character species of FFH habitat types is the only way of reaching a fully encompassing (“ecological”) evaluation of the conservation status. In this paper 24 zooological character species of the taxa mammals (1 sp.), plant hoppers (5 spp.), true bugs (5), carabid beetles (3), spiders (5 spp.) and harvestmen (5) have been selected to evaluate 19 FFH habitat types. The existing data sources were available for the whole National Park or at least for large parts of it.

The data basic for this project are Biodiversitätsdatenbank Nationalpark Hohe Tauern, ZOBODAT, Zoologische Datenbank des Landesmuseums Kärnten, Datenbank der KFFÖ, Herpetologische Datenbank des Naturhistorischen Museums Wien, Datensätze Thomas Huber, Datensätze Verein für Wildtierforschung, Arthropoda-Datenbank_OEKOTEAM_Komposch, Hopperbase-Datenbank_OEKOTEAM_ Holzinger, BioOffice-Datenbank_OEKOTEAM_Frieß, Land Kärnten & KIS, Collection Paill/Joanneum Graz, Sammlung Ausobsky und Landtierwelt der Mittleren Hohen Tauern.

Determination of measures

The development of nature conservation well-founded measures, based on the existing data, was a key objective of the project. As a basis for the allocation of the measures for the Habitats Directive habitat types were used: impact intensity, impact relevance (sub-area) and, where appropriate, altitude. Furthermore, it was considered that the FFH animal and plant species has to be promoted and ensured by means of appropriate measures in the medium and long term.

Database

Within the project a relationsl database built on SQL Server 2008™ is created. This database contains the results of the analysis as well as all input data. The geometries of the GIS data were integrated as spatial data types in the database and are available through GeoServer as a WMS (Web Map Service) or WFS (Web Feature Service). Point-type data were imported directly into the database BioOffice in Salzburger Haus der Natur. The data can be queried via BioOffice online or also on GeoServer. Furthermore, the database contains tables and views containing reference to the most important results.

Results

Extension and conservation status of the FFH-habitat types:

Approximately 75% (Salzburg) and 77% (Carinthia) of the Natura 2000 area are occupied by FFH-habitat types. The most extensive habitat types are, with a total of about 30% (Salzburg), and 25% (Carinthia), the silicate neglected grassland types (codes: 6150, 6230). Additionally there are in both Natura 2000 areas only few sites with limestone neglected grassland (approx. 3.5%). Approximately 15% (Salzburg) and 20% (Carinthia) are covered by boulders and rocks with pioneer vegetation (codes: 8110, 8120, 8210, 8220). Approximately 10% ist covered by glaciers (code: 8340). The proportion of forest (codes: 9410, 9420) is due to the hight altitude of the nature 2000 area about only 10%.

In view of the conservation status, the two Natura 2000 sites differ significantly in Salzburg and Carinthia. In Salzburg, the grasslands at lower altitudes (codes: 6230, 6510, 6520) are consistently rated as "B", and the alkaline fens (code: 7230) are also classified as "B". In contrast, all of Carinthia FFF habitat types are classified as "A".

Conservation status of mosses and vascular plants:

In the whole study area, no mosses were covered by the Annex II of the Habitats Directive were found.

The Lady's Slipper (*Cypripedium calceolus*) is not significantly present in the Hohe Tauern National Park (it is only known in one point). Therefore, the site's conservation status is not classified.

Conservatin status animals:

The current classification of the animals in Annex II of the Habitats Directive differs in many cases from the initial classification listed in the standard data form. The number of consistent in terms of their conservation status of protected animals is 4 Carinthia and Salzburg only 2 out of 10. Obvious changes are the conservation status of *Euphydryas aurinia*, currently with classification "A" while in the Standard Data Form for Carinthia was classified with a "D". Salzburg for the *Bombina variegata* was classified in the Standard Data Form "B", although this value is based on the current data "D". *Cottus gobio* and *Lutra lutra* were corrected for Salzburg by one level down.

Table 1: Area of FFH-habitat types in Hohte Tauern National Park Salzburg, impact relevance of alpine pasture farming (Almwirtschaft, AW), of infrastructe and tourism (IT), forestry (FW) and water use (1=no-low, 2=moderate, 3=high) and conservation status (GEZ; A=favourable, B=unfavourable –inadequate, C=unfavourable-bad).

FFH-Code	FFH-Habitat type	area NP [ha]	area NP [%]	EEH AW	EEH IT	EEH FW	EEH WW	GEZ
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation	21	0,03	1	2			A
3160	Natural dystrophic lakes and ponds	<1	< 0,01	1	1			A
3220	Alpine rivers and the herbaceous vegetation along their banks .	49	0,06	1	2		1	A
4060	Alpine and Boreal heaths	3.437	4,27	1	1			A
4070	*Bushes with Pinus mugo and Rhododendron hirsutum (Mugo-Rhododendretum hirsuti)	2.112	2,62	1	1			A
6150	Siliceous alpine and boreal grasslands	10.157	12,62	1	1			A
6170	Alpine and subalpine calcareous grasslands	2.904	3,61	2	1			A
6230	*Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe) – montane region	696	0,86	2	2			B
6230	*Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe) – subalpine region	10.873	13,51	1	1			A
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	111	0,14	1	1			A
6510	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis)	17	0,02	2	2			B
6520	Mountain hay meadows	214	0,27	2	2			B
7110	*Active raised bogs	<1	< 0,01	1	3			D
7140	Transition mires and quaking bogs	28	0,04	2	2			A*
7230	Alkaline fens	20	0,03	3	1			B (C)
7240	*Alpine pioneer formations of Caricion bicoloris-atrofuscae	5	0,01	1	3			A*
8110	Siliceous scree of the montane to snow levels (Androsacetalia alpinae and Galeopsetalia ladani)	5.426	6,74	1	1			A
8120	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)	456	0,57	1	1			A
8210	Calcareous rocky slopes with chasmophytic vegetation	1.241	1,54	1	1			A
8220	Siliceous rocky slopes with chasmophytic vegetation	5.911	7,34	1	1			A
8340	Permanent glaciers	7.658	9,51	1	1			A
9140	Medio-European subalpine beech woods with Acerand Rumex arifolius	1	< 0,01	1	1	2		A
9180	*Tilio-Acerion forests of slopes, screes and ravines	143	0,18	1	1	2		A
91D3	*Mountain pine bog woods	1	< 0,01	1	3	1		B (C)
91E0	*Alluvial forests with Alnus glutinosaand Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	74	0,09	2	2	2		B (C)
9410	Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	5.720	7,1	1	1	2		A
9420	Alpine Larix decidua and/or Pinus cembra forests	2.735	3,4	1	1	1		A
No FFH		20.499	25,46					
Total		**80.508**	**100**					

Table 2: Area of FFH-habitat types in Hohte Tauern National Park Carinthia, impact relevance of alpine pasture farming (Almwirtschaft, AW), of infrastructe and tourism (IT), forestry (FW) and water use (1=no-low, 2=moderate, 3=high) and conservation status (GEZ; A=favourable, B=unfavourable –inadequate, C=unfavourable-bad).

FFH-Code	Brief description	area NP [ha]	area NP [%]	EEH AW	EEH IT	EEH FW	EEH WW	GEZ
3150	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation	3	0,01	1	1			A
3220	Alpine rivers and the herbaceous vegetation along their banks .	30	0,07	1	1			A
4060	Alpine and Boreal heaths	1.152	2,62	1	1			A
4070	*Bushes with Pinus mugo and Rhododendron hirsutum (Mugo-Rhododendretum hirsuti)	452	1,03	1	1			A
6150	Siliceous alpine and boreal grasslands	7.714	17,54	2	1		1	A
6170	Alpine and subalpine calcareous grasslands	1.498	3,41	2	1			A
6230	*Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe) – montane region	226	0,51	1	1			A
6231	*Species-rich Nardus grasslands, on siliceous substrates in mountain areas (and submountain areas, in Continental Europe) – subalpine region	4.053	9,22	1	1			A
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	47	0,11	1	1			A
6520	Mountain hay meadows	41	0,09	1	1			A
7230	Alkaline fens	5	0,01	1	1			A
7240	*Alpine pioneer formations of Caricion bicoloris-atrofuscae	100	0,23	1	1			A
8110	Siliceous scree of the montane to snow levels (Androsacetalia alpinae and Galeopsetalia ladani)	4.101	9,33	1	1			A
8120	Calcareous and calcshist screes of the montane to alpine levels (Thlaspietea rotundifolii)	271	0,62	1	1			A
8210	Calcareous rocky slopes with chasmophytic vegetation	566	1,29	1	1			A
8220	Siliceous rocky slopes with chasmophytic vegetation	4.303	9,79	1	1			A
8340	Permanent glaciers	4.229	9,62					A
9140	Medio-European subalpine beech woods with Acerand Rumex arifolius	3	0,01	1	1			A
9180	*Tilio-Acerion forests of slopes, screes and ravines	45	0,1	1	1	2		A
9,10E+01	*Alluvial forests with Alnus glutinosaand Fraxinus excelsior (Alno-Padion, Alnion incanae, Salicion albae)	38	0,09		1	2		A
9410	Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	2.609	5,93	1	1	2		A
9420	Alpine Larix decidua and/or Pinus cembra forests	2.522	5,74	1	1	2		A
No FFH		9.959	22,65					
Total		**43.966**	**100**					

Table 3: Old and new conservation status of the animals of the FFH-Habitat directive Annex II in Hohte Tauern National Park Carinthia and Salzburg (A=favourable, B=unfavourable –inadequate, C=unfavourable-bad, D=not significant).

No	Scientific name	English name	Conservation status Carinthia		Conservation status Salzburg	
			new	old	new	old
1	*Euphydryas aurinia*	Marsh Fritillary	A	D	A	A
2	*Bombina variegata*	Yellow-bellied toad	x	---	D	B
3	*Cottus gobio*	European bullhead	x	---	C	B
4	*Rhinolophus hipposideros*	Lesser horseshoe bat	D	D	B	B
5	*Barbastella barbastellus*	Barbastelle	x	---	?	B
6	*Myotis myotis*	Greater mouse-eared bat	D	D	D	---
7	*Ursus arctos*	Brown bear	D	D	D	---
8	*Lutra lutra*	European otter	x	---	C	B
9	*Lynx lynx*	Eurasian lynx	D	D	D	---
10	*Canis lupus*	Gray wolf	D	---	D	---

Management measures

In total, 6 types of management measures for open land (not usable area, alpine madows) and 5 types of measurement has been assigned for forests and locates in maps.

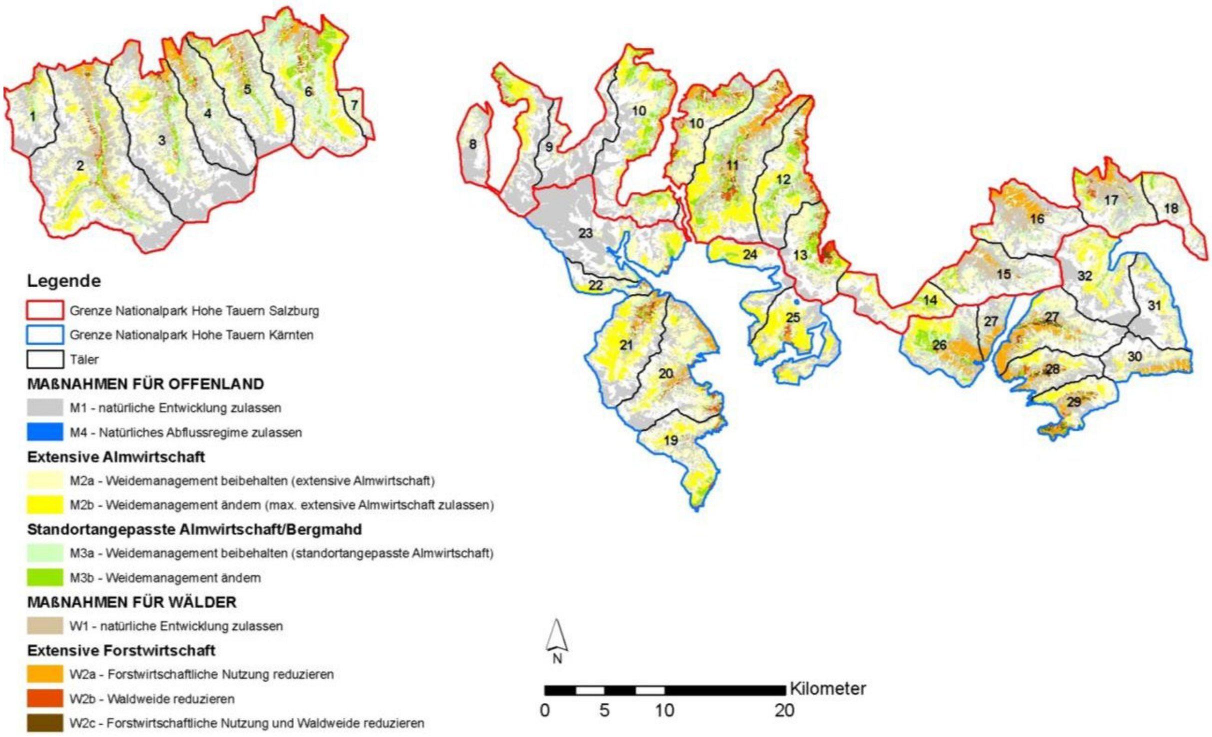

Figure 2: Management measures for open land (M1=natural development; M2=Extensive alpine pasture farming: M2a=Maintain extensive pasture management, M2b=Change/reduction of pasture intensity; M3=Locally adapted pasture/mountain meadows management: M3a=Maintain locally adapted pasture management, M3b=Change/reduction of pasture intensity; M4=Natural flow regime) and forests (W1=natural development; W2=Extensiv forestry: W2a=Reduction of forestry use, W2b: Reduction of forest grazing, W2c: Reduction of forestry use and forest grazing)

The specific management measures and explanations are given in detail within the description of all habitat types and species (EGGER et al. 2013). In addition, the following specific wildlife management measures are recommended:

- continuation and/or resumption of hay
- public relations
- sectoral, animal group-specific measures
- in-depth inventory surveys
- no further expansion of the road network (footpaths, roads).

Dicsussion and Conclusion

The resulting maps and quality of the work together with the cost effectiveness rate of the whole work demonstrate the suitability of the technique as a viable cost effective tool applicable also to other large protected areas.

Regarding the results of the conservation status, the Hohe Tauern National Park Carinthia clearly performs better than Salzburg. This could be essentially due to the inclusion of the more intensively used pastures in the peripheral zone of the National Park Salzburg. In the Hohe Tauern National Park Carinthia, the more extensively used core zone is just designated as Natura 2000 site.

In the assessing with "A" of the conservation status of the FFH-habitat type “Permanent glaciers” (code: 8340) global warming is not considered. Given the dramatic decline of glaciers, the score would likely be more severe ("C"?), though such point deserved a more thorough and dedicated discussion.

It was found that, the most important impact factor for the Natura 2000 habitat types is alpine farming. A second relevant facor ist tourism and infrastructres.

Despite a generally good data quality and data availability there are deficits due to the high complexity of the proposed questions. These are particularly relevant in view of the basic data to determine the habitats types and the state of consveration. Particular for the evaluation of the impact relevance on the individual polygons systematic field surveys are necessary. There is a high need for research related to Mountain hay meadows (code: 6520), Species-rich Nardus grasslands (code: 6230), Alpine and subalpine calcareous grasslands (code: 6170) and nearly all animals of FFH Habitat directive Annex II.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 167 - 170

Micro- and meiobiota patterns in glacier driven stream habitats

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Abstract

Glacier-fed rivers are among the most sensitive and endangered habitat types nowadays. Their upper reaches are located within areas of economic interest (e.g. skiing and glacier skiing, hydropower generation), but also within protected areas such as, for example, National Parks worldwide (e.g. Hohe Tauern, Pyrenees, Rocky Mountains). The majority of glacial river studies has focused on the macrozoobenthos. Thus, this study presents a comparison of the widely neglected stream micro- and meiobenthos (MMB) among different glacial-fed stream reaches driven by two different glacier catchments: the Möll River Catchment (MC) and the Kleinelendbach stream catchment (KC). The catchments differ in catchment and glacier area, and glacier retreat patterns. The stream reaches comprised different habitat types such as the glacier source and extreme harsh glacial stream main channels, but also benign, less glacier influenced side channels. Their ages (years since deglacierization) ranged from 0 to ~ 150 years. They were within the protected area of the Hohe Tauern National Park.

The regional diversity of the MMB (taxa numbers of fungi, algae, protists, nematodes, rotifers, invertebrates) was generally high in both catchments (MC: 270; KC: 291). The local (stream reach) diversity was also relatively high, but taxa numbers varied considerably between reaches and ranged from 64 – 195. Highest taxa numbers were recorded for benign stream habitats of the KC (195) and the MC (172). The latter was within the Sandur area downstream the margin of the Pasterze glacier. The benign sites represented not only local hot spots of diversity but also hot spots of ecological functionality with regard to the broad spectrum of abundant organisms, comprising primary producers (autotrophic flagellates, cyanobacteria, diatoms and other algae), decomposers (bacteria, fungi) and diverse consumers (heterotrophic flagellates, protists, nematodes, rotifers, copepods, tardigrades). ANOSIM resemblance analysis revealed similarity of fungi, protists and rotifers, and dissimilarity of bacteria, flagellates, diatoms and nematodes between the different stream reaches.

The perspectives of ongoing glacier retreat and expected alterations of glacial-fed rivers may have various consequences for the MMB: thermal and hydrological changes along main river channels will represent adaptive challenges to these organisms, whereas drying of side arms and surrounding wetlands will lead to regional extinctions. The latter would represent an enormous loss of diversity that may affect ecological processes and services of alpine areas. But actual habitat changes and their effects on biodiversity as well as on ecological processes and services of alpine glacier catchments clearly need further investigations.

Keywords

glacier retreat, glacial river, bacteria, fungi, algae, nematodes, rotifers, local diversity, regional diversity

Introduction

Several industries (i.e. ski and hiking tourisms, power generation) have regionally overexploited high alpine zones leading to their fragmentation, degradation and deterioration. But with increasing loss of intact alpine areas, awareness of their sensitivity and the need to preserve their ecological intactness has grown and protected alpine areas have been established world-wide. This protection is particularly of importance for glaciers and their forefields, because they represent unique, highly sensitive and intricately interwoven complex of icy, aquatic and terrestrial alpine habitats (McGregor et al. 1995). Several national parks worldwide comprise glacier catchments (e.g. Alps, Rocky Mountains; Pyrenees). Besides those negative affects above-mentioned, these peculiar habitats are affected by climate change. Climate change has been causing majorly (often rapid) retreat of glaciers (WGMS 2008), which are basically highly different in their characters (Cuffey & Paterson 2010). These differences, in turn, are responsible for differences and differently influenced changes of the hydrological and thermal regimes of glacier streams and rivers (Milner et al. 2009). All these changes are of influence on human water usage on the long run (IPCC 2007).

The final drastic consequence of complete glacier loss would be the loss of typically glacier-fed riverine habitats. These habitats are not only fed by surficial glacier meltwaters, but also by their subsurface storage (Malard 2003). Because macroinvertebrates have been the sole focus in glacier stream research, consequences of habitat alterations have majorly been discussed for them (Brown et al. 2010; Finn et al. 2010; Muhlfeld et. al. 2011). They generally represent less dense and diverse inhabitants of glacier-fed streams and rivers with species and individual numbers even distinctly decreasing river upstream towards glacier sources (MILNER et al. 2001; ILG & CASTELLA 2006; FUEREDER 2007).

Though widely neglected in glacier river research, benthic meioinvertebrates, and in particular nematodes among them, contribute to biological complexity in glacier-fed river habitats, where they occurred in relatively high densities and numbers of species (EISENDLE 2008). In general, benthic invertebrates of any size are important to ecosystem processes and services (PRATHER et al. 2012) - similarly as bacteria, algae and fungi. But despite the particular importance of the small groups (fungi, algae, bacteria and meiofauna), partly due to high turnover rates (short generations times), they are still the least studied organisms in glacier rivers. As a consequence, their alterations in response to changes of hydrological and thermal regimes are difficult to estimate and, moreover, far reaching effects of potential alterations for other organisms but also for the water quality of glacial rivers can hardly be assessed to date.

Ongoing retreat of alpine glaciers and expected changing river habitat conditions together with the awareness for a relatively unknown small biota, represent the background for this study. Its intention was to reveal potential differences of bacteria, fungi, diatoms, other algae, protists and meiofauna communities between different riverine habitats, whose conditions were hypothesized to be differently shaped among and between two catchments due to the different basic characters of these catchments.

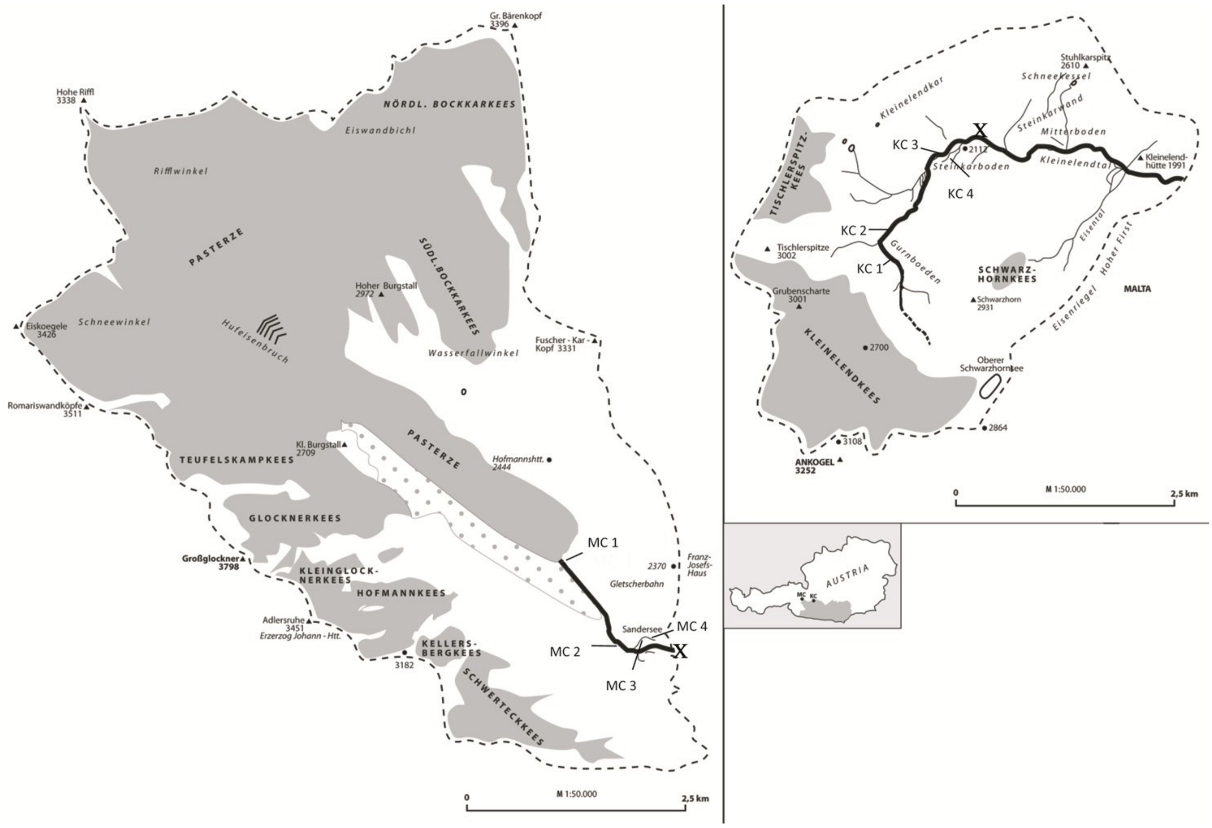

Figure 1: The two study sites situated within the Hohe Tauern National Park. MC = Möll River catchment and KC = Kleinelendbach stream catchment. MC1-4 and KC1-4 indicates the river reaches investigated therein.

Material and Methods

The two glacier catchments were situated in the Hohe Tauern National Park: the Möll river catchment (47°04'N12°45'E) and the Kleinelendbach stream catchment (47°04'N 13°15'E; Fig. 1). The former (MC) belongs to the Großglockner region and originates at the Pasterze glacier; the Kleinelendbachstream catchment (KC) belongs to the Ankogel region and originates at the Kleinelendkees. They differ in catchment and glacier area, and in their deglacierzation activity given the retreat patterns during the last decades and during the study period (Tab. 1). We sampled main stream reaches and side channels by corer sampling before during and after the glacier melt period in 2010. From these corer samples we analysed abundance patterns of bacteria, nano-flagellates, fungi (CFU counts), algae, protists, and small invertebrates (nematodes, rotifers, copepods, tardigrades and insects) as well as morphotypes of bacteria and nanoflagellates, genera of algae and protists, and species of fungi, nematodes and rotifers. In addition, five to ten stones were taken (except at MC3 and MC4, where we took small amounts of glacier silt) at each sampling occasion in order to obtain the number of diatom species.

We tested for significant differences of resemblance patterns between the reaches for each group (microbiota, algae, protists, fungi CFU, diatoms, nematodes, rotifers) by means of ANOSIM analysis (square root transformed or presence/absence data, Bray-Curtis similarity matrix).

Table 1: Characteristics of the two catchments situated in the Hohe Tauern National Park (MC = Möll River catchment, KC = Kleinelendbach stream catchment). * Summary of OEAV Gletscherberichte 1998-2010.

	MC	KC
Geographic coordinates (N/E)	47°04'/12°44'	47°04'/13°16'
Catchment area (km²)	36	12
Number of glaciers	9	2
Glacier area (km²)	22	3
Percentage glacierization	61	25
Main glacier	Pasterze glacier	Kleinelendkees glacier
Retreat 2010 (m)	40	2,7
Retreat since 1998 (m)*	403 (debris free tongue)	26

Results

The regional number of taxa was high: 271 and 290 in the MC and the KC, respectively. The local (river reach) taxa numbers ranged from 64 (MC2) – 195 (KC 4). Beside KC4 high taxa numbers were observed at MC3 (172) and MC 4 (166). Nematodes and rotifers dominated the invertebrates with percentage maxima ranging from 66% to 94%. High rotifer portions appeared at the Möll River glacier source (MC1: 94%) and the MC proglacial (MC2: 88%) and the oldest KC main channel reach (KC3: 80%), which is accompanied by glacier cliff remnants. Nematodes dominated particularly the benign reaches of the Sandur area (MC3: 51%, and MC4: 66%). Each nematode feeding type, according to Yeates et al. (1993), occurred at each reach. Copepods were present with higher portions only at KC4 (18%) and tardigrades only at MC3 (22%) and MC4 (33%). Chironomids and other insects such as stoneflies, mayflies and caddiesflies were rarely observed (≤ 1%).

Table 2: Ranges of bacteria and nanoflagellates (n=4; ind/cm²/ml), fungal CFU counts (n=5; ind/cm²), algae and protists (n=2-3; Ind/cm²) nematodes and rotifers (n=5; Ind/cm²/ml) at each reach summed for the study period. WT indicates the range of water temperatures measured at these sites during the study.

	Bacteria	Nanoflagellates	Algae	CFU - Fungi	Protists	Nematodes	Rotifers	WT
KC1	4.9E+05 - 1.1E+08	0.0E+00 - 7.1E+04	0 - 9.2E+04	0 - 347	0 - 102	0 - 1144	24 - 1060	7 - 9
KC2	3.4E+06 - 1.5E+08	1.4E+04 - 2.0E+05	3.8E+01 - 2.5E+04	0 - 80	0 - 1966	3 - 725	42 - 741	4 - 9
KC3	2.2E+06 - 1.1E+08	1.0E+04 - 8.5E+04	2.0E+01 - 1.2E+06	2 - 433	0 - 244	0 - 76	9 - 405	5 - 8
KC4	3.9E+07 - 8.6E+08	1.3E+05 - 1.0E+06	7.3E+03 - 4.3E+05	2 - 347	50 - 5184	46 - 3730	522 - 8712	8 - 12
MC1	3.9E+06 - 7.2E+07	1.9E+04 - 2.4E+05	6.1E+03 - 1.6E+05	9 - 249	0 - 390	1 - 11	9 - 202	0.3 - 0.5
MC2	9.4E+06 - 1.0E+08	3.2E+03 - 4.6E+05	0.0E+00 - 1.2E+03	1 - 218	0 - 113	3 - 27	15 - 264	0.6 – 1.4
MC3	5.0E+07 - 4.2E+08	3.4E+04 - 1.3E+06	4.7E+03 - 6.9E+06	4 - 110	0 - 25	53 - 4944	14 - 1858	9 - 15
MC4	1.8E+08 - 7.2E+08	1.9E+05 - 9.6E+05	0.0E+00 - 9.0E+05	4 - 839	0 - 41	397 - 4768	13 - 878	6 - 15

The abundance ranges of bacteria, nano-flagellates, algae, protists, fungi and invertebrates are shown in Table 2. The bacteria highest maxima were observed at the benign reaches (KC4 and MC4), the lowest at the uppermost reach of the Kleinelendbachstream (KC1). Highest nano-flagellate maxima appeared at MC3 and KC4, low values were observed not only at MC2, the instable proglacial of the Möll river site. The R-values of the ANOSIM analysis reveals that the resemblance patterns of most groups were significantly different between the reaches; only fungi, protists and rotifers were not significantly different between the reaches (Table 3).

Table 3: Results of the one-way ANOSIM analysis of respective groups based on Bray-Curtis resemblance matrices from square root transformed data (except diatoms - for which presence/absence data were used).

	Microbiota	Algae	Diatoms	Protists	Fungi	Nematodes	Rotifers	Invertebrates
R	0,49	0,54	0,47	0,25	0,05	0,66	0,17	0,65
p %	0,1	0,1	0,1	0,1	0,5	0,1	0,1	0,1
N ≥ 0	0	0	0	0	4	0	0	0

Discussion

The basic results of this study do not only show that the micro- and meiobenthos (MMB) have been wrongly neglected in glacier river research so far (see Milner et al. 2009), but also that protected areas are invaluable, undisturbed and suitable habitats for basic and highly timely research questions. This study reveals that the MMB contribute enormously to community complexity in glacier-fed river systems due to their high abundances and numbers of species. According to this, the micro-and meiobenthos can be assumed of major importance for glacier-fed rivers and their functioning. They consequently play a role in ecosystem services in glacier catchments. By comparisons of similarly aged habitat complexes (KC1 with MC2, or KC3 with KC4), we conclude that not stream age (year since the glacier retreat set free new habitats) but habitat conditions are the major determinants for the complexity of the benthic community.

Only certain groups (bacteria, fungi, the smaller nanoflagellates, diatoms, nematodes, tardigrades and bdelloid rotifers) contribute to the early coloniser communities, which might have specific, but so far unknown functions in glacier-fed streams. In general, the differences in the ANOSIM results indicate that habitat effects vary across the MMB groups. The similarity of the fungal patterns between the reaches, for example, might indicate the dominance of terrestrial effects over within-stream effects.

Hot spots of diversity (high species numbers) were found at the benign sites of the Möll and the Kleinelend catchments. Combined with high bacteria, flagellate, nematode and, partly high, CFU abundances, we consider these sites extremely active with regard to high nutrient assimilation and recycling, and thus, as highly functional sites involved in important ecosystem processes and services of alpine water reservoirs. The copepods and macroinvertebrates seem to be of little importance at such hot spots due to their minor abundances.

Retention, buffer and detoxification capacity of a complex small benthic biota with regard to pollutants derived from both short and long distance transports and short and long term storage (Bizzotto et al. 2009) could be considered, but should definitely be the focus of future studies. National parks provide invaluable habitats at least undisturbed from direct anthropogenic modifications, which might allow sensitive alpine riverine biota to adapt to and mitigate changing climate conditions. Furthermore, the undisturbed and morphological non-degraded river networks in protected alpine areas provide optimal conditions to study the consequences of climates changes and the risk involved for alpine water reservoirs and should therefore be used more often in this context as riverine "outdoor laboratories".

Acknowledgements

This study was financed by the Austrian Science Fund (FWF P-21922). We thank the Hohe Tauern National Park, Verbund Touristic, GROHAG, Cornelia & Michael Lunder, Eva Wilhelm and Johann Flöckner for their logistic support.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 171 - 174

Main Principles and Results of Landscape Planning of New Protected Area in Central Caucasus (Georgia)

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Keywords

Protected area, Landscape, Landscape Area, Geoecological Proceses, Function of Landscapes, Environment.

Actuality of the problem

The Central Caucasus is a part of the mountainous Caucasus ecosystems between Russia and Georgia. This territory with the face of medium and high mountain forests, meadows, subnival ecosystems represents **one of the key** and trans-border cooperation area in the Caucasus eco-region. Here, the main aim of landscape planning was the formation of new protected areas. Planned, protected areas cover the two historical-geographical provinces of-Phshavi and Khevsureti.

A special importance of Phshav-Khevsureti is connected with the unic **ethnocultural and natural** diversity in the Caucasus, its transitional location among other protected areas of the Central Caucasus (Tusheti, Kazbegi and North Caucasus), international enviromental coperation, ecological agriculture and the main area of tourism development.

Planning territory is represented by **several landscape units,** which are characterized by well-defined vertical zonality. The same are the formes for agricultural use of the territory, which is based on several millennial of experience.

Phshav-Khevsureti is poor with the land resources suitable for farming, however, rich with suitable mowing Livestock-pasture. The region is known for its great tradition of using medical plants, what increases its interest at intarnational level. Despite the moderate cold climate, Pshav-Khevsureti actively developed in many areas of agriculture. Agricultural activity mostly was carrying extensive character, what grew anthropogenic load and **transformation scales** for different ecosystems of the mountain.

As a result of such activity, the upper border of the forest landscape have been lowered, increased fragmentation of relief, suffered degradation of pasture species diversity, Subalpine forests destroyed, also many species of flora and fauna and other.

Currently, natural ecosystems of Pshav-Khevsureti in need of protection,(maintenance), improvement, and ecologically sustainable development, what preferably be carried out on the bases of the principles of landscape planning and by organizing protected area systems.

Currently, the main aim of landscape planning is preservation, development and improvement the **natural environment** of Pshav-Khevsureti, with respect of economic and social interests of the local population in sustainable development. Achieving such a goal is possible as through the creation of protected areas, so with the ecologically oriented planning for existing land usage. Territorial planning is essential for the promotion of geographical, ecological and cultural values that can become a solid foundation for the recreational farming.

It should be noted that in the vicinity of Pshav-Khevsureti planning areas are already **functioning** Tusheti Protected Areas and Kazbegi Nature Reserve, is being planned Kazbegi National Park. Creation of Pshav-Khevsuretis' new protected territories and connection through ecological corridors with the existing, is a prerequisite for proper successful regional and cross-border cooperation.

Geoghraphical and environmental characteristics of the Planning Area

Vertical extention of planning area reaches 3500m. It is characterized by complex orography. The main orographic units are the main Caucasian watershed and side ridge. Here, a number of passes are represented, what are important objects for planning such tourist routs as (Hiking, Horseback).

The planning areas main orographic units are distuinguished with high slope inclination (30-35^{o}) and typical alpine toothed rocky tarrain. From the mezoforms of relief, in nival and subnival zones mainly are developed circuses of old glacier origin, doors, U-shaped short valleys and the morain hills located at their foot. In the middle and high mountains of planning areas dominate erosion forms of rivers and mountain-valley that are mainly represented by the gorges similar to the 5th century and their watersheds slopes. In some of the high mountains, an important role plays ancient forms of glacier relief.

On the main Caucasian watershed ridge, glaciers were landing in all direction on the time of late Pleistocene. During the last half -century the glaciers were about 500meters step away.

Geodinamical processes are related as well as to endogenic (seismic activity) and egzogenic (depletion, denudation) action, so to the human economic activity. They are well characterized by well defined geographical (vertical) features and almost all forms of geodynamical processes-starting with nival-glacier and ending by erosion, denudation and accumulation processes.

Erosion processes caused significant damage to the region’s population and infrastructure. Here are many mud stream ravines, what pose a threat to the local community as well as the roads, and to the normal functioning of tourist routs.

From the majority of planning area rivers are typical high mountain rivers, for which the nesessary important factor for a large energy potencial is charecterized- a big drop in unit length, which deacreses towards river confluence. Great river energy of planning region creates a real base for the development of a low-power hydro electric power stations, what in conditions of mountainous and forested landscape is one of the most effective event from the point of economic, social, and enviromental view. Resource potential of rivers is significantly associated with the spread of forest, what promotes atmospheric precipitations gradually leaching and groundwater formation.

Due to the severe wheather and natural conditions and the lack of forest resourses among population was formed tradition of using caution towards economic usage of the forests:forests were not cut and defended near the populated and avalanche dangerouse places.

Wood was used as fuel, medium and small assortment of economic activity. Dwelling houses and industrial buildings here mainly are built of the stone and the wood used in relatively small quantities. The wood is used by shepards for pasturing agricultural activities and as fuel.

It is noteworthy that in Georgia from of 5 birch species, only 3 species are growing:(Betula Verrucosa), (Betula Litwinowii) and (Betulla Raddeana). The latter is the endemic, the relic and is included in the Red List of Georgia. The local birches charecteristic feature is that they often create straight trunk tree stands instead of crooked. It should be noted that here is compactly presented a high mountain forests of oak with relatively large fragments.

Here, is also the last border of spreading to the Eastern direction on the Main Caucasus for (Picea orientalis)Eastern Spruce. The dominant species in the forest are distingushed, Oriental Beech (Fagus orientalis), Hornbeam, Asp, represented by groups and units Maple, Ash, Elderberry, Nuts and more.

The basic principles for selection the planning areas

The selection of planning area is based on several principles, which is related to the creation of a network of protected areas and actual cross-border cooperation, the landscape diversity and uniqueness, ethno-cultural, socio-economic and environmental situation of the planning area.

The principle for actuality

Planning area represents one of the socio-economic most undeveloped regions that need to change already existing economic profile. Here, a number of demographic indicators substantially changed during last dacades- we face a demographic crises in full, which may lead to depopulation. In the effective implementation of Demographic and Economic Policy, an important role may play a new inviromental strategy, which related to the formation of a network of protected areas, alternative and safe energy sources, ecological agriculture and tourism development.

On the planning area and Caucasus ecoregion is developing cross-border environmental cooperation. It is useful for the current political processes of the Caucasus region. It is also important that with the aim of developing environmental cooperation and for the formation of protected areas, is actively working as the Georgian government so many of the local non-governmental and international environmental organizations.

International environmental organizations (The European Landscape Convention, WWF, GZT, TJS and others) are active in the formation of a network of protected areas, in order to protect high mountain ecosystems, what in Georgia is one of the most important prerequisites for developing the European values, The European Enviromental Law and principles and for the Caucasus countries’ integration into the European.

The formation of protected areas (national park, reserve, protected landscape, nature monument and other) in the Caucasus is based on the European experience and methodology, what in the region is the basis for further development and testing.

The unic principle

Planning protected areas are represented by high mountain ecosystems, which may be discussed together with the live wildelife species and ethnocultural diversity as the distinctive and unic space for Europe.

It should be noted that the planning area is presented with not a single important historical object and nature monument, which have a great importance in identification of the world’s mountainous territories and for peculiarity analysis development.

The principle of Socio-economic tensions

Extensive agriculture has developed mainly in protected planning area, in particular the livestock. Farm is practically deprived of food industry enterprises, what is an obstacle to its development. Virtually, no consideration of the requirements of the international markets for ecologically clean food production, the potential of which is quite large.

The vast majority of regional population was resettled in lowland areas in different years. Migration process is still underway, which contributes to the low level of household infrastructure and of industrial development. People actually don't posesss alternative energy equipment makers (The sun, wind, geothermal, biogas) and not familiar with these methods. In case of their usage, will be improved not only economic but also ecological situation.

Tourism is slightly developed on planning area, what is strongly connected to the lack of its strategy and traditions. It is also noted by the population that tourists' stream is decreasing annually, what is associated with lack of information and a low level of the development of appropriate infrastructure.

Through landscape design can be created a system of protected areas based on the principles of sustainable development. Its popularity and international recognition will provide many types of tourism development, especially, its ecological, historical-ethnographical, cognitive-educational, nutrition and other areas.

The principle of ecological tension

Ecological tension in the region is related to three factors: natural, anthropogenic and legal conflicts. **Natural Conflicts -** linked to by water erosion on the branches of Central Caucasus, high rates of physical exhaustion and separate geodynamic processes, continental climate (intensive physical exhaustion), high seasonal temperature amplitude and duration of snow cover (5-6 months).

Anthropogenic Conflicts-associated with the large scale utilization of a territory, in particular the development of livestock farming in the mountains. Beside the local population, the territory historically and actively used for summer pasture by large numbers of sheep brought from other areas, what increasing anthropogenic load and high mountains (subalpine) ecosystems mass destruction. Population indicates on the growth of prey animals numbers, however the poaching is intensive. As a result of anthropogenic impact, planning area diversity is significantly depleted, restoration of which should be facilitate by the formation and regime of the protected areas.

Legal Conflicts-are mainly related to the substantial disregard of the Georgian and International Enviromental Laws. From the point of Georgian Legislation should be mentioned the Georgian Law about ,,Environmental Protection", ,,Water," ,,Soils', ,, The Red List", ,,The Red Book", ,,Animal World", ,,Tourism and Resorts", The Sea, Reservoirs, Regulation and Engineering Protection of River Banks", ,,Cultural Heritage and other.

Landscape Planning Methodology

Landscape planning follows standardised procedures which normally consist of five interconnected and interdependent stages:

1 ***Inventory***. Gathering and summarising all available geographic information about the area's natural environment, its socio-economic conditions, and identifying major conflicts related to the population – nature use system;

2 ***Assessmen.*** Assessing the natural conditions and potential of the planning territory in terms of the categories of significance and sensitivity, also asssessing land use patterns and trends;

3 ***Development of goals*** for setting a concept of planning area component management;

4 ***Integration of objectives***. Setting an integrated goal-orientated concept of spatial management.

Results

The **key factors** of establishment of the Javakheti protected areas are:

- The transboundary position between Georgia, Armenia (the length of the planning area boundary is 45.3 km) and Turkey (the length of the planning area boundary is 43.2 km) that may lay the foundation of sustainable ecological cooperation in the Caucasus ecoregion;
- Biological and landscape diversity (volcanic terrain, canyons, volcanogenic lakes, mountain steppes, subalpine tall grasses, wetlands, routes of migratory birds, etc.);
- High recreational value (unique natural and cultural heritage sites);
- Environmental problems (biodiversity degradation, eutrophication and anthropogenic regulation of volcanogenic lakes, a need for conservation of planted forests, intensive impact on fauna species, intensive wind erosion and exhaustion, introduction of alien ichthyofauna species, overgrazing);
- Legal conflicts;
- Landscape value;
- Establishment of integrated PA system;
- Sustainable socioeconomic development of the region.

Landscape planning structure may be composed of key natural, recreational and economic components. It also can involve components that can be classified by their economic, natural, recreational and ecological value, by intensity of their influence on natural and social environment, and by their location (distance from the centre or radius).

PA category, value (ecological, recreational), natural anthropogenic and legal conflicts, also sectoral or complex area development goals make up the set of documents that form the **PA landscape planning basis**. PA development and management **goals**, involving conservation, improvement and development, are determined considering landscape functions.

The environmental, restorative and recreational functions of the landscape in the Javakheti planning area allow establishing two national parks, five sanctuaries, two protected landscapes and one natural monument. Their immediate proximity is an important condition of development of different trends of tourism and economy.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 175- 176

Challenges for sustainable tourism management in a UNESCO serial World Heritage Site. The case of the Dolomites.

Marianna Elmi

Keywords

Sustainable Tourism, UNESCO, tourism impacts, touristic pressure

Abstract

The poster presents an insight on the first results of a research project carried out by the European Academy of Bolzano, aiming at elaborating strategies for sustainable tourism in the UNESCO World Heritage Dolomites.

The Dolomites, located in the Northeastern Italian Alps, represent a particularly interesting case concerning the challenges for the common management of different protected areas. The site as a whole has been inscribed in the Natural World Heritage List in 2009 and is one of the few cases worldwide of serial mountainous site: it is in fact composed of nine different areas (*Systems*) not adjacent to each other.

The heterogeneity of the site, both from an administrative and a protection point of view, is high: the nine systems are spread among five Italian provinces[1] and three regions[2]. Various protected areas are included in the territory of the UNESCO World Heritage Dolomites: nine nature parks (six provincial, two regional and one national) and 26 NATURA 2000 areas.

The Dolomites' landscape and the possibility of both summer and winter activities attracts significant tourist flows (in year 2008, prior to the inscription, more than 25 million overnight stays have been registered in the surrounding municipalities); these flows are likely to increase after the inscription in the World Heritage List. The main challenges related to the sustainability of tourism in the area are the concentration in summer and winter peak periods and in specific attraction points. Therefore, seasonal and spatial hotspots can be highlighted, not homogeneously distributed among the nine components of the site.

On the basis of these conditions, the International Union for the Conservation of Nature (IUCN) requested to integrate in the overall management plan of the a general sustainable tourism strategy for the overall Dolomites.

The analysis presented in the poster focuses on the challenges linked to the development of the common strategies, by comparing two Systems included in the UNESCO World Heritage Dolomites. These cases have been selected due to their heterogeneous tourism development and related impacts; the comparison is based on tourism-related indicators elaborated on the basis of data collected in the surrounding municipalities.

The first of the two Systems considered is the Puez-Odle/Puez-Geisler located in the Autonomous Province of Bolzano/Bozen. This site which presents a high level of tourism intensity with a related high level of tourism infrastructure development. In this System the population growth rate from 2001 to 2011 has been positive: one of the reasons for that is that tourism represents an important generator of income and workplaces, making the area attractive for residents. Nevertheless the high number of visitors implies some negative impacts, mainly due to overcrowding in specific hotspots and seasons.

The second System considered is the Dolomiti Friulane, located in the provinces of Udine and Pordenone: this System, on the contrary, presents the lowest values of tourism intensity among the entire World Heritage Dolomites, combined with a low touristic infrastructure. The municipalities surrounding the area have seen in the years 2001 to 2011 a decline of population and tourism does not yet represent a consistent and continuous source of income that could enhance the attractiveness of the area also for residents.

The comparison of the cases cases show that, in order to be effective, the development of a general strategy for the serial site of the Dolomites must take in account the different levels of tourism impacts and development observable among the different areas included in the site. Therefore, depending on the context, different aspects of sustainability have to be stressed: on the one hand, strategies fostering the reduction of the impacts of tourism have to be developed (environmental sustainability), while on the other hand, the need of the local population to make tourism a steady source of income has to be taken in account (social and economic sustainability).

In order to provide a general strategy for the overall Dolomites, five main strategic priorities have hence been highlighted: tourism demand and offer, mobility, governance, information and communication and monitoring. These priorities, which will be translated in concrete measures developed at local level, are briefly presented in the conclusive section of the poster.

[1]The Autonomous provinces of Trento and Bolzano and the Provinces of Belluno, Pordenone and Udine.
[2]The Trentino – Alto Adige / Südtirol region, the Veneto Region and the Friuli-Venezia Giulia region.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 177 - 184

The Carpathian Ecological Network GIS approach to detect the landscape permeability for particular umbrella species

Filippo Favilli, Elisa Ravazzoli, Christian Hoffmann, Thomas Streifeneder

Abstract

Large protected areas are fundamental for ecological processes to operate over spatial and temporal scales and for the survival of wildlife. Nevertheless, the increasing landscape fragmentation in Europe, due to the extension of human-related facilities, poses serious threats to the survival of biodiversity.

In this respect, BioREGIO Carpathians, an ETC European project, aims to face this issue studying biodiversity in the Carpathian area and introducing a GIS analysis to enhance ecological connectivity between protected and natural areas.

The GIS analysis is based on three steps. First, a habitat suitability model is created by using CorridorDesign. It identifies patches of suitable habitats by assigning different suitability values to ecological factors for each species. The model returns the suitability value (0-100%) indicating the appropriateness of a particular land cover patch for the dispersal of a species. The second step consists on reclassifying the suitability values by considering the presence of species-specific ecological factors. It enables to identify core areas for each species. The third step seeks to identify ecological corridors by using LinkageMapper; it allows to detect the most probable corridors by applying a minimum-cost analysis and calculating the least cost paths for passing through the land cover matrix. This comprehensive GIS approach has been applied in two protected areas at the border of Romania and Serbia. The on-going study is enabling us to highlight the role of protected areas in maintaining viable wildlife populations identifying the main core areas and dispersal paths for terrestrial and aquatic mammals. Additional aims are also to study the barriers blocking the dispersal and to suggest policy recommendations for their overcome.

Keywords

Carpathians, umbrella species, ecological connectivity, barrier

Introduction

Road infrastructures endanger many wildlife populations by reducing connectivity among the habitat patches (Forman et al. 2003). Fragmentation increases the risk of collisions with vehicles and limits the access to resources (Jaeger & Madriñán 2011). Ecological corridors are "landscape elements which serve as a linkage between historically connected habitat areas" (McEuen 1993). A regional ecological network can provide connectivity between spatially separated populations, countering biological processes that lead to species extinction (Beier 1995; Bennett 1998, 2003; Taylor et al. 2006). The project *BioREGIO* Carpathians applies a combination of *CorridorDesign* (Majka et al. 2007) and *Linkage Mapper* (http://code.google.com/p/linkage-mapper/), two ESRI ArcGIS 10 spatial analysis tools to build a Habitat Suitability Model (HSM) and Network Linkages for selected umbrella species in the Carpathians. The present study aims to detect the most probable core areas and least-cost paths for the Eurasian Lynx and to highlight the role of protected areas at the Romanian/Serbian border as linkage nodes. The objectives are to give an answer to the following research questions: Which are the most suitable landscape patches for the lynx? Are there chances that a lynx will reach another patch? If yes, using which path? Are there barriers in the identified routes? Are they surmountable? What is the role of protected areas for the maintenance of the regional ecological connectivity? To reply efficiently to these questions it is fundamental to: (i) set the parameters for the HSM, (ii) assess the connectivity via the visualization of core areas and least-cost paths, and (iii) identify possible barriers.

Study area

The study areas are the Iron Gate Nature Park in Romania and Djerdap National Park in Serbia (Fig. 1). Iron Gates Nature Park, at the south Romanian borders with Serbia, is a site of Community importance ROSCI0206 and a Ramsar site no. 1946. National Park Djerdap present a high level of wilderness and it is situated in the north-east of the Republic of Serbia, along the international border with Rumania. In both areas lynxes are reported as residents (Sommerwerk et al. 2009).

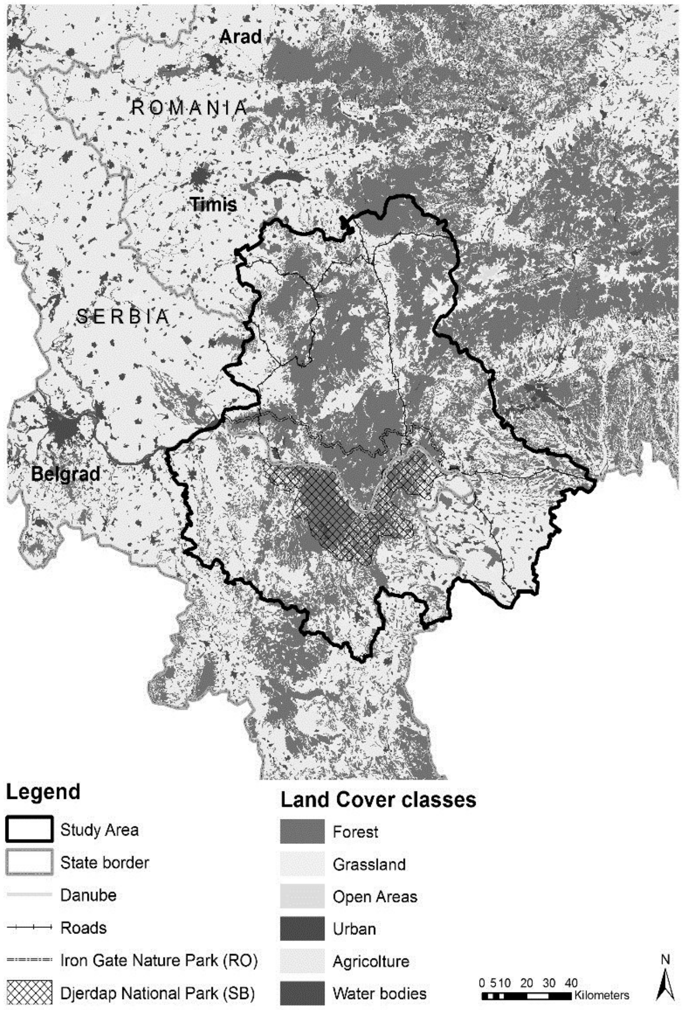

Figure 1: Study Area

Methods

Umbrella species

The Eurasian Lynx (*Lynx lynx* L.) is a highly selective mammal which prefers forest sites with at least 60% of forest cover (FAWCETT 1997). It avoids human activities and disturbed habitats. Lynx has large spatial requirements, which vary according to prey density and composition. Lynxes have a home range estimated between 70 (females) and 200 (males) km² (SCHADT et al. 2002). In non-wooded habitats, they can use alternative cover such as scrub and rocks. Lynxes do not stay permanently in forest areas < 30 km² and the minimum core area sizes (100 km² – breeding patch; 200 km² – population patch) can be interrupted by open areas, but not by human infrastructures (SCHADT et al. 2002; KRAMER-SCHADT et al. 2004, 2011).

Habitat Suitability Model (HSM)

The creation of a HSM is a two-steps process perused by applying the *CorridorDesign* GIS tool. In the first step, the habitat suitability is identified on the bases of the species' ecological preferences. According to the preferred land-cover types their suitability is valued from 0 to 100. The pixels having a suitability values above 50 were selected, in the second step, to identify breeding and population patches (core areas) following species' landscape perception. For a complete explanation of the model refer to MAJKA et al. (2007). Table 1 shows the selected values for the lynx used in our study.

Table 1: Factors, classes and weights used for the calculation of the first step Habitat Suitability Model

LC (40%)	*V %*	**Topo (20%)**	*V %*	**Elev meter asl (10%)**	*V %*	**Dist Human m (15%)**	*V %*	**Dist Roads m (15%)**	*V %*
Forest	*100*	0-30°	*50*	0-500	*50*	0-100	*0*	0-50	*0*
Grassland	*50*	30-60°	*100*	500-1000	*100*	100-500	*25*	50-200	*50*
Open areas	*25*	60-90°	*100*	1000-1500	*100*	500-1000	*50*	>200	*100*
Urban	*0*			1500-2000	*100*	>1000	*100*		
Agriculture	*25*			2000-2500	*50*				
Water bodies	*25*			>2500	*0*				

LC: Land Cover classes; Topo: Topographic Position classes; Elev: Elevation classes; Dist Human: Euclidean distance from the closest human settlement classes; Dist Roads: Euclidean distance from the closest main road classes; V: Suitability Value. In brackets the weight of each factor

Factors' classes and weights are combined through a geometric mean. The pixel remains 0 if only one category is 0. Each pixel can then be assigned to a certain suitability class:

1. Suitability: 50 - 100% = Optimal habitat
2. Suitability: 25 - 50% = Sub-optimal habitat
3. Suitability: 0 - 25% = Occasional habitat
4. Suitability: 0 = Avoided, barrier

In the second step, a moving window of 200-m radius around each pixel with > 50% suitability was applied to select those patches fulfilling the species' spatial requirements (Table 2):

Table 2: Classification of suitable patches' size

Patch size (ha)	Patch
0-10.000	Suitable but smaller than a breeding patch
10.000-20.000	Potential breeding patch
> 20.000	Potential population patch – core area

<u>Lynx connectivity/Least-Cost Paths (LCPs)</u>

The identification of probable connectivity is perused by applying the GIS tool Linkage Mapper. Resistance values for the landscape patches were necessary in order to calculate the LCPs between the identified core areas. Resistance values are defined as the opposite of the suitability and reflect the energetic cost for a certain species to move across those cells. The basic assumption of the model supposes that species move where the landscape provides less resistance (Beier et al. 2009; Conrad et al. 2012).

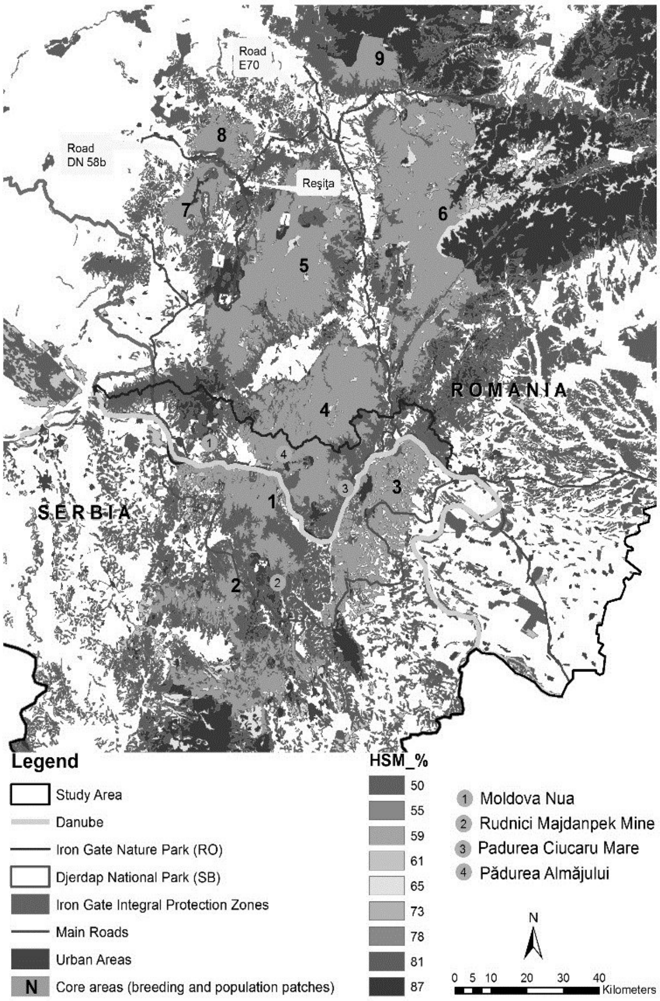

Figure 2: Habitat Suitability Model and core areas

Dataset

Land cover and additional geographical data were acquired for the countries considered. CORINE Land Cover 2006 at a resolution of 100x100m was used as a database for the habitat suitability model and the identification of the cost-path analyses. The first step in the preprocessing of digital maps was the standardization to the Projected Coordinate System ETRS 1989 LCC with the projection Lambert Conformal Conic. The environmental variables were acquired from the European Environmental Agency, the Joint Research Center and from the protected areas administrations. Digital Elevation Model (DEM) of the study area was used as a factor because the species occurs within a certain range of elevation. The topographic position was generated from the command Spatial analyst/surface/slope tool in ArcGIS 10. Distance to human settlements and distance to roads were created as a raster image by using the tool Euclidean distance in the ArcGIS toolbox. The cell size was set to that of the CORINE land cover grid.

Results

The HSM steps highlighted the complex mosaics of forest landscapes which are highly preferred by the lynx. The model identified the core areas displayed in Figure 2. Six population patches (core areas 1–6) located on both sides of the Danube, and three breeding patches in Romania (7–9) indicate a high probability that the lynx could be distributed in the study area.

In the Serbian side, the potential distribution of the lynx is spread all over the Djerdap National Park, in direct connection with the Balkan populations. One population is represented by core area 1 and 2 (separated by the Rudnici Majdanpek mine), the second by core area 3. As concerning the Rumanian side, the lynx populations are separated in 6 main population and breeding patches (Fig. 2). The south-western Carpathians' lynx populations are known to inhabit the entire area north from the Danube (i.e., ROZYLOWICZ et al. 2011). Core area 4 includes the inner part of the Iron Gate Nature Park and some "integral protection zones" (1, 3 and 4 in Fig. 2). These areas could represent the passage sites of emigrating lynxes from Romania to Serbia. Core area 5 is part of the National Parks Semenic-Cheile Caraşului and Cheile Nerei-Beuşniţa where the lynx is reported as residential (STANCIU 2008). This area, although big enough (87.000ha) to support 4 male lynxes is separated from the rest of the Carpathians population by a highly frequented international road – E70. Core area 6 is the biggest in the study area and is connected with the Carpathians Mountains. Breeding patches 7 and 8 are separated by the national road DN58b close to the city of Reşiţa (Fig. 2). Breeding patch 9 is represented only partially in the study area.

The ecological connectivity for the lynx has been estimated starting from each of the identified core areas. *Linkage Mapper* detected 31 LCPs in the territories with the lower resistance. We selected 16 LCPs as those highlighting a general view of the ecological network (Fig. 3). LCPs were categorized according to: the CWD (cost-weighted distance), their length, the presence of barriers that increase their mortality risk (LCP risk), and the presence of a protected area, which increases their safety (LCP safe). LCPs were then divided in 5 cut-off categories (1 – Best; 5 – Worst) to identify the sites where the lynx may disperse most likely (Table 3).

Table 3: LCPs classification

LCP ID	CWD (Meters)	LCP (Meters)	LCP risk	LCP safe	Land Cover*	Barrier	Usage	Category
16	34.082	1838	0	1	1	None	Highly Probable	**1**
14	167.728	7887	0	1	1	Agriculture	Highly Probable	**1**
10	87.806	3455	1	1	1-6	DN57/ Danube	(?)	**2**
12	83.860	3289	1	1	1-6	DN6/ DN57/ Danube	(?)	**2**
15	147.597	10.166	0	0	1-3	Agriculture	Probable	**2**
9	41.314	865	1	1	1-6	DN57/ Danube	(?)	**3**
13	225.601	13.340	0	0	1	Urban zone	Possible	**3**
1	28.443	624	1	0	1	DN58b	Possible	**3**
2	247.331	11.142	1	0	1-4-5	DN58	Possible	**3**
6	154.113	4462	1	0	1-3-4	DN68	Possible	**3**
8	482.063	28.736	0	2	1-6	DN57/ Danube	(?)	**3**
11	77.503	2997	1	0	1-5	DN6	Possible	**3**
7	172.290	5797	1	0	1-3-5	DN6/ Agriculture	Possible	**3**
4	240.811	10.315	2	0	1	DN58/ Urban zone/ Mine	Difficult	**4**
3	771.166	29.277	1	0	1-4-5-6	DN6/ Agriculture	Extremely Difficult	**5**
5	679.716	23.185	2	0	1-4-5-6	DN6/ DN58b/ Agriculture	Extremely Difficult	**5**

*Land Cover classes: 1 = Forest; 2 = Grassland; 3 = Open Areas; 4 = Urban Areas; 5 = Agriculture; 6 = Water Bodies

From the 16 selected LCPs, only 2 can be assigned to Category 1 because they are inside a forest in a protected area and do not meet any barrier. All the LCPs through the Danube have been marked with a (?) because of the uncertainties if the lynx has ever crossed it by swimming. It is more likely to assume the presence of the Danube as an insurmountable barrier, although sporadic lynx observations in this region were made and Serbian lynx populations have acquired some of the characteristics of the Balkan ones (ATANASOV 1968; PAUNOVIC et al. 2001). Nevertheless, the Danube has a seasonal changeability and for the lynx it could be passable during some winter months (Simeonovski & Zlatanova 2001; Spassov 2001). The LCPs belonging to Categories 1 to 3 seem to be usable by the lynx. The 4 and 5 ones are unlikely to be used due to the less suitable landcover classes the lynx would have to pass through and on the kind of barriers encountered.

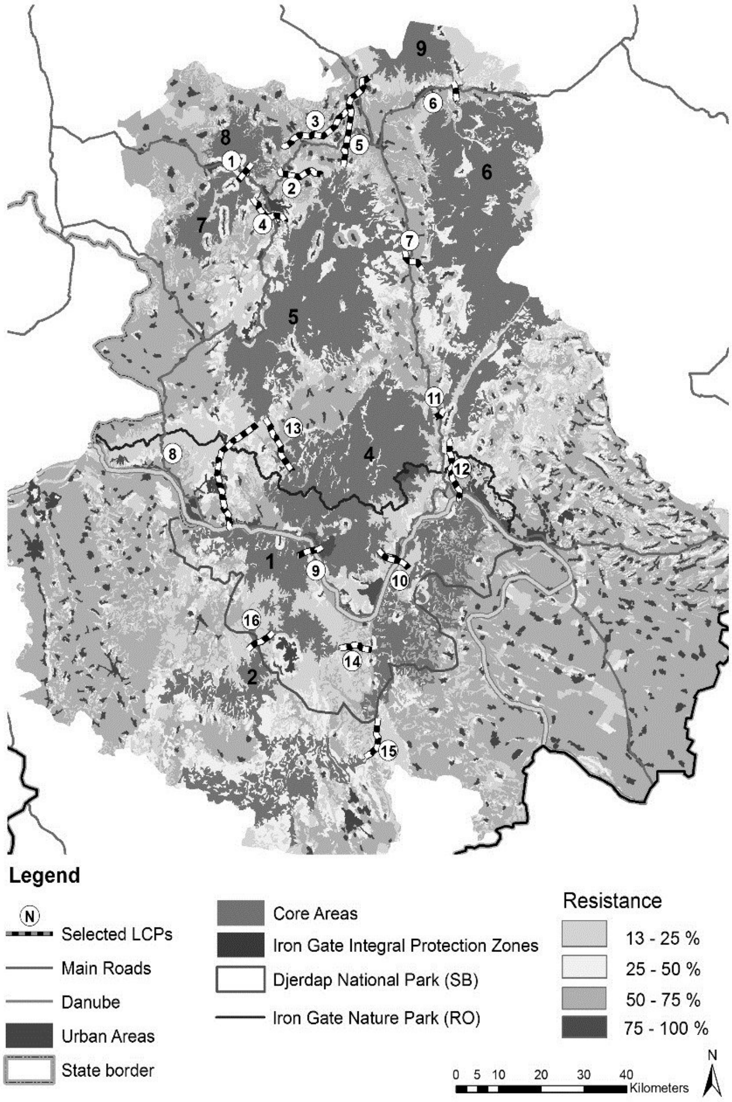

Figure 3: Selected Least-Cost Paths

Discussion

The suitability and connectivity results indicate that the majority of the study area is highly suitable for the lynx. The GIS model is useful to study the distribution of suitable habitats and patch connectivity and to promote actions in wildlife conservation, when field data are limited. *CorridorDesign* has proven to be efficient for the detection of the lynx's most suitable habitat, only referring on ecological habits. *Linkage Mapper* has enabled the identification of the main possible connections between probable core areas to enhance the areas' ecological connectivity. The lynx's spatial requirements are huge and the large forest habitats in the Carpathians could soon become a fragmented landscape mosaics, thus large-scale cross-boundary approaches are needed (Mladenoff et al. 1995). The Serbian part of the study area confirmed of being a highly suitable habitat for the lynx, due to the National Park Djerdap and to the lower presence of roads and big urban areas. The Djerdap National Park represents the most northern lynx distribution from the Balkans with which it is directly connected. A ecological connection between core areas 1, 2 and 3 (total size: 112.351 ha) could sustain 10 residential lynxes. The "Nature Park Iron Gate" and the rest of the Romanian study area (including two National Parks) play a major role in protecting this species at the southern borders of its Carpathians' distribution. An enhanced connectivity between core areas 4, 5 and 6 (total size: 260.548 ha) could sustain more than 20 residential lynx, which is the prerequisite for the survival of a viable population (Schadt et al. 2002). The *Linkage Mapper* analysis enabled the identification of the gaps in the potential ecological connections. Figure 4 shows the LCP number 7 connecting core areas 5 and 6 in the vicinity of the city of Fenes, identifying the site where possible engineering intervention for the maintenance of the ecological network could be placed. In this case, the site selected is where the National Road DN6 runs closer to fragmented forested and open areas which could be used by the lynx as stepping stones. DN6 is a highly frequented road, but the presence of stepping stones in the vicinity, joined by a green infrastructure facility could render possible the establishment of an ecological connection between the two core areas (Fig. 4).

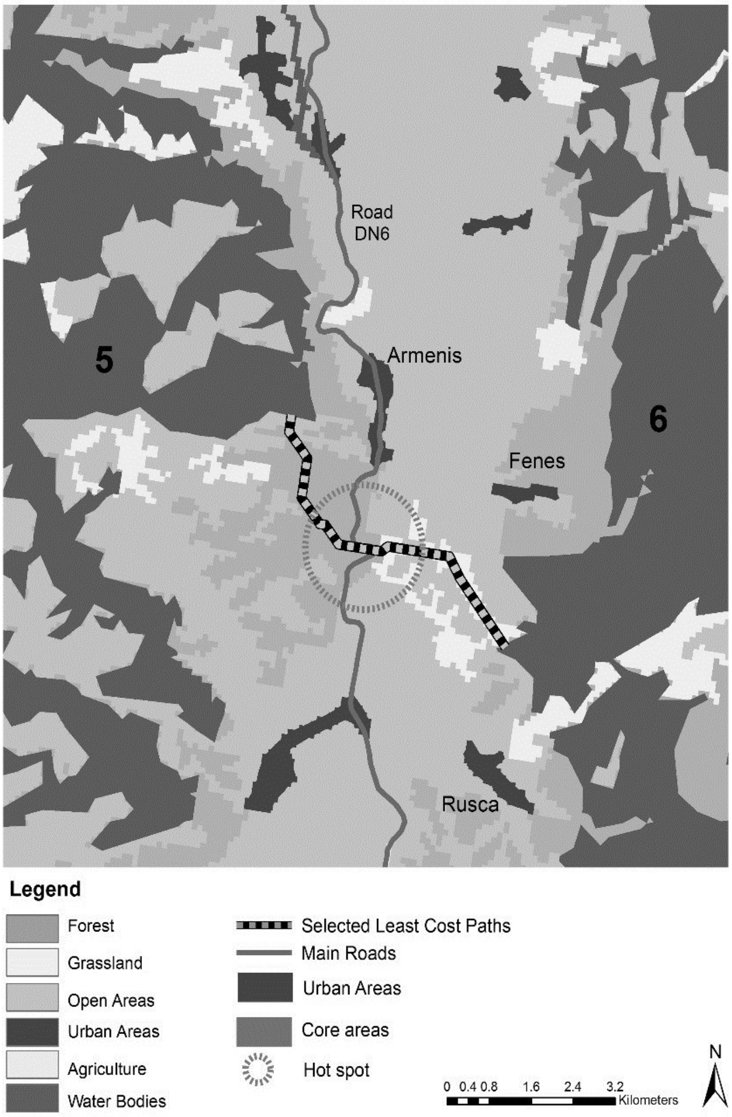

Figure 4: Closer view of the LCP 7 and barrier

Conclusions

The questions addressed at the beginning of the study have now been answered showing that some of the identified routes are of highly improbable lynx use due to the kind of encountered barriers and landcover changes. The "integral protection zones" inside of the Iron Gate National Park have proved their importance for wildlife protection and connectivity. The GIS approach gave us the opportunity to highlighting the role of protected areas as "safe passage zones", requiring only few data and offering a good picture about landscape fragmentation and ecological connectivity. Some of the LCPs have the characteristics to be effectively used for connecting the lynx's main patches. Generally speaking, following only a visual interpretation of the results, the ecological connectivity inside of the studied area seems rather good. Main roads and urban areas act as barriers for the lynx's connectivity. Nevertheless, the sites which could be important for enhancing ecological connectivity and for deriving specific recommendation can be selected. In this next phase, the role of local expert will be decisive for concrete actions.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 185 - 190

Faunistic Characterisation of Alpine Springs in the Swiss National Park

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Abstract

Springs are unique ecosystems for highly adapted organisms that are endangered by anthropogenic impacts. Alpine springs are even more special as species have to adapt to lower temperatures and a short growth season during summer. The springs in the Swiss National Park have not been influenced by anthropogenic impacts since 1914, when the park was founded. In 1942 the only complete faunistic study of springs in the Swiss National Park was realised. A new monitoring of these unaffected alpine springs is of special interest today. In this Master's project 20 springs of the Swiss National Park were characterised. In early summer and autumn 2012 the springs were mapped and physiochemical parameters were measured. The macroinvertebrates were sampled quantitatively with a surber-sampler and qualitatively by hand-picking. Results show that Diptera, Trichoptera and Plecoptera are the most diverse orders. Within these orders cold-stenothermal species with alpine altitudinal preferences and endemic species were found. They are partly endangered or at least vulnerable in Switzerland. This underlines the importance of protected areas as refuges for endangered species living in endangered habitats such as springs. Moreover, a protection of the springs outside of the park would be desirable.

Keywords

Alpine springs, Swiss National Park, macroinvertebrates, endangered species

Introduction

Springs are ecotones between the groundwater and the surface water and provide a habitat for specialised organisms due to constant environmental conditions (VAN DER KAMP 1995; GERECKE & FRANZ 2006). Due to environmental changes and anthropogenic impacts springs are highly endangered. In Switzerland only few springs still remain in a natural condition (ZOLLHÖFER 1997). Alpine springs are sensitive habitats as they often exhibit a high degree of individuality (BONETTINI & CANTONATI 1996) and usually have a small spatial extent (CANTONATI & ORTLER 1998). A comprehensive review of alpine springs is given by CANTONATI et al. (2006), recent studies on alpine springs in Switzerland are rare (but see e.g. WEBER 2004; ROBINSON et al 2008).

The Swiss National Park (SNP) was founded in 1914 and has been subject to total nature protection since then. As research is one of the main aims of the Park, the fauna and flora is well investigated. However, scientific research on springs in the SNP was mostly limited to chemical and physical parameters until now (NOLD & SCHMASSMANN 1955; DÖRING 2002). There is only one study from NADIG (1942), who intensively investigated five springs around Il Fuorn.

In this study 20 springs were investigated whereof 15 are situated within the borders of the Swiss National Park and five in the area of Buffalora. The spring fauna was quantitatively sampled and physico-chemical as well as structural parameters were monitored. An explicit aim was to provide an inventory of macroinvertebrates living in the studied springs. The main questions were (a) to determine the main abiotic factors influencing the macroinvertebrate assemblages of the springs within and outside of the SNP and (b) to assess the function of the SNP as a refuge for endangered species. This study gives a first comprehensive insight into the fauna of the springs around Il Fuorn in the Swiss National Park and the Alp Buffalora in the Biosfera Val Müstair.

Methods

The Swiss National Park is located in the southeast of Switzerland in the canton Grisons. The area of the park measures 172 square kilometres with an elevation of 1400 to 3174 m a.s.l.. Fifteen of the investigated springs are situated within the park borders around the hotel Il Fuorn (Val Ftur, God dal Fuorn, Val Chavagl, Val Brüna), five springs are located in the region Buffalora in the biosphere reserve Val Müstair. The geology in the study area consists of limestone (TRÜMPY et al. 1997). The altitudinal range varies from 1770 m to 2255 m a.s.l.. This alpine to subalpine area is covered by snow up to 9 months a year. The mean precipitation at Buffalora is 793 mm/a (1968 m; MeteoSchweiz). The average annual air temperature reaches 0.7° C, whereupon temperatures vary between -9.2 °C during winter and 10.3° C during summer. Since 1990 increasing temperatures have been measured (KETTERER & HALLER 2009). The studied springs all flow into the Ova dal Fuorn that feeds the river Spöl.

All springs were sampled twice, in early June and late September 2012. Of each spring four quantitative samples were taken with a small surber-sampler (10 x 10 cm; 500 µm mesh) and preserved in 70% ethanol. Additionally the springs were sampled by hand-picking. The samples were sorted in the laboratory and the specimens were determined to species level whenever possible. Water temperature, pH, oxygen (mg/l, %), and electrical conductivity were measured using portable meters (WTW, Weilheim, Germany). The springs were mapped and evaluated based on the manual of Lubini et al. (2009).

All statistical analyses were calculated using PRIMER 6.0 (Clarke & Gorley 2006). The statistical analysis of the faunistic data was performed with the data of the quantitative sampling. For the faunistic data the Bray-Curtis similarity and a log (x+1) – transformation were used. Abiotic data was normalized and the Euclidian distance was used as similarity measure. Ordination of the springs was conducted using non-metric multidimensional scaling (nMDS). The analysis of similarities-procedure (ANOSIM), which is analogous to an ANOVA, but relies on a similarity matrix and makes few assumptions on the data was used for testing the grouping of the springs. Additionally a principal components analysis was performed with the abiotic data in order to extract the most important substrate types characterizing the springs.

Results

The water temperature in the springs varied from 3.0 °C (BUF3) to 7.0 °C (LIM) during the summer sampling (mean: 5.1 °C). The temperature amplitude was between 0.1 (GF3, LIM) and 4.7 (BUF4). The pH ranged from 7.2 (Q2) to 8.9 (VCh2) and the electrical conductivity from 107 µS/cm (BUF3) to 575 µS/cm (GF1). The only limnocrene spring had a very high electrical conductivity (1511 µS/cm). The oxygen concentration varied from 4.6 mg/l (GF2) to 10.0 mg/l (OFb2) and the saturation from 47% to 98%. The limnocrene had very low values with an oxygen concentration of 0.3 mg/l (3%). Discharge varied from 2 L/min (Buf2) to 144 L/min in VCh3 (Tab. 1). Several springs had a much lower discharge in autumn (VCH2, GF1-GF3, BUF1), and spring BUF5 did not show any surface flow in autumn. Most springs were rheocrenes. The springs Q4, GF1 and BUF5 were grouped as helocrenes and BUF1 and LIM are typical limnocrenes.

Table 1: Abiotic characteristics of the investigated springs. Electrical conductivity and oxygen content and saturation are given as means of two measurements. *: the physico-chemistry of Buf5 was monitored once, the pH is therefore a single measurement

Site	Area	Altitude [m]	pH [median]	conductivity [µS/cm; 25°C]	O_2 [mg/l]	O_2 [%]	discharge [l/min]	temperature [°C; summer]	temperature [°C; autumn]	no of substrates
Q1	Val Ftur	1832	7,9	273	8,1	96	9,6	5,0	5,3	5
Q2	Val Ftur	1920	7,4	328	7,5	93	3,6	5,7	6,7	7
Q3	Val Ftur	1960	7,8	286	8,1	96	6,0	4,5	4,8	6
Q4	Val Ftur	1900	8,2	275	7,7	93	9,6	5,2	5,4	4
Q5	Val Ftur	1780	8,0	275	9,6	95	36,0	5,2	5,7	6
FiW	Val Ftur	1770	7,6	319	6,9	84	3,6	4,4	6,7	4
Q6	Val Chavagl	1975	8,3	240	9,5	93	24,0	3,0	4,8	7
Q7	Val Chavagl	1965	8,5	266	8,9	87	9,6	4,0	4,7	6
Q8	Val Chavagl	1845	8,1	276	9,6	94	144,0	3,0	5,2	5
GF1	God dal Fuorn	1800	8,3	575	6,6	68	3,6	5,2	7,0	8
GF2	God dal Fuorn	1802	8,2	324	4,6	47	4,2	3,8	6,5	8
GF3	God dal Fuorn	1805	8,0	226	8,0	79	4,2	5,9	6,0	5
Lim	God dal Fuorn	1822	7,5	1511	0,3	3	16,8	7,0	6,9	4
Buf1	Buffalora	2177	7,6	161	7,7	79	14,4	4,9	5,2	5
Buf2	Buffalora	2176	7,7	213	8,4	91	1,8	4,4	7,4	6
Buf3	Buffalora	2255	8,3	107	9,5	93	16,8	2,8	3,0	4
Buf4	Buffalora	2163	7,9	259	6,8	73	5,4	2,7	7,4	7
Buf5	Buffalora	1980	7.9*	-	-	-	6,0	4,4	-	7
OFb2	Buffalora	1960	8,1	185	10,0	98	78,0	4,4	4,6	7

In the 20 springs 70 taxa were identified altogether, of which 46 taxa were determined to species level (Tab. 2, see appendix, p. 189-190). The most diverse order were Diptera (20 taxa), Trichoptera (17 taxa), and Plecoptera (12 taxa). Less diverse were Gastropoda (11), Coleoptera (4), and Ephemeroptera (2). Only one taxon appeared in the orders of Turbellaria, Oligochaeta, Bivalvia, Acari and Ostracoda. A rather high diversity is, however, expected within the Acari, of which the results are not yet available. Among the EPT-taxa (Ephemeroptera, Plecoptera, Trichoptera) 15 of 26 species are listed on the Red List (Lubini et al. 2012). *Nemoura undulata*, a species highly isolated and threatened with extinction, was found in the highest situated spring of the study on the Alp Buffalora. *Acrophylax zerberus*, a near endemic species (Oertli et al. 2008), *Drusus melanchaetes*, *Drusus nigrescens* and *Rhyacophila bonaparti* are vulnerable species of the Trichoptera. Also the molluscs *Quickella arenaria*, *Vertigo genesii* and *Truncatellina monodon* show a restricted distribution.

The principal components analysis (PCA) conducted with the abiotic data showed that the PC axes one and two explained 32 and 21% of the variance, respectively. The first three PC axes together explained 71% of the variance. Component one is dominated by the oxygen concentration on the positive axis and by the electrical conductivity on the negative axis. Component two is dominated by the number of substrates and the temperature amplitude on the positive axis. The limnocrene shows a very high loading on the negative axis of PC1 as it had a very high electrical conductivity.

The nMDS-diagram shows a rather homogeneous composition of the macroinvertebrate fauna in the springs with the limnocrene and the highest spring BUF3 being the most different. The analysis of similarities (ANOSIM) provided overall significant differences between the sampling sites (R: 0.293, p: 0.007). The differences between the springs in the Val Chavagl and around God dal Fuorn were highest (R: 0.778) (Fig. 1).

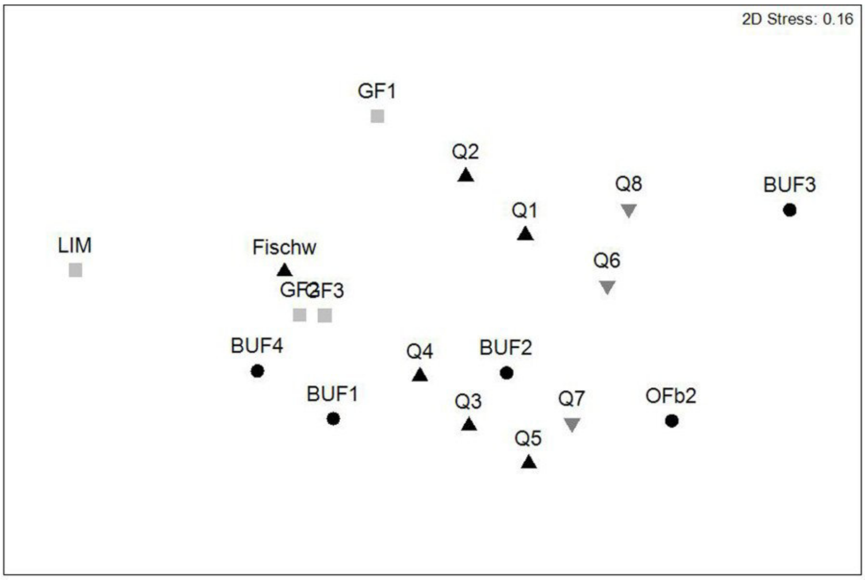

Figure 1: Non-metric multidimensional scaling (nMDS) of the investigated springs based on the average of the faunistic data; similarity index: Bray-Curtis, transformation: log (x+1); factor: area; ▼ = Val Chavagl; ■ = God dal Fuorn; ▲= Val Ftur; ● = Buffalora; Analysis of Similarities (ANOSIM) with area as discriminating factor: R = 0.293, p = 0.007.

Discussion

Electrical conductivity was determined as the main environmental factor differentiating the springs. This is mostly due to the high electrical conductivity of the limnocrene, which was also reported by DÖRING (2002) and NADIG (1942). It also had extremely low oxygen concentrations emphasizing the special character of this spring. It differs morphologically from the other springs due to its large size (62 m^2) and the depth of the pond (2.1 m) (NADIG 1942). Extreme conditions are also indicated by high sulphate concentrations measured by NADIG (1942) and also by DÖRING (2002). Apart from this limnocrene spring the abiotic parameters showed moderate differences between the sampled springs. The studied area provides similar environmental conditions for the macroinvertebrates as all springs are situated on the same geological layer. The altitudinal difference between the lowest and highest spring is less than 500 m. However, all springs in the area of the Alp Buffalora outside of the SNP are above the tree line minimizing the input of leaf-litter as an important food-source.

Comparisons with the red list of molluscs (RÜETSCHI et al. 2012) and of the Ephemeroptera, Plecoptera and Trichoptera (LUBINI et al. 2012) showed that the SNP is an important nature protection zone. Most of the identified gastropods are not vulnerable terrestrial species. The two endangered species which were found are both associated with wet conditions occurring on meadows, bogs and also next to springs (BOSCHI 2011). *Quickella arenaria* is vulnerable due to its fragmented habitat in the Alps. Concerning climate change this species might be replaced by more common species such as *Succinella oblonga* (TURNER et al. 1998). *Vertigo genesii* shows its main distribution in the canton Grisons. *V. genesii* is an endemic species for Switzerland (TURNER et al. 1998) and highly endangered (BOSCHI 2011). According to WARINGER & GRAF (2011) *Drusus melanchaetes* and *Drusus nigrescens* are endemic Trichoptera for the western Alps, with *D. melanchaetes* being restricted to an altitudinal distribution between 1960 m and 2560 m (MALICKY 2004). In the Swiss National Park they probably reach the eastern border of their distribution area. The species of the Drusinae are generally often restricted to small distribution areas and are typical cold-stenothermic species, which only occur in water bodies with a high water quality and constant low water temperatures. They are therefore valuable bioindicators (GRAF et al. 2002; WARINGER & GRAF 2011). Overall, six different species of the genus Drusus were found in this study, most of them in the small Val Ftur. Among the Trichoptera listed as vulnerable many spring specialists are found (LUBINI et al. 2012). The highly endangered Plecoptera *Nemoura undulata* is an endemic species of the central Alps above 1800 meters and only appears in isolated patches in Switzerland (LUBINI et al. 2012). Two specimens of *Nemoura undulata* were also detected in the Berchtesgaden National Park in Germany (GERECKE & FRANZ 2006) but not in the Gesäuse National Park in the eastern part of Austria (GERECKE et al. 2012).

On the one hand similar species assemblages were detected in the investigated springs. On the other hand many of the endangered or vulnerable species only occurred in one single spring. This underlines the high individuality of the fauna of the sampled springs. It is therefore likely for species to go extinct if springs get damaged or polluted. This is especially true for the springs at Alp Buffalora outside of the SNP, which are at least potentially threatened by anthropogenic impacts. Moreover, the study revealed a grouping of the springs according to the valley or area they are situated. This higher similarity of the macroinvertebrate assemblages of neighboured springs hints at the restricted dispersal abilities of spring species. The study stresses the importance of protected areas as refuges for endangered species living in unique habitats such as springs.

Conclusion

In the high altitudinal springs within the Swiss National Park rare species occurring in low abundances were found that are endangered of extinction if springs get disturbed. Compared to other alpine regions, the springs in the SNP are totally protected and suffer only minor anthropogenic impact. Considering Global Change and anthropogenic impacts the SNP provides a valuable refuge for the crenobiontic and cold-stenotherm fauna in an alpine area. Moreover, a protection of the springs outside of the park, especially in the Biosfera Val Müstair, would be desirable as they are also inhabited by endangered species.

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Tab. 2: List of presence (+) and absence (-) of the 70 taxa at each investigated site.

	Q1	Q2	Q3	Q4	Q5	FiW	Q6	Q7	Q8	GF1	GF2	GF3	LIM	BUF1	BUF2	BUF3	BUF4	BUF5	OFb2
Turbellaria																			
Crenobia alpina (Dana, 1766)	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+
Oligochaeta	-	+	+	+	-	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Gastropoda																		-	
Galba truncatula (Müller, 1774)	-	+	-	-	-	+	-	-	-	+	+	-	+	-	+	-	+	+	-
Cochlicopa cf. lubrica (Müller, 1774)	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
Euconulus fulvus (Gray, 1840)	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Trochulus cf. sericeus (Draparnaud, 1801)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Punctum pygmaeum (Draparnaud, 1801)	-	+	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
Pyramidula pusilla (Vallot, 1801)	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Quickella cf. arenaria (Bouchard-Chanteraux. 1837)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
Columella cf. edentula (Draparnaud, 1805)	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Truncatellina monodon (Held, 1837)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vertigo genesii (Gredler, 1856)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nesovitrea petronella (Pfeiffer, 1853)	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+
Bivalvia																		-	
Pisidum cf. personatum (Malm, 1855)	-	-	-	-	-	+	-	-	-	-	+	+	+	+	-	-	+	+	-
Acari	-	-	+	+	-	+	+	-	-	-	+	-	-	+	+	-	+	+	+
Ostracoda	-	-	-	+	-	+	-	-	-	+	+	+	-	+	+	-	+	-	-
Ephemeroptera																		-	
Baetis alpinus (Pictet, 1843)	+	-	-	-	-	-	-	-	+	-	-	+	-	+		-	-	-	+
Rhithrogena loyolaea (Navas, 1922)	-	+	-	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-
Plecoptera																		-	
Leuctra armata (Kempny, 1899)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Leuctra gr. braueri-muranyii	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
Leuctra cf. rosinae (Kempny, 1900)	-	-	-	-	+	-	-	+	+	-	-	-	-	-	-	+	-	-	-
Amphinemura sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Nemoura cinerea (Retzius, 1783)	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Nemoura mortoni (Ris, 1902)	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-	+	+	+
Nemoura cf. sinuata (Ris, 1902)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Nemoura undulata (Ris, 1902)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
Nemurella pictetii (Klapalek, 1900)	+	-	-	-	-	+	-	-	-	+	+	+	-	+	+	-	+	+	-
Protonemura cf. lateralis (Ris, 1902)	+	-	-	+	+	+	-	+	+	-	-	-	-	+	+	-	-	-	+
Dictyogenus alpinum (Pictet, 1841)	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Isoperla rivulorum (Pictet, 1841)	-	-	-	-	+	+	-	-	+	-	-	-	-	-	+	-	-	-	+
Coleoptera																		-	
Agabus bipustulatus (Linnaeus, 1767)	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroporus sp	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haliplus lineatocollis (Marsham, 1802)	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnebius sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-

	Q1	Q2	Q3	Q4	Q5	FiW	Q6	Q7	Q8	GF1	GF2	GF3	LIM	BUF1	BUF2	BUF3	BUF4	BUF5	OFb2
Trichoptera																			
Beraea pullata (Curtis, 1834)	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-
Lithax niger (Hage, 1859)	-	+	+	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	+
Acrophylax zerberus (Brauer, 1867)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
Chaetopterygini/Stenophylacini	-	-	+	+	-	-	-	+	-	-	-	+	-	-	+	-	-	-	+
Consorophylax consors (McLachlan 1880)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus biguttatus (Stephens, 1837)	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus chrysotus (Rambur, 1842)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus discolor (Rambur, 1842)	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drusus melanchaetes (McLachlan, 1876)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Drusus monticola (McLachlan, 1876)	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Drusus nigrescens (Meyer-Dür, 1875)	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnephilus coenosus (Curtis, 1834)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Parachiana picicornis (Pictet, 1834)	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-
Plectrocnemia conspersa (McLachlan, 1871)	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Rhyacophila bonaparti (Schmid, 1947)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophila glareosa (McLachlan, 1867)	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophila sensu stricto	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptera																			
Ceratopogoninae	-	+	-	+	-	+	-	-	-	+	+	-	+	+	+	-	+	-	+
Chironomidae	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Prodiamesa olivaceae (Meigen, 1818)	-	-	-	-	-	+	-	-	-	-	+	-	+	+	-	-	+	-	-
Tanypodinae	-	-	+	+	+	+	-	-	-	-	+	+	-	-	+	-	+	-	-
Chironomini	-	-	-	+	-	-	-	-	-	+	+	+	+	+	-	-	+	-	-
Tanytarsini	+	+	+	+	-	+	+	+	-	+	+	+	+	+	+	-	+	-	+
Culicidae	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Dixa sp.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolichopodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Clinocerinae	-	-	+	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-	-
Limoniinae	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dicranota sp.	-	-	+	+	-	-	-	+	+	-	+	-	-	+	+	-	-	-	-
Eleophila sp.	+	-	-	-	-	+	-	-	-	+	-	+	-	+	+	-	-	-	-
Psychodidae	-	-	+	+	-	-	-	-	-	-	+	-	-	-	+	-	+	-	-
Oxycera cf. pardalina (Meigen, 1822)	+	-	+	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-
Oxycera cf pseudoamoena (Dusek & Rozkosny, 1974)	+	+	+	+	+	-	-	-	-	-	-	-	+	-	+	-	-	-	-
Oxycera rara (Scopoli, 1783)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Thaumalea sp.	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
Tipula sp.	+	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Number of Species	14	22	21	18	14	20	7	9	12	16	18	15	11	20	24	4	17	10	15

Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 191 - 196

Potential habitats for the European Wildcat (*Felis silvestris silvestris*, Schreber 1777) in Austria – a basis for further steps in conservation

Sarah Friembichler & Leopold Slotta-Bachmayr

Abstract

Based on literature research a GIS (geographical information system) model for potential European wildcat habitat in Austria was created. Different environmental parameters, landcover, duration of snow covering and size of appropriate area, were included.

The results demonstrate that there exists sufficient potential habitat. 44 % of Austria is suitable for the wildcat. The most adequate areas for the wildcat are situated in the east and northeast of Austria. Large, connected and appropriate patches are to be found in the southeast of Styria, Burgenland and Lower Austria. Due to the long duration and height of snow cover, the Alps are unsuitable for the wildcat.

Comparing potential habitats for whole Austria and around observation sites, wildcats are significantly observed more often in suitable and optimal habitats. These results suggest that the model describes wildcat habitat appropriately. The results of this study are the basis for further decision according to spatial distribution of populations, monitoring, habitat improvement or possible release sites for supplementation of the wildcat population in Austria.

Keywords

conservation, decision making, *Felis silvestris silvestris*, Geographic Information System, potential habitat, European Wildcat

Introduction

Formerly the European wildcat was spread across large parts of the Austria, concentrating in the east of Austria, where the climate is more continental and milder. Due to increasing hunting pressure and the loss of adequate habitat the autochthon wildcat population disappeared in the fifties of the last century (Bauer 2001). Spitzenberger (2005) published that the wildcat is nowadays considered to be extinct and little is known about the existence and spreading of this shy carnivore in Austria.

In 2007 the team of the Thayatal national park newly discovered the European wildcat by using lure sticks to get hair sampling (Mölich 2007). Based on this new data and the whole lack of information an Austria-wide operating coordination and reporting office was founded, which collects all Austrian wildcat data. Till the year 2012, 128 wildcat indications across whole Austria were documented (Friembichler et al. 2012).

Furthermore an action plan for the conservation of the European wildcat in Austria was formulated (Slotta-Bachmayr et al. 2012). Basis of the action plan is the evaluation of wildcat habitat in Austria, a GIS Model.

The aim of this GIS Model is the identification of potential wildcat habitat in Austria. The obtained model forms the foundation for further measures concerning the conservation of the wildcat in Austria. The results are the basis for decisions about locations for further population monitoring, habitat improvement or population supplementation.

Material and Methods

Environmental parameters

Landcover

"*Felis silvestris silvestris* is primarily associated with natural forests. Large wildcat densities are reached in broad-leaved or mixed forests with low densities of humans (IUCN 2008). Coniferous forests are avoided. Old deciduous-, oak-, beech and mixed forests with various structures and habitat patches are preferred. In these types of habitat, the wildcats find necessary shelter, a home range with sufficient prey and other resources for raising their kittens (Hemmer 1993; Raimer 2001; Hofrichter 2005).

Corine Land Cover data from the year 2000 are available for whole Austria (1:100.000, smallest unit 25 ha). Because the wildcat depends mostly on woodland habitats and due to the fact that the distance to the nearest woodland is crucial for wildcat suitability, categories take type and distance to woodland into account.

Depending on the suitability values vary between zero (unsuitable for wildcats) and four (very appropriate for wildcats) (Table. 1)

Table 1: Classification of different land covering categories (CORINE Landcover) as suitable habitats for wildcats

Landcover categories			**score**
Artificial surface	all categories		**0**
Agricultural areas	arable land	non-irrigated arable land	
		less than 200 m from woodland	**3**
		200 m – 500 m from woodland	**2**
		500 m- 2500 m from woodland	**1**
		more than 2500 m from woodland	**0**
	permanent crops	vineyards	**3**
	pastures	pastures	
		less than 200 from woodland	**4**
		200 m- 500 m from woodland	**3**
		500 m – 2500 m from woodland	**2**
		2500m- 5000 m from woodland	**1**
		more than 5000 m from woodland	**0**
	heterogeneous agricultural areas	complex cultivation patterns	
		less than 200 m from woodland	**3**
		200 m – 500 m from woodland	**2**
		500 m- 2500 m from woodland	**1**
		more than 2500 m from woodland	**0**
		land principally occupied by agriculture, with significant areas of natural vegetation	
		less than 200 from woodland	**4**
		200 m- 500 m from woodland	**3**
		500 m – 2500 m from woodland	**2**
		2500m- 5000 m from woodland	**1**
		more than 5000 m from woodland	**0**
Forests and seminatural areas	forests	broad-leaved forest	**4**
		mixed forest	**4**
		coniferous forest	**3**
	shrub and/or herbaceous vegetation associations	natural grassland	
		less than 200 from woodland	**4**
		200 m- 500 m from woodland	**3**
		500 m – 2500 m from woodland	**2**
		2500m- 5000 m from woodland	**1**
		more than 5000 m from woodland	**0**
		moors and heathland	
		less than 200 from woodland	**4**
		200 m- 500 m from woodland	**3**
		500 m – 2500 m from woodland	**2**
		2500m- 5000 m from woodland	**1**
		more than 5000 m from woodland	**0**
		transitional woodland/shrub	**4**
	open spaces with little or no vegetation	bare rock	**0**
		sparsely vegetated areas	**1**
		glaciers and perpetual snow	**0**
Wetlands	inland wetlands	inland marshes	**0**
		less than 200 m from woodland	**3**
		200 m – 500 m from woodland	**2**
		500 m- 2500 m from woodland	**1**
		more than 2500 m from woodland	**0**
		peatbogs	**4**
		less than 200 m from woodland	**3**
		200 m – 500 m from woodland	**2**
		500 m- 2500 m from woodland	**1**
		more than 2500 m from woodland	**0**
Water bodies	all categories		**0**

Duration of Snow Cover

The European wildcat has a preference for sunny, warm regions with mild climate (PIECHOCKI 1990) and avoids high mountains and regions with long, strong winters (HOFRICHTER 2005). Because the wildcat doesn't hibernate, it depends on hunting the whole year. Snowy winters are problematic, because its main prey (small rodents) can hide easily under the snow. For the European wildcat an average snow covering of less than 100 days are necessary to build up a population surviving over a longer period (HEPTNER & SLUDSKIJ 1980; PIECHOCKI 1990; RAIMER 1991; LINN 1992; HEMMER 1993; MÖLICH & KLAUS 2003; BAUER 2001; MERMOD & LIBEREK 2002; HOFRICHTER 2005).

The data of snow covering were obtained from the Central Austrian Institute for Meteorology and Geodynamics in the period between 1961 and 2007 (raster data, 250 m by 250 m). The snow data are divided into three categories:

- snow covering less than 50 days a year = 4
- snow covering 51-100 days a year = 2
- snow covering more than 100 days a year = 0

Patch size

The size of the appropriate areas is important because isolated families cannot survive on a long run. At least 50 adult and unrelated animals are necessary to allow a population to survive. Even under favourable conditions 50 wildcats need about 20.000 hectares un-fragmented habitat (RAIMER 2001). To withstand most of the fluctuations in biotic and abiotic factors 500 individuals are required. Therefore the space requirements of an intact wildcat population are approximately 165.000 hectares of appropriate habitat (RAIMER 2001).

Due to land cover and duration of snow covering as adequate classified habitats patches are rated depending on their size:

- patches > 100 000 ha - 4
- patches 10 000 – 100.000 ha - 3
- patches 1 000 – 10.000 ha – 2
- patches < 1 000 ha and inappropriate habitat – 1

Model building

The overall suitability of the habitat is given as product of all factors. Variable land- and snow covering are essential for wildcat occurrence. Patch size is non-essential. Essential variables may reduce to 0 and will then lead to a zero overall score. Non-essential variables enhance the value of a habitat and they are never rated with 0. In order to identify potential wildcat habitats the calculated values are reclassified into three new categories:

- inappropriate habitats
- subotimal suitable habitats
- suitable habitats

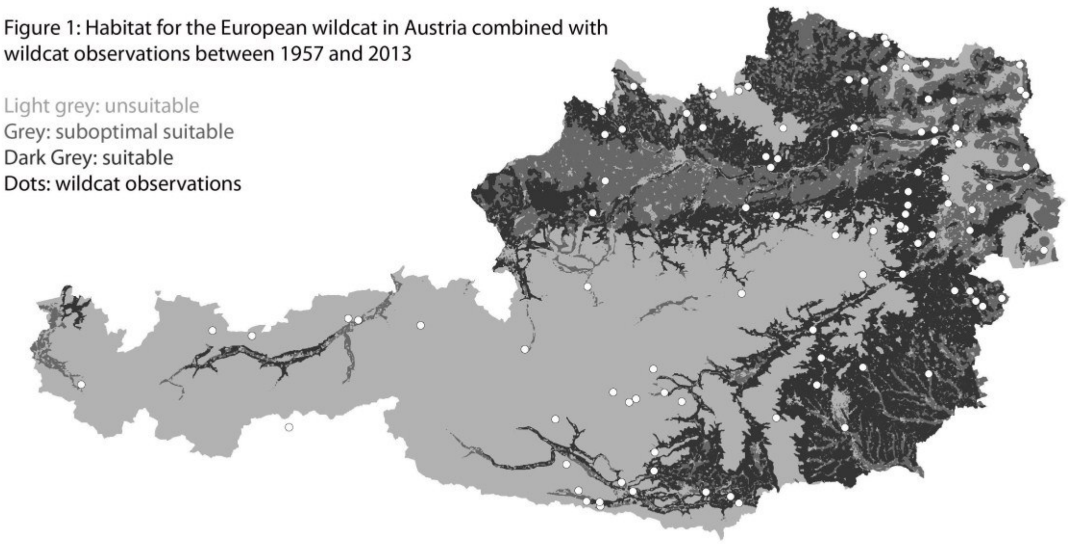
Model evaluation

The model was evaluated by combination of the habitat model with the sites of wildcat observations since 1955. Therefore a circle with a radius of 1865 m was placed around each point of discovery. Such a circle has the size of an average home range (KLAR 2007). Within each circle the suitability of the habitat for wildcats was calculated. A Chi² test was carried out to prove the significant differences of the habitats surrounding wildcat observations and the available potential habitats all over Austria.

Software

For analysis a geographic information system (GIS) software was used (ESRI ArcGIS 9.1).

Figure 1: Habitat for the European wildcat in Austria combined with wildcat observations between 1957 and 2013

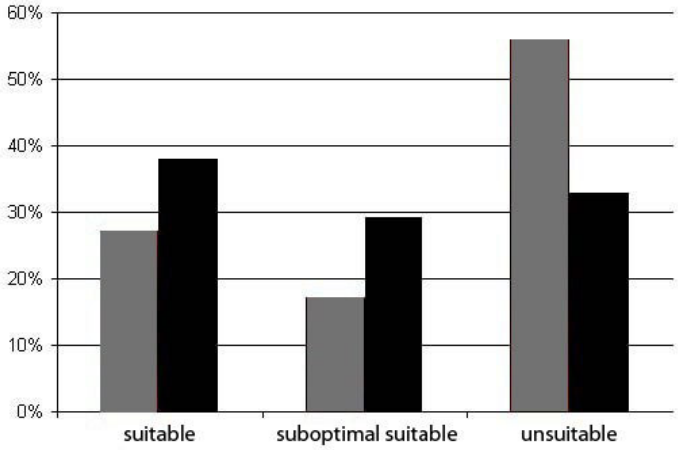


Results

The results show 36.749 ha of suitable habitats all over Austria. This means that 44 % of the whole country is suitable for the European wildcat (Fig. 1). Due to the long duration and height of snow covering, the Alps in the centre of Austria provide unsuitable habitat. Only small parts of the valley bottoms of the river Inn and Rhine are at least suitable for the wildcat. On the northern, eastern and southern edge of the Alps huge suitable areas are found. 17% of whole Austria are suboptimal suitable and 27% are optimal suitable wildcat habitat. (Fig. 2) The most adequate areas for the wildcat are predominantly situated on the northern edge of the alps, along the river Danube, in the northern parts of Lower Austria, Burgenland and south-eastern Styria and some parts of Carinthia.(Fig.1).

The combination of potential habitat and observations since 1950 shows that about 60% of all observations are found in suitable habitats. 45 % of the observations are connected to suitable and 15 % to optimal habitats. The comparison of habitats available for whole Austria and around wildcat observation points shows a significant difference (Chi²-test, p<0,005, Fig. 2). These results suggest that the presented model gives a realistic picture of potential wildcat habitats for the whole of Austria.

Figure 2: Distribution of suitable, suboptimal suitable and unsuitable habitat in the whole of Austria (grey) and observation sites around (black)



Discussion

The result of this study demonstrates that there is sufficient suitable habitat for the European wildcat in Austria. A habitat model for the wildcat in Austria was already developed by DIEBERGER (1994). His model was based on altitude, snow depth, precipitation, forest covering and the acceptance by hunters. DIEBERGERS models, as well as the one presented above, use forest covering as an important factor and also include altitude, snow depth and precipitation. We think that from these parameters duration of snow covering describes the suitability of wildcat habitat best. Duration of snow covering also correlates with altitude, and therefore altitude weren't included separately. There is no hint from literature that precipitation may be an important habitat parameter for European wildcat. DIEBERGER (1994) also uses acceptance by humans as a variable. Acceptance by humans may decide about recovery or extinction of different carnivore species all over the world. Therefore it is quite important to consider such a factor in a habitat model. The factor acceptance unfortunately couldn't be included in our model because we hadn't the appropriate data.

In the current model also habitat size is used. The parameter is not essential for wildcat occurrence, but for the long term stability of populations.

Considering the results of the presented model, the most adequate areas for the wildcat are predominantly situated in the east and northeast of Austria. The Alps are unsuitable because of long snow covering, as DIEZEL & MÜLLER – USIN (1962) already recognized. These results were also supported by DIEBERGER (1994), He considered the east and northeast of Austria as suitable habitats and the optimal areas are situated in the forest areas of the Weinviertel district.

Comparing the results of the habitat model with wildcat observation of the last 60 years, about 60 % of the observations are found in suitable habitats. Wildcats are hardly to differ from domestic cats (PIECHOCKI 1990). Therefore we have to consider that observations of domestic cats will also be included in this data set. In some observations the exact location is not available and the coordinates of the nearest community were included on the map. The model also describes the habitat suitability for the whole year. During summer, without snow covering, much larger amounts may be available for migratory wild cats as described above.

So it turns out that the presented model makes appropriate statements about suitable habitats for the European wildcat in Austria. Therefore it is an important basis for further management decisions like the location of the European wildcat populations. With the aid of the habitat model it's possible to focus on the most suitable areas, searching for wildcats. Furthermore communication programs to inform hunters and other stakeholders about the wildcat and improve the acceptance and habitat improvement measures are necessary. Therefore the habitat model gives a hint, where to start first.

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Conference Volume | 5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill | pages 197 - 204

Framework for long-term ecological research in alpine river systems

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Abstract

Long-term observations and experiments have never been more important for testing ecological theory and for addressing today's most difficult environmental challenges. Among them, climate change processes pose a considerable threat to global biodiversity and are recognized to particularly affect alpine landscapes. This high climatic sensitivity and lack of significant human impact make alpine river basins important environments for examining hydrological and ecological response to global change. Two interdisciplinary research projects carried out in six glaciated catchments in the Hohe Tauern NP, aimed at defining climate–hydrology–ecology interactions and demonstrating the importance of alpine river systems as indicator environments of hydrological and ecological impacts of climate change and variability. We addressed major research gaps through detailed multidisciplinary field investigations into, (a) alpine river system hydrology, geomorphology and physicochemical habitat, and (b) temporal and spatial patterns in aquatic macroinvertebrates, coupled with, (c) the application and further development of an invertebrate species traits method, and (d) innovative modelling approaches. Based on these results, we propose a framework of integrated, long-term ecological research in alpine headwater systems and its application in other alpine areas. Within this kind of LTER network, interdisciplinary approaches are fundamental for predicting stream hydromorphology and ecology under scenarios of future climate variability, for assessing the utility of alpine river systems as indicators of global change, and for developing conservation strategies for these fragile ecosystems.

Keywords

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

Introduction

Climate change and freshwater ecosystems

Alpine and arctic regions including their glaciers and snow fields play a critical role in the water cycle, as they store water mainly during the cold season and release it as meltwater during the warm season. Globally, 50 % of river system receive their discharge from water of snow and ice (Barnett et al. 2005). Due to global climate change snow and ice cover has decreased strongly within the last century (Bates et al. 2008). Global climate change scenarios suggest that this decrease will continue. Within the next century, glacier retreat will persist, weather will be characterised by stronger and longer dry periods and precipitation is more pronounced by rain instead by snow (Beniston 2003). Predictions to 2100 for areas such as the European Alps suggest a continued glacier retreat, more intense/longer droughts, and widespread precipitation shifts from snow to rain. As a consequence, mountain hydrology and geomorphology will alter significantly, leading to substantial change on the water regime of snow- and ice-dominated regions, both on the global scale and on the regional scale (Milner et al. 2009). This will lead to the creation of new habitats for the colonisation and development of plant and animal species during the process of primary succession (e.g. Chapin et al. 1994, Kaufmann 2001).

On the other hand, the fauna of alpine headwater streams is strongly adapted to the environmental conditions and under the scenarios of future alpine meltwater reductions some of these aquatic species are vulnerable to extinction (Jacobsen et al. 2012, Füreder 2012). As aquatic ecosystems also can sustain populations of higher organisms such as fish, amphibians and birds, the potential effects could be felt much more widely than in river systems. However, the potential effects of alterations to alpine river hydrology and biodiversity across other alpine areas can only be speculated at present due to minimal baseline data on alpine basin hydrology, geomorphology effects on basin hydrology, temperature and water chemistry, and linkages between these aspects and river ecology.

Protected areas – an optimal arena for long-term ecological research

The rapidity at which global landscapes are being transformed by environmental change has revived the importance of biological monitoring (Robinson et al. 2011). There are several reasons for conducting (long-term) ecological research in protected areas: i) The specific regions where designated as protected areas since they harbour some of the most characteristic and/or biodiverse habitats including best adapted and endemic assemblages on the planet. ii) They typically show the least historical impacts from humans and likely represent areas showing natural patterns, process dynamics and fluctuations that can be compared with areas more directly impacted by humans, especially as the human population grows. iii) These conditions may carry for the generation of data from biomonitoring programmes which are essential to be used for understanding eco-evolutionary and ecosystem processes better in the face of rapid landscape transformation.

Aims of research

For the framework of the long-term ecological research in alpine river systems we addressed these major research gaps through detailed multidisciplinary field investigations into: (a) alpine river system hydrology, (b) proglacial and alpine river geomorphology and physicochemical habitat, and (c) aquatic macroinvertebrates, coupled with (d) the application and further development of an invertebrate species traits method to be used with results from PROSECCO.ALPS for (e) various modelling approaches, combining data from a, b, c, and d, to predict hydroecological dynamics and change under various climate scenarios (these are still under evaluation). It was the aim to undertake intense biological field work within a three-years period to elaborate and define adequate methodologies for long-term research and to gain a comprehensive set of basic data for the future monitoring.

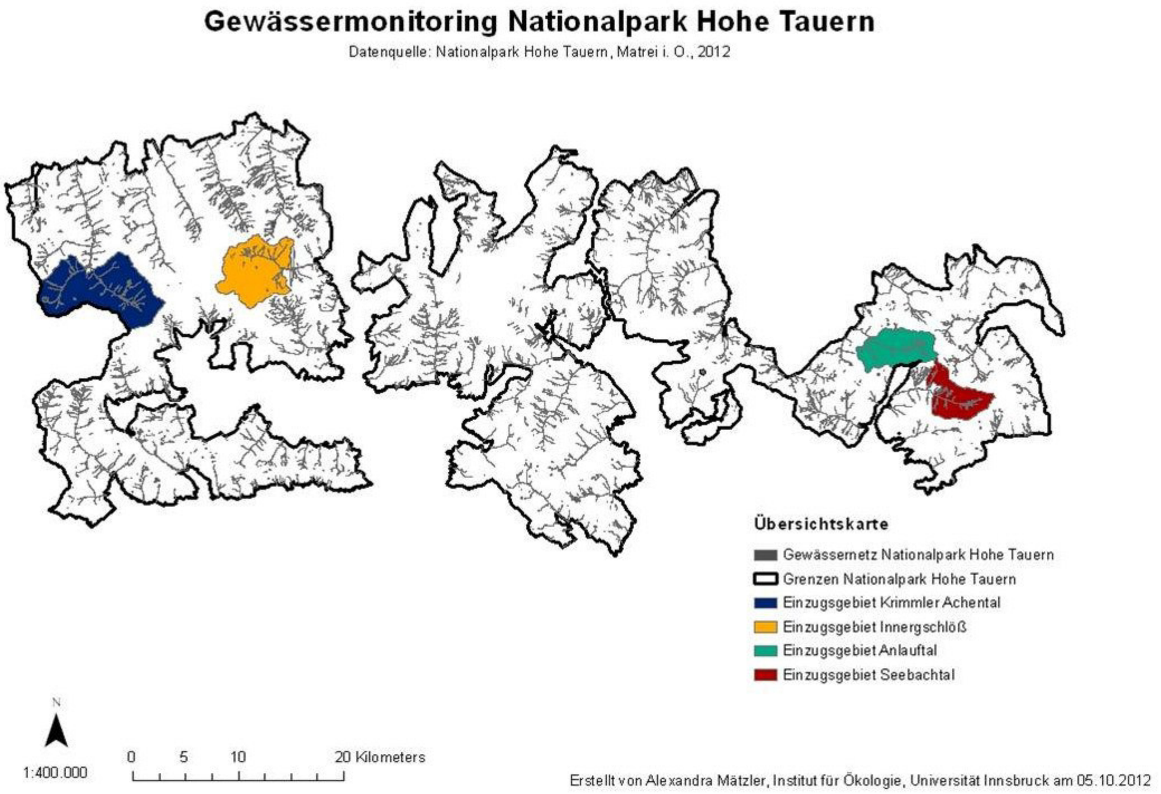

Figure 1: Nationalpark Hohe Tauern in Austria, location of the catchments (Krimmler Achental, Innergschlöß, Seebachtal, Anlauftal), where freshwater monitoring was implemented

Study Area and methodology for long-term ecological monitoring

The study area comprises the largest protected region in Central Europe, the Hohe Tauern National Park (NPHT; Fig. 1), which is situated in the Austrian Central Alps with an area of 1800 km². For the realization of a future freshwater monitoring, an inventory of existing freshwaters was already established for the national park (FÜREDER et al. 2002), including 279 streams (981 km stream/river length, catchment area >1 km²) and 136 lakes and alpine ponds. Based on habitat assessments, including catchment and rivermorphology characteristics, the stream and river types present were defined. A combination of selected methods and the results of habitat assessments (38 out of 61 assessment categories) enabled a comprehensive characterization of alpine stream and river systems to be developed (FÜREDER 2007). For the definition of stream/river types, 161 stream sections that reached natural or semi-natural habitat quality were selected and classified according to three main criteria: a) origin (glacial vs. spring-fed), b) position within the stream network (headwater, middle and lower reaches; following principally the biocoenotic concept of ILLIES & BOTOSANEANU 1963), but also including knowledge from recent literature on alpine and arctic streams, and c) channel morphology, i.e., meandering, braided, sinuous, constrained. From the existing data sets, stream reaches of known natural or semi-natural conditions were selected. Altitude and glaciation of the catchment were the environmental data used for the analysis of geomorphology and provided the baseline dataset in the selected catchments.

For the future long-term freshwater monitoring, four catchments in a well-balanced spatial distribution, i.e. Innergschlöß in SW, Krimmler Achental in NW, Seebachtal in SE, and Anlauftal in NE (Fig. 1, Fig. 2). We collected 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 herein presented 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 evident.

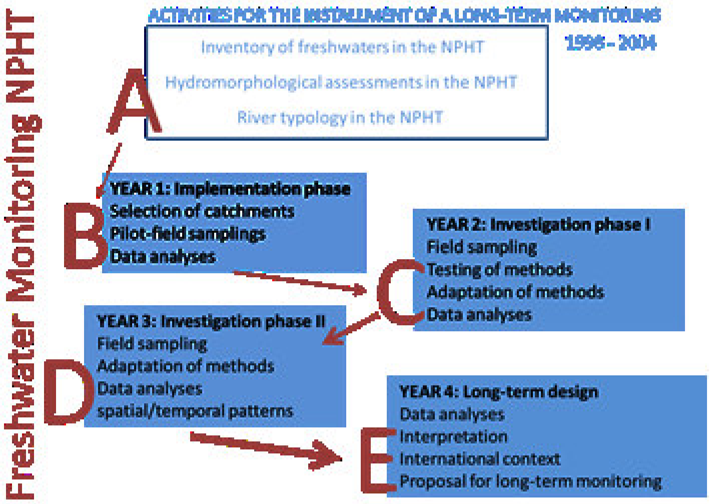

Figure 2: Project phases for the implementation of the freshwater monitoring in the NPHT

The search for an adequate tool-box to monitor the structure and functioning of aquatic ecosystems

The understanding and interpretation of ecosystem dynamics induced by environmental change requires a special set of indicators and their relevant and adequate application. Long-term research is considered fundamental for studying the effect of environmental change on ecosystem structure and function. It offers opportunities to observe and document slow, rare, subtle or complex changes frequently missed by shorter studies (LIKENS 1989, JACKSON & FÜREDER 2006). Whilst the importance of long-term ecological records is well documented, the availability of year-on-year records spanning more than two decades is currently low for river ecosystems (e.g. OBACH et al. 2001, DURANCE & ORMEROD 2007, MILNER et al. 2009). There is a complex interaction of hydrological, thermal and water quality regime shifts, changes to the energy base of aquatic food webs, and dispersal constraints of individual species. All these constraints respond to environmental change and influence riverine communities (e.g. WOODWARD et al., in press). Our framework for long-term ecological research from a variety of river ecosystems in the NPHT will help to uncover general patterns and location-specific responses in order to better understand climate change driven effects.

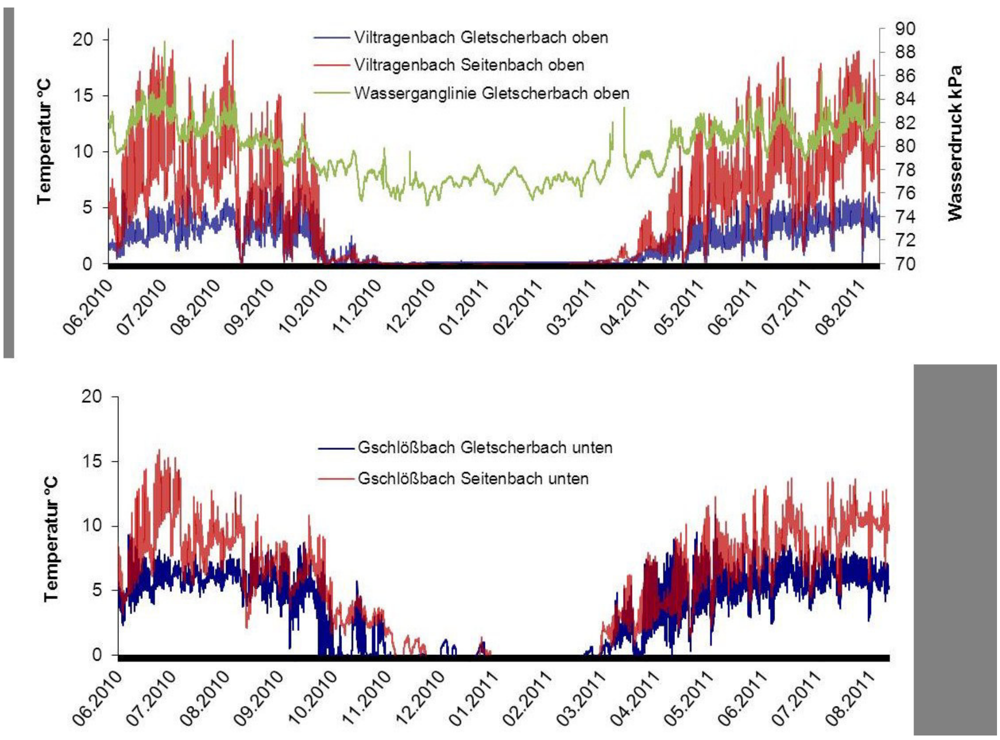

Figure 3: Example of temperature and discharge fluctuation patterns in Viltragenbach (Innerglösch)

For the intended long-term monitoring a comprehensive set of hydrophyscial and chemical as well as biological data now exist, which were used to define adequate field methodologies, sample analyses and indicators and serve as an excellent basis for the future explaination of environmental/climate change. In particular we have

- Discharge and temperature recording from installed loggers (Fig. 3)
- Water chemical analysis
- Benthic macroinvertebrates (Fig. 4) - taxa lists and spatial and temporal distribution of communities

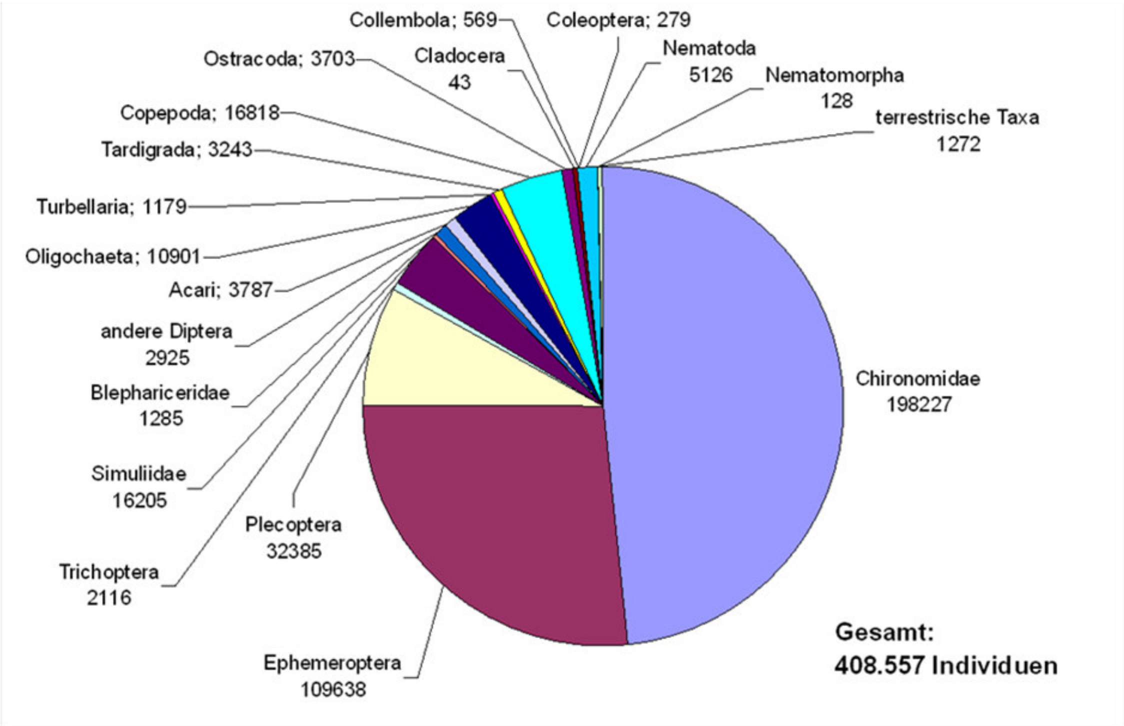

Figure 4: More than 400.000 invertebrates were collected during the research period 2009 – 2011 belonging to 18 higher taxonomic groups

In high altitude and latitude regions glaciers contribute significantly to river flow (e.g. FÜREDER 2007). Interpretation of climate-change scenarios propose marked shifts in the floral and faunal composition of rivers over coming decades due to projected decreases in suspended sediment load, higher water temperature and increases channel stability as catchment glacier cover decreases (e.g. ILG & CASTELLA 2006, BROWN et al. 2007, MILNER et al. 2009). Most regions of the world have seen decreases in glacial mass over the last 50-60 years (ZEMP et al. 2009), extensive and rapid retreat has been observed for many of the Alpine glaciers (e.g. FISCHER 2010). Here, glacial retreat has been occurring rapidly since around 1850 (end of the Little Ice Age), opening up vast areas of deglaciated terrain, and creating hundreds of meters of new rivers that subsequently undergo colonization and primary succession by biotic communities (FINN et al. 2010).

The use of multiple biological traits to characterize the functional composition and diversity of stream invertebrate communities (cf. typical focus on structure/biodiversity) is now well established in the ecological literature (POFF 1997; TOWNSEND et al. 1997; USSEGLIO-POLATERA et al. 2000; FÜREDER 2007, STATZNER & BÊCHE 2010) although few long-term studies exist (but see: BÊCHE et al. 2006, BÊCHE & RESH 2007). Functional classifications group species with similar biological and ecological traits (e.g. life-history, mobility, morphological, and ecological), attributes that have been shaped by natural selection over evolutionary time scales (POFF et al. 2006) and which influence how species respond to contemporary environmental change.

Whilst there are no published studies of how stream macroinvertebrate biological trait composition changes over time as glaciers retreat and disappear, several studies have used a space-for-time substitution to infer trait responses to glacial influence (SNOOK & MILNER 2002, ILG & CASTELLA 2006, FÜREDER 2007). These studies indicate that where glacierization is high, macroinvertebrates are typically cold stenotherms, with small sized streamlined/flattened bodies, possessing clinging habits and displaying omnivorous feeding.

Change in the species trait composition of Alpine river ecosystems over time should theoretically be similar to findings across European rivers if variables such as increased disturbance, and low water temperature and food supply associated with high glacierisation act as environmental drivers, or 'filters' (sensu SOUTHWOOD 1988, POFF 1997, STATZNER et al. 2001, 2004, 2008), to colonization. We can expect that glacial river macroinvertebrate community would show the following changes over time as glacial ice cover in the catchment decreased - see Fig. 5 and FÜREDER (2007) for more details:

(i) increased functional diversity, associated with higher taxonomic richness and habitat changes,

(ii) a shift towards short life cycles as stream temperature increased (ILG & CASTELLA 2006),

(iii) increased aerial mobility of invertebrate taxa as early colonizers (typically weak flying Chironomidae with long-range dispersal capabilities: MILNER 1994) were replaced by stronger flying insects;

(iv) shifts in macroinvertebrate morphology, in particular larger organisms colonizing as glacial influence (and thus disturbance) decreased;

(v) a loss of cold-stenotherms as stream temperature increased (BROWN et al. 2007, FÜREDER 2007), and

(vi) to the relative abundance of functional feeding groups, in particular more shredders linked to the establishment and increased development of riparian vegetation, and predators being the last trophic group to colonise (see MÄTZLER & FÜREDER, this issue).

Under exploitation of the three-years baseline data, these hypothesis are now being tested and expended to two additional catchments, the Goldberg and Pasterze catchments (investigated within the project PROSECCO.ALPS). This allows us to consider in particular the role of hydrology and geomorphology in six catchments.

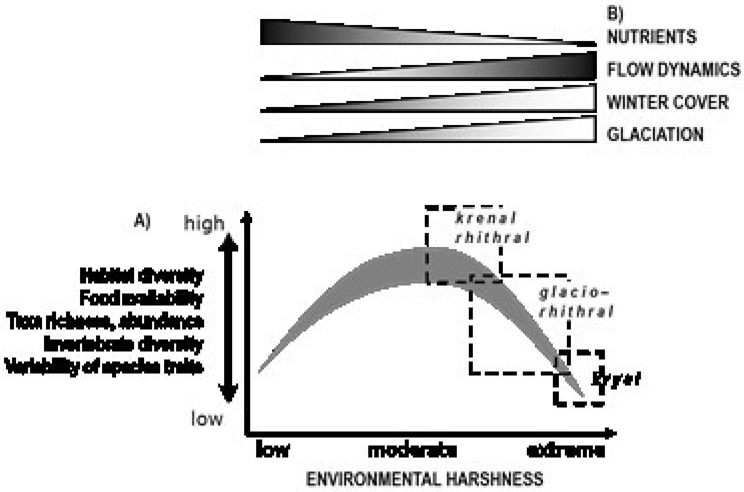

Figure 5: Scenario of environmental and climate change effects on key environmental conditions and consequently on the structure and function of the invertebrate fauna in alpine streams (from: Füreder, 2007; modified).

Paving the way for a long-term monitoring

Early ecologists recognised that environmental conditions were temporally dynamic (MCINTOSH 1985) and that the temporal length of a study contributed significantly to its conclusions, generalisations and/or predictions. For example, observations distributed across several days or months may differ from those that span years or decades because longer studies have a greater probability of observing or helping to explain slow, rare, subtle or complex changes in natural environments – see references in JACKSON & FÜREDER (2006). WEATHERHEAD (1986) observed that authors noted unusual events less frequently in longer studies, presumably because the longer temporal perspective modified the definition of an unusual event. Although the value of long-term ecological perspectives is well documented – references in JACKSON & FÜREDER (2006), the collection of long-term data is still limited by funding constraints, personal or institutional changes in research directions, research careers that last a maximum of 30–40 years and the absence or inaccessibility of comparable data from older research (e.g. STATZNER et al. 1994). In a review paper, JACKSON & FÜREDER (2006) already illustrated the value of long-term ecological studies of freshwater macroinvertebrates by examining the availability and characteristics of long-term data and describing recent contributions such long-term studies have made to lotic and lentic ecology.

The intention to install a long-term hydrobiological monitoring program has been in place in the Hohe Tauern Nationalpark since 1998, however mostly in a preparatory face. In its first stage, an inventory of all freshwater ecosystems was developed, followed by a hydromorphological characterisation and assessment. Now the results of the first implementation phase exist. Now all prerequisites for a long-term monitoring are available, ready for a program that would link the Nationalpark Hohe Tauern research activities with freshwater research worldwide.

JACKSON & FÜREDER (2006) emphasised the need of long-term monitoring in science and provided three suggestions (*in italic below*) that should help expand and secure the temporal scale in studies of freshwater macroinvertebrates. These intentions were certainly fulfilled with our planned long-term freshwater monitoring program in the Nationalpark Hohe Tauern, because:

1. *Researchers need to look to both continuous and discontinuous approaches to generate long-term studies.* Both can measure change over time, but in different ways and with different investments. The involvement of the University of Innsbruck would guarantee the synergy of larger and smaller research projects, like PhD and Master theses, where both institutions would benefit from long-term data and specific research questions.
2. *Ongoing studies with long-term potential need to be transferred to colleagues dedicated to continuing the effort.* The existence of a long-term data set would attract other colleagues more easily to continue.
3. *After papers are published and researchers retire or move to new projects, options are needed to archive raw data with essential annotation and in some cases voucher specimens so they can be retrieved later. Peer-reviewed publications are valuable sources of information and insight, but they are often not a good source of data for generating a long-term perspective because the data are generally not presented with that purpose in mind.* Also in this respect, the Nationalpark Hohe Tauern with its infrastructure offers

excellent possibilities by the Biodiversity Databank to archive data to be available for various specific analyses, also other than climate and environmental change questions.

In conclusion, protected areas in general are under pressures from multiple stressors, but they also carry the legacies of past landscapes and climates, and the burden of future large-scale changes (ROBINSON et al. 2011). They are an ideal arena for long-term biomonitoring, as they feature past and future ecological knowledge for the benefit of scientists, resource managers, and the public. With our framework and already existing comprehensive set of data we are ready to generate important information for which to test scientific principles, to define potential climate change effects and to learn from management actions. This long-term biomonitoring program would provide connections between the Nationalpark Hohe Tauern to a planned worldwide network for monitoring glacial rivers. The therein produced biological information and the expected interpretation and better understanding of changes makes protected areas ever more important.

Acknowledgements

We thank several colleagues and collaborators who helped in fieldwork and laboratory analysis. In particular we thank Alexandra Mätzler, Gerald Andre, Georg Niedrist, Sabrina Schönenberger, Ursula Winder, Stefanie Aumayr, Astrid Tischler, Julia Krug, Felix Lassacher and Stefan Schütz - their relevant research and contribution to this projects is either presented here as an oral or poster presentation or will be included in future publications. We are also grateful to the colleagues and rangers of the Hohe Tauern Nationalpark who enormously helped in assistance and logistics. We further appreciate the financial support of the Nationalpark Hohe Tauern, the Lebensministerium, the Land Salzburg und the European Union (Europäischer Landwirtschaftsfond für die Entwicklung des ländlichen Raumes), who financed the Freshwater Monitoring Nationalpark Hohe Tauern as well as the Austrian Academy of Sciences, who financed the project PROSECCO.ALPS.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 205 - 210

Depicting community perspectives: repeat photography and participatory research as tools for assessing environmental services in Sagarmatha National Park, Nepal

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Abstract

Efforts have been made to provide a scientific basis for using environmental services as a conceptual tool to improve conservation and livelihoods in mountain protected areas (MtPAS). Little attention has been paid to locals' concerns, which can illuminate the complex interplay between mountain ecosystems, environmental services and human well-being. This study uses a novel application of repeat photography to examine local perceptions of change in ES in Sagarmatha (Mt. Everest) National Park. We argue that our methodology could complement biophysical ecosystem assessments in MtPAS.

Keywords

environmental services, repeat photography, perceptions, Sagarmatha National Park, participatory research, qualitative methodology, photo-interviewing, UNESCO World Heritage Site, mountain protected areas, conservation, livelihoods, human well-being.

Introduction

Mountain ecosystems provide many environmental services (ES): protection from natural hazards, water provision and regulation, food and fiber production, and scenic beauty (e.g., Körner & Ohsawa 2005), all of which are sensitive to climate and land use changes. The Khumbu region (or SNPBZ - Sagarmatha National Park and Buffer Zone; fig. 2) has changed rapidly in recent years (e.g. Byers 2005; Stevens 2003).

Himalayan case studies reveal overexploitation, fragmentation and degradation (e.g. Chaudhary et al. 2007). These affect ecosystems' ability to provide ES, which affects human well-being (e.g. TEEB 2010). Despite efforts to provide a scientific basis for using ES for conservation in mountain areas (e.g. Grêt-Regamey et al. 2012; Rasul et al. 2011), little attention is paid to locals' concerns (Zilberman 2007), especially in the Himalayas.

This article presents and tests repeat photography as a way to examine local perceptions of change in selected ES: food, fodder, water provision, aesthetic landscape, timber and protection from natural hazards.

Case area

SNP and its buffer zone (BZ) is in the Solu Khumbu district of north-eastern Nepal (fig. 1). SNPBZ is administered by three village development committees (VDCs) (fig. 1).Recent satellite images show dramatic changes in higher mountain environments, with new lakes and retreating glaciers (Bajracharya et al. 2007; Mool et al. 2001). Since assessing and improving ES requires integrating diverse stakeholders' knowledge, recognizing power imbalances, and grappling with complex social-ecological systems, we believe our methodology could complement biophysical ecosystem assessments in MtPAs.

Historical photos were used in a diachronic photo-diary (143 side-by-side photos) from both the cultural and natural resource perspective over nearly six decades. We re-took selected photos across all 3 VDCs.

Methodology

We used a case study approach (de Vaus 2001) and qualitative interviews, as these focus on concepts relevant to research participants.

Purposive sampling (Henderson 1991) was used to select interviewees who were communicative and concerned about the region's development. We also used theoretical sampling (Hunziker et al. 2007), to find contrast among interviewees (Garrard et al. 2013b forthcoming), for example in age. 46 locals were interviewed. We assessed the sample's sufficiency via LINCOLN & GRUBA`s (1985) guideline for ending data collection: the appearance of regularities in the data.

In each interview, we presented topographical maps and a diachronic photo-diary, which helped researchers and participants elucidate difficult concepts. We discussed perceptions of changes over time, then changes in selected ES. Interviewees ranked the degree of change on a 7-point Likert scale from -3 (negative change) to +3 (positive change) for each ES. Interviews were subjected to qualitative content analysis (HAY 2000).

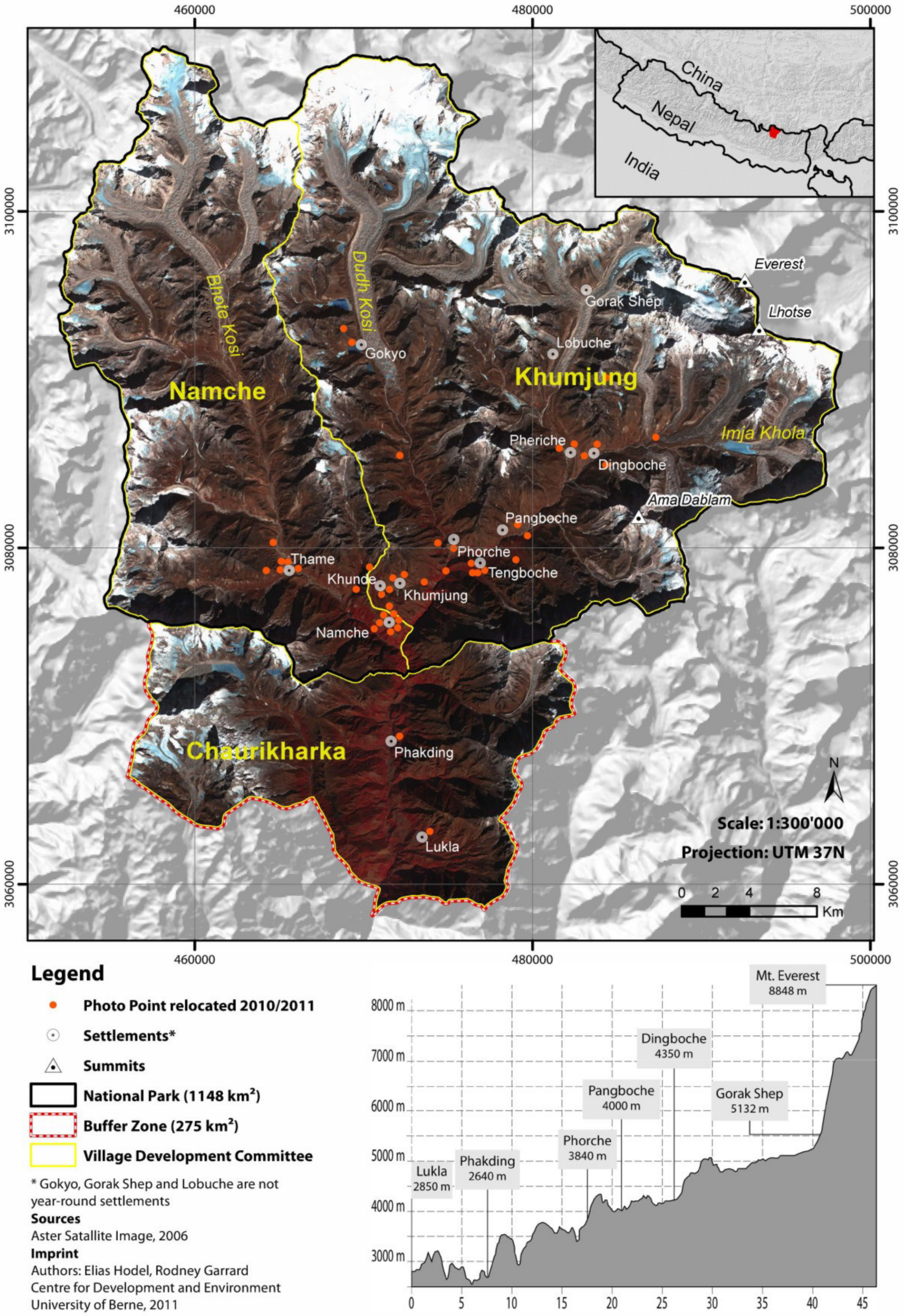

Figure 1: Sagarmatha National Park and Buffer Zone (SNPBZ)

Figure 2: [left to right] Namche 1950 (Photo: C. Houston), courtesy of A. Byers; Namche 1995 (Photo: A. Byers); Namche 2010 (Photo: R. Garrard).

Results

Interviewees made complex evaluations of multiple ES. All VDCs outlined negative changes to regulating services (protection from landslides and flooding) and provisioning services (firewood) and positive changes to water provision. Changes in cultural services (aesthetic landscape) and provisioning services (building timber) were seen positively if of value for tourism, especially by those wealthier individuals, or negatively if at odds with local values (e.g. access to forests).

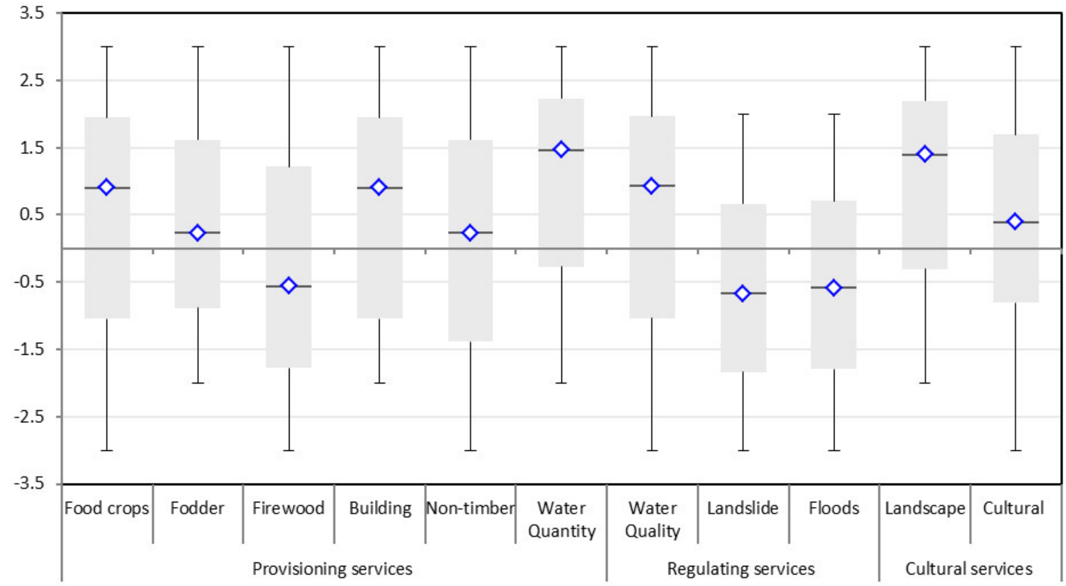

Figure 3: Perceptions of change in relation to selected ES in SNPBZ; the Likert assessment mean, 75% quartile, and ranges are shown. (N=46).

<u>Food crops and fodder</u>

53% of participants say traditional farming is getting harder. 67% blame demographic and economic factors (increased tourist demand, reduction of Sherpa workforce); 21% blame intensification of production factors (chemical fertilisers, new seed types, irrigation, greenhouses).

Most think the changes in farming are positive (fig. 3) but are worried about recent climate variability (ZIERROGEL & CALDER, 2003).

<u>Firewood and timber</u>

National Parks conservation policies are seen as failing to balance local well-being, conservation and development:

> FS610: we used to manage the collection of firewood within the community through our *shinngi nawa* [timber use tradition]... Now we are only allowed to collect two times a year [for] 10 days and we feel that next year it will be five days and then no access at all....

Since 1979, the SNP Forestry Programme has planted about 2 million seedlings in the region (GURUNG et al. 2010). Yet only 36% of participants believe the forest situation has improved, and 14% report degradation of the forest.

Water

81% say water provisioning is better (fig. 3). Virtually 100% of the park's population now has safe drinking water. However, 66% think winter snow has decreased, and 51% said monsoon rains are now heavier, but shorter.

This and increased demand are affecting water supply in five of the villages.

92% said the water has always been of very good quality, in contrast to this report:

> "Water sources along the major trails are being contaminated from improper affluent discharge, human waste, and garbage dumping. Sewerage and toilet waste can be found piped into nearby streams and rivers." (SNPBZ Management Plan, 2006: 46).

The uncertainties about the relationship between precipitation, watershed functions and land-use changes in SNPBZ need further exploration (GARRARD et al. 2013a forthcoming).

Landslides and floods

75% worried about changes to regulating services: river flooding, landslides and erosion due to land-use change.

With predictions of more intense rain (IPCC 2007), and more building in high-risk zones, landslides and floods are likely to accelerate.

Aesthetic landscape and culture

Participants are positive about cultural services (e.g. aesthetic landscape) especially lodge development for its tourism potential (fig. 3), but 27% worry about the deteriorating environment:

> CS1710: Look at these changes here (Gokyo photo # 90) even in this remote place it looks like a city... The way we live nowadays it's not natural.

17% thought tourist income was not fairly distributed, and 52% thought the significant change in SNPBZ was inflation. Sherpas' perception of their villages is changing; lodges have replaced *gombas* [monasteries] as the centre of civic life. 73% are concerned about recent in-migration of lowlanders.

Discussion

This paper has posed a question that is both empirical and methodological. Empirically, the study suggests three things. First, adverse changes in regulating services (landslides and flooding) are a concern, which underscores the need for a risk assessment and reduction programme based on improved understanding of local priorities.

Second, multiple complex factors affect perception of local ES change. This is reflected in participants' attention to the visual photo-diary and attachment to natural resource governance.

Finally, most interpretations of ES change carried an evaluative weight, often dualistic and rooted in each participant's values. This coloured the Likert scale assessment and shed light on aspects a more systematic assessment might ignore.

The perceived ES changes tally with case studies of incipient 'mountain transition' (e.g., CHAUDHARY et al. 2007) where economies struggle to cope with tourism. Unless policies change, the region's sustainability is threatened.

These empirical results help answer the methodological question: does this method work? As seen above, it provides valuable insights, allowing participants to discuss what matters most to them, not to the researcher, and to assess positive, as well as negative, change.

This aspires to be a first step in influencing conservation policies in SNPBZ towards broader participation for locals.

This article can be read in full in eco.mont Vol. 4 No. 2:
http://hw.oeaw.ac.at/eco.mont_collection?frames=yes

Acknowledgements

The authors wish to thank the participants and the community of the Khumbu; The Dept. of National Parks, Kathamndu; ICIMOD, Kathmandu; Ev-K2-CNR, Kathmandu; The Swiss Development Cooperation; Pemba Yangi Sherpa, Sonam Futi Sherpa, Gyanu Raja Maharjan, Da Yula Sherpa, Pasang Tendi Sherpa, Alton Byers, Ang Rita Sherpa, Tengboche Ringboche, Lama Gieshe, Sonam Hishi Sherpa and Tenzing Tashi Sherpa.

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Distribution, abundance and habitat requirements of protected bird species in the Hohe Tauern National Park (Austria): combining field work and habitat modelling

M. Gattermayr, C. Ragger, J. Pollheimer & J. Frühauf

Abstract

Designing conservation strategies and implementing conservation measures for protected species requires reliable knowledge about i) habitat requirements, ii) spatial distribution, and iii) population size of the target species in the area of interest. The Hohe Tauern National Park is the largest protected area in the Alps and includes, e. g., extensive areas of alpine grassland, rocky habitat, and montane to subalpine forest. With aid from the European Union (EU), a study was launched which covered 67 % of the national park and focused on 12 bird species listed in Annex I of the EU Birds Directive, including, e. g., grouse, woodpeckers and owls. As these species occur at low densities and are difficult to detect, the rough alpine terrain and a limited amount of resources available for field work posed considerable challenges to gain sufficient data. Thus, we implemented a multi-step approach which included the selection of 133 sample plots on the basis of preliminary MaxEnt-models of suitable habitat for the target species using pre-existing bird records; bird mapping during the breeding season in 2011 and 2012; the collection of habitat data at the bird's locations and at independent random points (e. g. deadwood, canopy cover); the use of spatial models of preferred habitat features and other environmental data for the creation of final models of suitable habitat for the target species; and the estimation of their population sizes by linear extrapolation of the correlations between the total amount of suitable habitat and the bird's numbers within the sample plots. According to our estimates, the study area holds populations of international importance of two species (Rock Partridge *Alectoris graeca*, Pygmy Owl *Glaucidium passerinum*) and 8-9 species meet the thresholds for national importance. Our results suggest that there is a need for more large-scale studies of 'difficult' species, and that some previous regional and national estimates should be revised. This is because major under- or overestimations of populations may lead to the setting of inappropriate conservation priorities and to inefficient use of available funds. We will discuss some advantages of our methodological approach, which yielded distribution maps of comparably high spatial precision, reasonably accurate population estimates, and information about habitat requirements and potential risks which provide a sound basis for planning and implementation of conservation measures, and for monitoring as well. We argue that the importance of the Hohe Tauern National Park in particular for the conservation of alpine species like Ptarmigan (*Lagopus mutus*) will increase as climate change is proceeding.

Keywords

Hohe Tauern National Park, sampling design, bird mapping, population estimates, habitat suitability models, MaxEnt, conservation, climate change

Introduction

With app. 1,857 km², the Hohe Tauern National Park is the largest protected area in the Alps. As altitudes range from 1,000 to 3,798 m a. s. l., it holds a great variety of habitats and species. More specifically, its importance is related to the extensive areas of alpine grassland, dwarf heath and rocky habitat, and – to a lower extent – of montane to subalpine forest. As these habitats are supposed to hold important populations of associated species, almost the whole national park area is designated as Special Protected Area under the EU Birds Directive. However, knowledge about some of the qualifying bird species listed in Annex I of the Directive is insufficient, because i) they occur at low densities, ii) they are difficult to detect or nocturnal, and iii) dedicated investigations are particularly demanding in the rough alpine environments. This is a serious drawback for the design and implementation of suitable management measures aimed at securing or improving their conservation status as required by the Birds Directive, and for the establishment of monitoring schemes. Therefore, from 2009 to 2012, with financial aid of the EU, a detailed study was carried out in the fraction of the national park belonging to the federal states of Carinthia and Salzburg, which account for 67 % of the park's surface. We focused on 12 species of Annex I of the EU Birds Directive: Hazel Grouse *Tetrastes bonasia*, Ptarmigan *Lagopus mutus helveticus*, Black Grouse *Lyrurus tetrix*, Capercaillie *Tetrao urogallus*, Rock Partridge *Alectoris graeca*, Pygmy *Glaucidium passerinum* and Boreal Owl *Aegolius funereus,* Grey-faced *Picus canus*, Black *Dryocopus martius*, Three-toed *Picoides tridactylus,* and White-backed Woodpecker *Dendrocopos leucotos* and Red-backed Shrike *Lanius collurio*. The aim of the project was to gain reliable knowledge about i) the species' habitat requirements, ii) their spatial distribution and iii) their population size in the study area.

Methods

In a first step we produced preliminary models of the birds' potential habitats with MaxEnt, a recently but well established technique, which achieves high predictive power by using presence data only (ELITH et al. 2006; PHILLIPS et al. 2006). To this purpose, we used pre-existing bird records and environmental data available for the whole study area (e. g. habitat type, elevation model, etc.) as predictors. The models had a resolution of 50 x 50 m and served for the selection of sample plots as follows: i) they included at least app. 20 % of total potential habitat in the study area for those species expected to be reasonably common; ii) the share of potential habitat was highest in those species which were supposed to be least numerous and/or most difficult to detect; iii) the plots represented a wide range of habitat quality; and iv) the plots were nearly evenly distributed over the whole study area. In total, we selected 133 sample plots (mean size 1.68 km², altitude 1,000 to 2,670 m a. s. l.), which accounted for app. 18 % (223.5 km²) of the study area.

Woodpeckers, grouse and the Rock Partridge were mapped three times (103 plots); two night mappings were carried out for owls (30 plots); the Red-backed Shrike was mapped only in Salzburg. In total, 369 days of field work has been spent during the season of territorial activity by 23 experienced ornithologists. When a target species was located, its position was determined by GPS and information about sex, behaviour etc. was recorded as well as data relating to a number of small-scale habitat features. The same habitat features were collected independently at a random sample stratified by habitat types (n = 657).

These two data sets were used to identify species-specific preferences for habitat features by multivariate statistical analysis. The locations of such preferred habitat features were treated in the same way as bird records, as we created MaxEnt-models to estimate the probability of their occurrence for the whole study area. Together with the other environmental data, those 'modelled habitat features' were used as predictors to build the final models of suitable habitat for each bird species. Within the limitations of available sample sizes, bird records were selected with respect to their information content. All MaxEnt were validated by using 50 % of bird records as 'training data' and 50 % as 'test data', which allowed us to carry out binomial tests. The selection of the most informative predictor variables was based on the jackknife-procedure performed by MaxEnt.

For each sample plot and each species, we determined i) the number of territories (or displaying males in the case of Black Grouse and Capercaillie) using conventional methods (BIBBY et al. 1995); and ii) the total amount of suitable habitat by summing up predicted occurrences over all 50 x 50 m grids. Circumstantial evidence (e. g. lack of accessibility during periods of maximal territorial activity) indicated that the real numbers were most likely underestimated in a number of sample plots. After exclusion of sample plots with likely underestimation, we computed linear correlation coefficients between total suitable habitat and the numbers of territories or males. Finally, estimates for the total numbers of territories or males within the whole study area were obtained by linear extrapolation of those correlation coefficients.

Table 1: Estimates for current population size in the two surveyed fractions of the Hohe Tauern National Park (Carinthia and Salzburg).

species	number of pairs in np Carinthia	number of pairs in np Salzburg	Total number of breeding pairs
Hazel Grouse	60-90	140-210	200-300
Ptarmigan	400-650	770-1.250	1,170-1,900
Black Grouse*	190-250	290-380	480-630
Capercaillie*	25-35	55-70	80-105
Rock Partridge	170-210	120-150	290-360
Pygmy Owl	40-80	60-130	100-210
Boreal Owl	55-65	90-105	145-170
Grey-faced Woodpecker	30-60	35-80	65-140
Black Woodpecker	14-18	26-30	40-48
White-backed Woodpecker**	0	1-5	1-5
Three-toed Woodpecker	250-320	300-390	550-710
Red-backed Shrike**	n.a.	5-10	n.a.

* males with territorial behaviour

** estimate based on expert judgment

Results

In total, bird data included 1,159 records. Ptarmigan, Black Grouse, and Three-toed Woodpecker were the most common species with 453, 190 and 128 records, respectively. 39 records belonged to the elusive Rock Partridge. Even after partial exclusion of records, the remaining data were sufficient to build habitat suitability models for all species with the exception of White-backed Woodpecker (three records) and Red-backed Shrike (seven). The predictive power of all models may be rated as 'outstanding' (HOSMER & LEMESHOW 2000). Moreover, all Binomial-tests of omission performed by MaxEnt were significant at $p < 0.0001$. Also, the predictions resulted to be quite precise even at small scale after visual inspection.

In all 10 species, the models gained most predictive power from the ‚modelled habitat features', which represent small-scale habitat information that initially was not available for the whole study area. According to the jackknife-procedure, such habitat features accounted for most information gain in every habitat model. For example, the most important predictor for the Black Woodpecker were ≥ 20 dead trees with a diameter of at least 20 cm at breast height.

Overall, the occurrence of forest species was positively correlated to mature stands with not too steep slope (< 35°). A medium canopy cover or tree gaps, interspersed open areas and a high density of thick standing dead trees were the most important habitat features. Several species were positively associated with forestry practices which support such habitat structures (single tree felling). The habitat requirements of the three species of open habitats in the subalpine to alpine belt were less homogeneous and rather showed specific preferences regarding vegetation. However, subalpine and alpine grasslands grazed by cattle and sheep appeared to be suitable habitats for all tree species. Also, wind-exposed hills play an important role as they provide access to food during periods with snow cover and are used for courtship displaying and territorial calling. Ptarmigans were positively correlated with the occurrence of snow fields, where protein-rich herbs become accessible during snow-melting. The population estimates resulting from linear extrapolation to the whole study area are presented in table 1.

Discussion

Our results suggest that the methodological approach chosen for the selection of sample areas was efficient within the given availability of resources for field work. Instead of sampling habitats in proportion to their share in the study area, using preliminary habitat suitability models we markedly increased our sampling effort in habitats for those species supposed to be less numerous and/or less detectable at the expenses of habitats of commoner species. As a result, we got a quantity of records which allowed us to produce satisfactory habitat suitability models for all species as well as reasonably accurate population estimates except for those species present with less than 10 territories. A retrospective analysis revealed that we mapped 19.5 % (Ptarmigan) to 35.4 % (Black Woodpecker) of suitable habitat, but only 18 % of the whole study area; these values are negatively correlated to estimated population size, which is a desirable pattern.

Another aspect of our approach – the use of spatial models of preferred habitat features as predictors in the bird's habitat models – may be considered as very successful, as they improved considerably the predictive power of the bird's models and accounted for most information in all instances.

Our results suggest that recent population estimates for the two federal states Carinthia and Salzburg should be revised. For instance, Slotta-Bachmayr et al. (2012) estimated 11-100 pairs of Rock Partridge in the whole federal state of Salzburg. We estimate 120-150 pairs only within the national park, while the species is occurring even outside. According to Feldner et al. (2006), the national park would include 43-80 % of the regional Ptarmigan population in Carinthia. This is unlikely, as the national park accounts for app. 12 % of alpine grasslands in that federal state only. As similar or even more pronounced disproportions indicate, it is very likely that the regional figures are underestimates in several species.

According to our results the study area holds nationally very important populations of Rock Partridge (30-32 % of Austria) and Three-toed Woodpecker (15-25 %), national important populations of Ptarmigan, Black Grouse, Capercaillie, Pygmy and Boreal Owl, Grey-faced Woodpecker. More significant, two species (Rock Partridge, Pygmy Owl) are of international importance as they meet the 0.1 % threshold (Ramsar Convention Secretariat, 2011) and three species have 'higher relevance than average' (Ptarmigan, Boreal Owl, Three-toed Woodpecker). But, these ratings may change if more accurate national estimates would be available. However, as our study was carried out on app. 67 % of the Hohe Tauern National Park, and because most species are markedly exceeding the mentioned thresholds, it seems unlikely that the general picture of its importance will substantially change.

Under the conditions of ongoing climate change, rising temperatures will reduce the surface of habitat suitable for birds of higher altitudes, and habitat quality may decrease as well. The Ptarmigan will face substantial habitat losses by upward expansion of the forest. Thus, this species will probably become extinct in many mountain ranges. In Switzerland, Ptarmigan decreased markedly in the last decades (Revermann et al. 2012), in Austria there is no evidence for a decrease, but this is most probably due to the lack of long-term studies. In our study area, the species was found between 1,800 and 2,800 m with highest suitability values between 2,100 and 2,400 m. In the Hohe Tauern National Park, where more than 260 peaks are higher than 3,000 m, Ptarmigan may retain a substantial, even if substantially reduced population because of the mentioned time delays and, simply, because surface is decreasing with altitude. Nonetheless, the importance of this protected area could increase in the foreseeable future in particular for species of subalpine to alpine habitats.

A major achievement of this study was the gain of knowledge about species-specific habitat requirements and potentially adverse human influences on habitat suitability. Within forests, the preservation of stands with low to medium degree of canopy cover, with mature trees of different age classes and with high densities of large-sized standing deadwood is essential. In the management zone of the national park, timber harvesting should be limited to single-tree felling. Our results clearly show that many species are benefitting from the use of forest for cattle grazing, whereas some stakeholders are promoting the spatial segregation of livestock grazing and timber production, we strongly recommend supporting this traditional practice by dedicated funds. Similarly, the grazing of cattle and sheep on subalpine to alpine grasslands and dwarf shrubs should be continued and, where possible, re-established to maintain the open character of those habitats. This is even more important as climate change is stimulating forest expansion above the current tree-line.

Conclusions

The discrepancies between our and other recent estimates demonstrate that there is a need for further field work in combination with habitat modelling to improve knowledge about the distribution and the size of populations of bird species associated with montane to alpine habitats in Austria. Lack of reliable figures causes considerable uncertainty for the assessment of the importance of already designated or potential protected areas, entailing some risk that inappropriate conservation priorities are set.

Especially in the case of species difficult to detect or living at low densities, an efficient sampling design is crucial. Our results demonstrate that even a huge effort (mapping of 223.5 km²) yielded just sufficient data for the rarer species, as habitat models based on less than 30 suitable records may result in unsatisfactory spatial predictions and population estimates. Thus, we argue that studies aiming at the production of reliable distribution maps and population estimates for grouse, woodpeckers and owls inhabiting montane to alpine environments are only cost-efficient if they cover very large and if they are based on approaches which include careful selection of sample plots, statistical analysis and habitat modelling. This is even more true because the effort for planning and analysing will increase only marginally with the total size of the area investigated.

Our findings regarding habitat use and habitat preferences allowed us to describe the habitat requirements of 10 species of conservation concern in the study area and to draw some conclusions about recent population trends on the basis of known land-use changes. These results are a reliable basis to identify suitable management measures, to define specific and quantitative targets for the preservation or achievement of a favourable conservation status as well as for long-term monitoring.

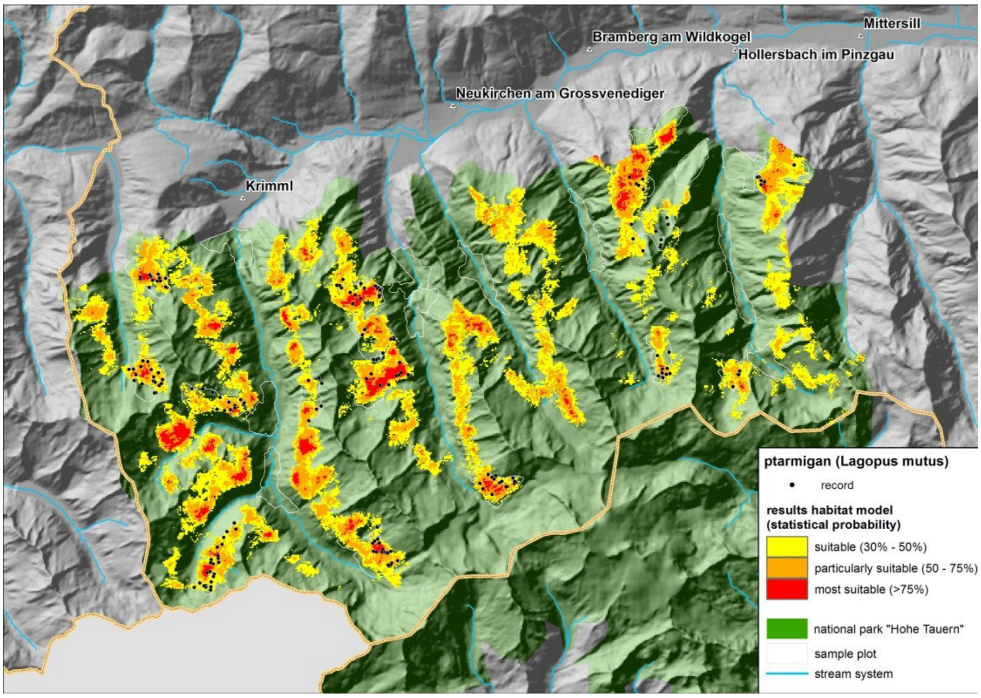

Figure 1: Partial view of the habitat model for the ptarmigan (*Lagopus mutus)* covering a representative part of the national park Hohe Tauern within the federal state of Salzburg.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 215 - 218

Griffon Vulture Monitoring in the National Park Hohe Tauern

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Abstract

The eastern Alps are regularly visited by Griffon Vultures during summer time. The Griffons arrive mostly from Croatia but also from other countries. In April the first individuals reach the southern Alps and 1-2 months later the Hohe Tauern National Park. The number of summer visitors decreased in the last years. In 2012 the numbers of birds observed were rather low (20 to 30 individuals). By contrast, a project for the conservation of the species carried out in Friuli (Italy) has seen an increase of the species and the establishment of some small breeding colonies. During the project synchronous counts are done at all roosting sites and results are compared with historic data. Several birds should be trapped and fitted with satellite transmitters in order to get data about use of roosting sites and food resources. The aim of the study is to explain the observed decrease and to provide data for the future management of the species.

Keywords

Griffon Vulture, monitoring, decrease, Hohe Tauern National Park

Introduction

Since ever Griffon Vulture (*Gyps fulvus*) spent the summer months in the eastern Alps (HERREN & HAURI 1963). However, the numbers have been declining since many years, probably due to the populations decline recorded in the Balkans (SLOTTA-BACHMAYR et al. 2004). Actually we can observe a strong decrease in the Hohe Tauern and a quite strong increase in the Italian-Croatian population. The number of summering birds is currently estimated at 100-150 individuals but not more than 30 birds reach the National Park. Griffons use a huge territory including mountainous areas of Austria, Slovenia and Friuli (I). The beginning of a restocking project in NE Italy in the late 80s changed the modalities of appearance of the species in the Alps. In fact, birds are flying northwards earlier and spend some time at the area of the feeding site in Cornino before flying into the Alps.

The main aim of the research project carried out in the National Park Hohe Tauern is to understand the features of summer aestivation in the Austrian Alps. To achieve such purpose, we monitor the number of birds, the most important foraging areas and roosting places (all located in the country of Salzburg).

The study and marking carried out in Croatia since 1990 (SUŠIC 2000) have allowed us to make interesting observations, documenting the movements of different individuals over the years. The results demonstrate that the great majority of the Griffons which arrive in the Alps come from the colonies in northern Croatia with approximately have 180 breeding pairs (SUŠIC*, pers. com.*).

The situation of the Griffon Vulture in the Hohe Tauern National Park

Historically up to 200 vultures have been reported to have spent the summer in the Austrian Alps, but the species has never been breeding in the area (TRATZ 1954-1955). The mean number of birds in the last decades was about 50 to 100 individuals. This number is very far from actual observation data. There is a continuous decrease from year to year. Several roosting sites are not used anymore. The actual number of birds does not exceed 30 individuals. We can yet observe regional shifts depending on the availability of sheep.

The first individuals arrive in April-May in the southern part of the aestivation area (Friuli and Slovenia), while in the Hohe Tauern they appear in June and mostly in July. Other arrivals are recorded at the end of August or during September when some young birds of the year appear, together with a few adults that have finished the breeding cycle. From September the presence of wild birds begins to low, in Friuli the majority of departures take place during October-November, in this area for a few years a number of birds (20-30) have begun to winter joining the colony on a permanent basis (GENERO 2000; *ined.*). In 2012 the last griffon vulture left Austria the 16th of October.

The situation in the eastern Alps changed in the last years due to a project carried on in NE Italy (GENERO & PERCO 1997). The aim of the project is the conservation and the reintroduction of this vulture in the eastern Alps. A relevant aspect of the project is the attraction that the colony and the feeding point exercise over Griffons arriving from other countries. These Griffons learn to be familiar with the area and return in subsequent years. The visit mode is extremely variable. Some birds remain for the entire summer, whilst others frequent the area for only a few days. Others still return regularly, coming from other Alpine areas or perhaps from even different nesting colonies. The number of birds involved has risen rapidly in recent years, exceeding 200 in 2012. Most of the birds are in their second-fourth years but adults are also regularly observed.

The project in the Hohe Tauern National Park

Due to the importance of the Griffon Vulture for the Hohe Tauern area, in 2012 a project started with the aim to increase the knowledge of the appearance modalities of this species in the area. The research will continue for at least 3 years. First of all it was important to collect and analyze all the historical and recent data available for the area of the National Park. Some historical data are stored in the database of the "Haus der Natur" in Salzburg or by private people, yet most information about griffon vultures was collected during the Bearded Vulture project. This is an important source of data that has never been considered properly, even if it can give important information about the last decades. Unfortunately there are no continuous data about the main roosting site, located above the village of Rauris.

It is difficult to estimate the number of birds in the region, due to the different areas and roosting places frequented. In order to perform a detailed census, a simultaneous count of the main roosting places used by griffons in the Hohe Tauern and at the feeding point in Friuli was planned for the years 2012 and 2013. The study allows also to define the use of the different roosting sites used during summer time and connected with the importance of other factors like availability and distribution of food and management actions in the area. The project intends also to study the movements of birds and the connections with other populations. For this issue, more actions are planned, such as observations in some key spots in order to identify the marks of the birds (rings, wing tags and bleached feathers). In consideration of the small amount of birds with such marks and the difficulties related with observations at long distances, it is expected to catch some Griffons in the Nature Reserve Lago di Cornino and in the National Park area, so to provide them with suitable marking codes. An important point is the use of satellite telemetry. Due to GPS technology it is possible to study not only bird movements, but also some other aspects such as behaviour and activity. It is also possible to obtain accurate measurements of home range size, habitat use, territorial and seasonal behaviour. For this aim, 6 transmitters are expected to be applied on birds' backs in summer 2013.

To catch the birds in the feeding point in NE Italy and in the NPHT, different methods will be used: a cage, already built at the feeding point of Cornino, and a spring trap. The capture of the birds is also a good opportunity to perform sample taking, in order to test the presence of metal and of other pollutants.

Results

Capture of birds and application of satellite transmitters are expected for the summer 2013. In the year 2012 we started with detailed observations and simultaneous counts in the main roosting places in the Salzburg Region and in the feeding point in NE Italy. The results are summarized in the Tab. 1. Counts were carried out in 5 occasions from mid June until end of September.

Table 1: Simultaneous counts of Griffons in the main roosting places of Salzburg Region and in the feeding point in NE Italy.

Time	Krumltal	Rauris	Kaprun	Stubachtal	Felbertal	Hollersbachtal	Total	Friuli
15.06.2012	3	0	0	0	0	0	**3**	**154**
28.07.2012	0	0	9	17	0	0	**26**	**51**
17.08.2012	0	0	0	6	0	0	**6**	**174**
05.09.2012	8	0	0	14	0	0	**22**	**158**
26.09.2012	0	0	0	7	0	0	**7**	**130**

The results show the low number of griffons observed during the whole summer in the NPHT in contrast with the high numbers regularly monitored at the feeding place. The variability can be explained with regular movements between the two areas (the distances are about 90-120 km) apparently related with the presence of food in the mountains and the weather conditions. When the first snowfalls occur in late summer, vultures fly back to Friuli. It was possible to observe that traditional roosting places (Rauris and Krumltal) were rarely used during 2012, despite the continuous presence of some griffons (never more than 20) in the Krumltal. The most important roosting place in 2012 was the one in the Stubachtal (Fig. 1).

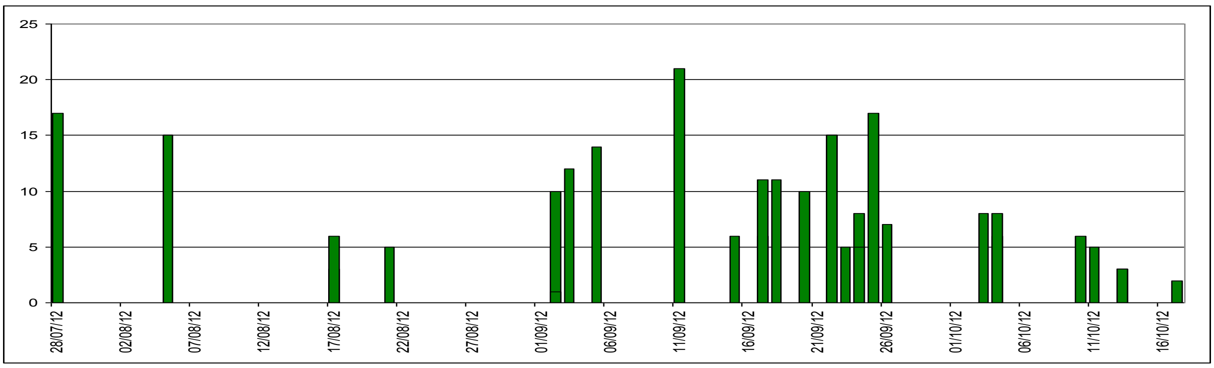

Figure 1: Counts of Griffons in the roosting place of Stubachtal (2012).

The roosting site in the Stubachtal was regularly frequented by a variable number of birds. In a few occasions it exceeded 15 animals and reached a maximum of 21 on the 15.09.2012. The absence of birds in some surveys demonstrate how fast vultures change their roosting site in relation to food supply and weather conditions. Nevertheless, the different numbers of the site Stubachtal are not correlated with other roosting sites in the area (Tab.1). Therefore it is possible that the birds had moved down to Friuli because of bad weather or little food availability. Another possibility is the presence of unknown roosting sites. Due to the high observation distances and a lack of observers in some areas it was not possible to recognise individual marks.

Figure 2: View on the Moosenwand in Rauris, the most important historical roosting site for Griffons in the eastern Alps. From 1991 the site started to be used rarely (Photo F. Genero).

Conclusions

Based on these preliminary results, it seems important to monitor birds movements in a coordinated manner in all the surrounding countries, in order to study the movements of the vultures and to better understand the strategies employed in the seasonal use of the territory. In the 2012, for the first time, a simultaneous count was carried out in the 6 main roosting places of the NPHT Salzburg and in Friuli. The first results confirm the decrease of the species in the Hohe Tauern in contrast with the increase in the southern Alps and in the colonies of Croatia. This trend could be also related to the strong attraction that both the feeding place and the colony located in Cornino play on griffon vultures.

The vulture project in Friuli brought to a general increase of the presence of Griffon Vultures in the eastern Alps. However, this increase is visible in certain areas, while other traditional areas show a heavy decrease in the number of summering birds. On the other hand more and more vultures coming from southern France have spent the summer in the western Alps over the last years (1500 birds during the Alpine griffon vulture monitoring day).

However, the reduced presence in Austria could be also related with the decline of the traditional sheep farming recorded in some valleys. In the central part of the National Park most animals that die on the alpine pastures are left on the ground, but in many other areas they are removed.

The research will continue at least for other 2 years and we expect to get much more information with the application of the satellite telemetry system in 2013.

Figure 3: One of the higher roosting places in the Hohe Tauern (Rauris Krumltal, about 2600 m) (Photo F. Genero).

Figure 4: The feeding point in Friuli attracts a high number of vultures (Photo F. Genero).

Acknowledgements

The project is financed by the National Park Hohe Tauern Salzburg and the monitoring was carried out with the help of the National Park staff, local hunters and by Tanja Bacher. We thank Ferdinand Lainer of the National Park Hote Tauern for the coordination of the project. A special thank to Nina Roth Callies and Hans Frey for providing historical data collected from the beginning of the Bearded Vulture project. Other data were provided by the "Haus der Natur" in Salzburg. For the observations in the Nature Reserve Lago di Cornino, we thank the local Community of Forgaria del Friuli, Arduino Candolini and Sara Berra. For the planning of the research and the building of the trap we thank Stefano Filacorda and Andrea Madinelli of the Dipartimento di Scienze Agrarie e Ambientali, University of Udine.

We wish to thank Mita Drius for her kind review.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 219 - 222

Cryptic bumblebee species of the *Bombus lucorum*-complex in the Austrian Alps

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Abstract

Bumblebees are among the most important pollinators in the high mountain regions. Within the *Bombus lucorum*-complex, at least two cryptic species (*Bombus lucorum*, *B. cryptarum*) inhabit the Austrian Alps, a third one (*B. magnus*) cannot be excluded to occur.

Recent molecular studies indicate that colour-patterns used for identification do not correspond with distinct molecular operational taxonomic units, each of which represents one of the species of the *Bombus lucorum*-complex. Furthermore, no characteristic colour pattern for one of these species was found and some traits show a gradual variation among the species. A reliable identification of females seems to be impossible based on morphological characters.

DNA-barcoding represents an appropriate method for the determination of species and provides a basis for studying altitudinal preferences as well as ecological and morphological characteristics within the *Bombus lucorum*-complex. The present study focuses on the following research questions: Are there differences in the occurrence of the species in various geographical expositions and elevations in the Austrian Alps? Do the species show different flower preferences? How reliable are morphological characters when re-evaluating DNA-barcoded specimens of the *Bombus lucorum*-complex?

Keywords

Bombus lucorum-complex, bumblebees, cryptic species, Austrian Alps, DNA-barcoding

Introduction

Bumblebees (*Bombus* spp.) are important pollinators in various habitats, especially above the treeline of European alpine regions (NEUMAYER & PAULUS 1999). Around 250 bumblebee-species are described worldwide, that predominantly prefer the temperate and northern parts of the world. In Austria, 47 species of the genus *Bombus* were reported representing one of the "hot spots" of biodiversity of these insects.

One group of very common bumblebees form a cluster of species, the so called *Bombus lucorum*-complex. The taxonomic status of these closely related species belonging to the complex of *Bombus lucorum* s. l. has been intensively discussed in the last decades. Three distinct species, i.e., *Bombus lucorum* L., *Bombus cryptarum* Fabr., *Bombus magnus* Vogt are strongly suggested to be widespread in various habitats across Central Europe. Studies on morphological/morphometric characters, enzyme electrophoresis, male labial gland compounds, and in particular nucleotide sequences improved the current understanding however did not settle the discussion about the species composition within this group. It turned out to be impossible to clearly separate the males and workers using morphological characters (MURRAY et al. 2008) as they are used in the common literature for the determination of bumblebees (MAUSS 1994, AMIET 1996, GOKCEZADE et al. 2010, NEUMAYER & MAUSS in prep). A number of cryptic species was revealed that are nearly identical in morphology (MURRAY et al. 2008, WILLIAMS et al. 2012). Although diagnostic characters frequently overlap, queens of the *Bombus lucorum*-complex can reasonably be determined by experts (CAROLAN et al. 2012).

Especially in field work, discrimination methods are not trustworthy and, therefore, reliable information about niche differentiation of the cryptic species is very limited. DNA-barcoding represents an appropriate method for determination of these bumblebee species and will be used in the ongoing investigation to study niche differentiation of the cryptic species within the *Bombus lucorum*-complex in the Austrian Alps.

Our study will focus on the following research questions:

Which of the cryptic species of the *Bombus lucorum*-complex occur in the Austrian Alps and where do they occur?

Do the species show different habitat preferences regarding exposition and elevation of their habitats?

Do they prefer different flower species and do they differ in flower visiting behaviour?

Studying the distribution of the cryptic species in Austria will provide the basis for future monitoring programs and long-term studies. The investigation of the habitat requirements of the bumblebees of the *Bombus lucorum*-complex is fundamental for a more detailed knowledge of pollination networks in alpine ecosystems.

Methods

<u>Field study</u>

Bumblebees were collected in seven different regions of the Austrian Alps (Silvretta, Kaunertal, Karwendel, Glocknergroup/north, Glocknergroup/south, Gesäuse, Schneeberg) in July and August 2012. We aimed to collect ten bumblebees of the *B. lucorum*-complex in each of the following altitudinal ranges (if present) in the various mountains: 1000 – 1100 m, 1300 – 1400 m, 1600 – 1700 m, 1900 – 2000 m, 2200 – 2300 m, 2500 – 2600 m, and 2800 – 2900 m a.sl. From all collected individuals GPS-data of sampling site (geographic position, exposition, altitude), habitat type, flower species visited and activity on the plant (pollen collecting, nectar feeding, nectar robbing) were recorded. All collected bumblebees were stored in 99% ethanol in the field.

<u>DNA barcoding procedure</u>

DNA was extracted from three legs of each individual using DNeasy Blood & Tissue extraction Kit (Qiagen); the CO1 region was amplified and sequenced using standard techniques. Primers used for PCR and sequencing were LCO1490 and HCO2198 (Folmer et al. 1994). Sequences were assembled and aligned using BioEdit v7.1.7; neighbour joining trees were constructed using Mega v5.1 for phylogenetic analysis.

Results and Discussion

The year 2012 showed exceptionally low numbers of bumblebees of the *B. lucorum*-complex in comparison to other years (Neumayer unpublished). In total, 77 individuals of the *B. lucorum*-complex were collected (plus three individuals of *B. terrestris*).

The DNA barcodes revealed 52 individuals of *B. lucorum* and 25 individuals of *B. cryptarum*. No *B. magnus* was found in the investigated areas (Fig. 1). Up to now, it seems that *B. magnus* does not occur in the Austrian Alps above 1000 m a. sl., although *Calluna vulgaris* rich habitats were sampled that are known to be preferred by *B. magnus* in Scotland (Waters et al. 2011). Syntopic occurrence of *B. lucorum* and *B. cryptarum* was recorded in different sampling areas and indicates species separation. The results suggest that *B. lucorum* was more abundant than *B. cryptarum* in 2012 except in the southern slopes of the Glockner Group. Furthermore, 71% of *B. cryptarum* were found between 1900 m and 2000 m. The altitudinal distribution suggests that *B. cryptarum* prefers habitats located around 2000 m a.sl. However, due to the incomplete sampling in the last year these results must be regarded as preliminary.

First analysis of the flower visiting preferences revealed that both studied species of the *B. lucorum*-complex were collected mainly on *Calluna vulgaris* (*B. lucorum*: 34% vs. *B. cryptarum*: 38% of visited flowers) and on flowers of *Trifolium*-species (*B. lucorum*: 28% vs. *B. cryptarum*: 19% of visited flowers).

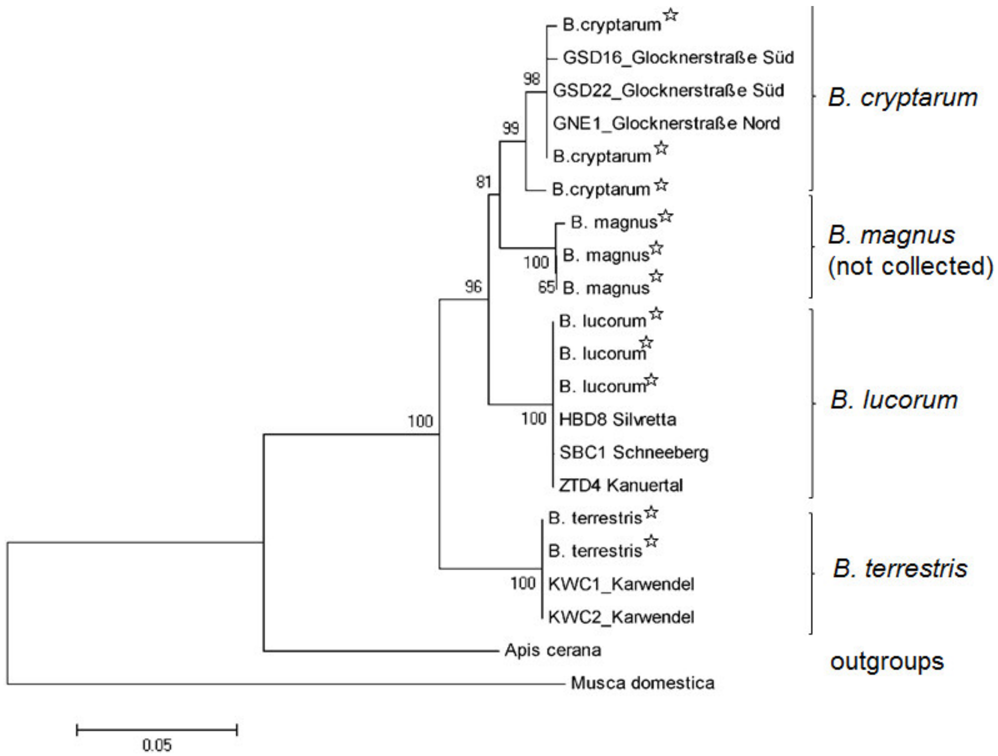

Figure 1: The closely related bumblebees *Bombus lucorum*, *B. cryptarum* and *B. magnus* represent clear operational taxonomic units as shown in the phylogenetic tree. A K2P based Neighbour-Joining Tree (CO1) of selected specimens from different sampling areas in Austria; node support values from 1000 replicates; * sequences from GeneBank.

Conclusions and outlook

Based on previous studies in the Austrian Alps, we conclude that only 5-15% of the usual numbers were present in the study areas in the summer 2012 (NEUMAYER unpublished). The sampling in the study areas will be completed in 2013. Based on the experiences of the last year we decided to expand the sampling transects to lower parts of the respective region. Additionally, bumblebees will be collected also in northern regions of Austria and in eastern parts of the Austrian Alps according to the established sampling protocol. The recently started investigation of morphological features of the DNA-barcoded specimens will give us the opportunity to re-evaluate the diagnostic characters of the various taxonomic entities in the *B. lucorum*-complex. This includes the study of well-established diagnostic characters of the species but it is also aimed to find new characters for reliable determination. Expected results of the study will allow analyses of ecological differentiation of closely related insects concerning geographic and altitudinal distribution, habitat preferences and foraging behaviour.

Acknowledgments

We are grateful to the following institutions for financial support: National Park Gesäuse, Naturpark Kaunergrat, Alpenpark Karwendel, Naturpark Zillertal, Abteilung Umweltschutz der Tiroler Landesregierung and the Department of Integrative Zoology of the University of Vienna.

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Conference Volume | 5th Symposium for Research in Protected Areas | 10 to 12 June 2013, Mittersill | pages 223 - 226

Examinations on alpine brown trout populations (*Salmo trutta* f. *fario*) in the province of Salzburg (Austria)

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Abstract

The present thesis is concerned with the examination of four alpine rivers in the mountainous part of the province of Salzburg (Austria). A special feature of these rivers is their isolation from usual fish migratory pathways, which would possibly favor the preservation of autochthonous populations of the brown trout (*Salmo trutta* f. *fario*). Beside hydromorphological habitat analyses, microsatellite DNA data were collected as well as isotope chemistry from otoliths. The data combination showed that two of the investigated populations are rather autochthonous; the others have already indicated more genetic introgression and influence by men. In addition, integrating data obtained from otolith microchemistry and microsatellite DNA can provide complementary information on the natal origin and genetic structure of brown trouts at any life stage. This information will be valuable for studies of the population dynamics and quality of mixed-stock samples collected from the alpine region. The hydromorphological analyses demonstrated that all four rivers have a high structural diversity and deserve the title “extreme habitat”.

Keywords

autochthonous, S*almo trutta*, otolith, isotope, microsatellite DNA

Introduction

The brown trout (*Salmo trutta* f. *fario*) represents an important ecological component of natural river systems, especially in higher altitudes (Rhithral). Due to a long stocking tradition by allochthonous forms from whole Europe and their high economic benefit, natural wild-living brown trout populations became rare (WEISS et al. 2001). Therefore and also because of the high popularity of brown trouts, many scientists choose them as a model organism for investigations of animals within natural habitats. Besides, examinations on relict populations are spectacular, as they have become seldom in populated areas. Moreover, the increasing economic pressure on our river systems strengthens more than ever the necessity of preservation strategies for the whole aquatic fauna. For such an expedient preservation, knowledge about the current state including its natural dynamic is the first step.

In cooperation with the government of Salzburg, department for water protection (Gewässerschutz), it was attempted to get continuing information about habitat requirements, structure and size of brown trout populations living in an extreme ecosystems and to further acquire detailed information of the actual genetic and physiological condition. The selection of the rivers was based on special criteria. For increasing the probability to find autochthonous populations, the rivers or river segments should be isolated from usual fish migratory pathways as a result of their geomorphological development (JÄGER et al. 2004). In addition it was beneficial, if a genetic data set of the populations from previous studies has already existed. Based on these criteria the four alpine rivers Blühnbach (Pongau), Anlaufbach (Pongau), Fuscherache (Pinzgau) and Windbach (Pinzgau) were selected (Fig. 1).

Another aspect was the location within a protected area; inasmuch as such river systems should have been less anthropogenic influenced. In order to find populations which deserve protection, long-term management and monitoring can get organized more easily from official institutions, than in river systems with private holders, as well. The Anlaufbach and the Windbach are located within the “Nationalpark Hohe Tauern”.

Methods

The study included a survey on abiotic factors in these habitats within epirhithral rivers of the alpine region, as well as the evaluation of quantity and quality of local trout populations.

Besides surveying several physical and chemical variables, a special method for habitat mapping was utilized, the so called „mesohabitat-mapping“ (PARASIEWICZ 2007a,b, PARASIEWICZ & WALKNER 2007). This method quantifies the hydraulic diversity of habitats or river units by calculating its unique hydrosignatures. Actually, this is a measure which quantifies the variability in depth and flow characteristics within a defined section of a river. As additional feature, this method includes a determination of substrate qualities and quantities along river beds, as they are crucial for fish populations. The identification of brown trout populations was performed in cooperation with the Department of Zoology at the University of Graz by means of mitochondrial DNA analysis and microsatellite techniques (WEISS et al. 2009). Additionally, application of morphometric techniques allowed a morphological classification of various trout populations (LAHNSTEINER et al. 2003). In order to identify past stockings events in these habitats, isotope analysis of extracted otoliths and the associated water samples were performed at the Department of Analytic Chemistry at the University of Natural Recourses and Life Science ("BOKU", Vienna). The detailed method was studied in STURM (2008).

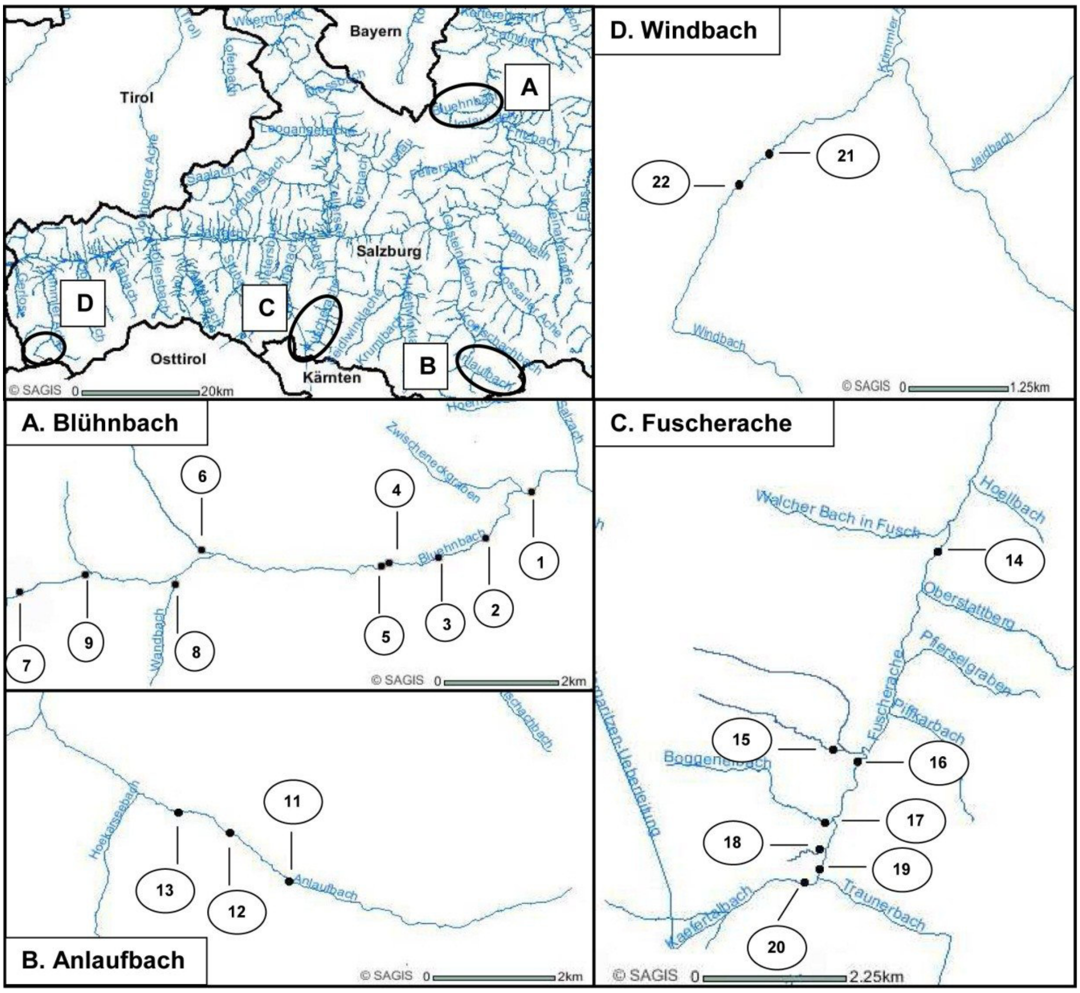

Figure 1: Investigation area and sample sites from the river Blünbach, Anlaufbach, Fuscherache, Windbach

Results

All abiotic variables of the estimated rivers indicate the presence of a high degree of nativeness in these alpine rivers as well as the necessity for highly adapted local fish populations in these special habitats. The rivers are characterized by extreme factors such as low electric conductivity (≤ 266 µS) low temperatures even in summer (≤ 14,4°C), high velocity (max. 1,5 – 2,3 m/s), high substrate dynamics and high gradients (4 – 8 %). As example, Huet (1949) fixed the upper limitation of the trout region with a gradient of 5%. According to Peter (1989), a gradient between 5 – 15 % appears as a limiting parameter, gradient higher than 15 % affects the conditions for a self-keeping fish population in a very unfavorable way.

Another important issue of this research was the estimation of the magnitude of human influences on isolated fish populations. The results clearly showed that even in isolated alpine rivers such influences could be readably detected. Considering all data (genetic, morphomertric and isotope), only two of the four prospected rivers, Fuscherache (Pinzgau) and Anlaufbach (Pongau), contained a mostly autochthonous trout population. In the other two rivers, Blühnbach (Pongau) and Windbach (Pinzgau), data revealed a more intense influence due to past stocking events. And though the examined rivers are all within the same drainage system, the genetic structure on microsatellite information is quite different among the populations, which implicates the development of local genetic variations in isolated habitats. The results can be compared with the studies DUFTNER et al. (2009) and LAHNSTEINER (2005), who also investigated the genetics of the present populations.

The combination of different data sources allowed the development of a statistical classification model to clearly separate autochthonous from allochtonous brown trouts. Especially the combination of microsatellite information and isotope data enabled this classification on a high level. The study indicates that otolith microchemistry and genetic information can provide unique and complementary information on the population structure of fishes. For trouts, otolith microchemistry can elucidate whether the fishes came from natural habitats or from hatcheries, but this information does not directly corroborate genetic structure.

The following morphometric analyses of the identified fishes revealed, that even if the genetic constitution of fish is autochthon, however, exhibit a different phenotype when they were hold in hatcheries than those, which stayed in native habitats the whole lifetime. In the opposite, genetic allochthonous fishes living under natural conditions, showed a more natural phenotype than typical hatchery fishes.

Another important detection was that genetic autochtonous fishes, which have been raised under nearly natural conditions, show adoptive characteristics like upstream movements and a higher fitness compared with conventional hatchery fishes.

Discussion

The ability of integrating different data sets like otolith microchemistry and microsatellite data offer significant possibilities of an integral identification of fish populations on the basis of individuals. Origin based questions as well as analyses considering nativeness and genetic fitness can be cleared. Furthermore, the data provide a holistic life-history of the examined population (CAMPANA et al. 2000). Also FREYER et al. (2007) emphasise the relevance of the integration of genetic and otolith isotopes investigation for identification of stocking structures in fish populations, as you receives not only information about the degree of anthropogenic interference but also about their dynamic (date of stocking, origin the of hatchery fish, etc.). Also specific migratory movements within short term scales can be answered from the isotope chemistry (KENNEDY et al. 2002, HOBBS et al. 2010).

The high physiological and ecological plasticity of the brown trout and the nativeness of habitat structures underline once more the needing of suitable and efficient protection management. To achieve that, however, an a priori identification of the trout populations as well as the elevation of the environmental situation of the fish habitat is absolutely necessary.

The variation in the genetic structure and the high adoptive degree of alpine brown trout population and the positive result of natural raised stocking fishes emphasise the support of a new and more effective stocking management, which improves the ecological value and decreases the economic effort at once (KLUPP 1991, UIBLEIN et al. 2000, SPARIC & WEISS 2008, WEISS et al. 2009). Due to the infrastructural and political possibilities, national parks and similar institutions are more than ever claimed in protection and preservation issues.

Conclusion

The acquired knowledge can be used to work out even more specific and efficient management strategies for the preservation and protection of native alpine river systems and their fish populations. This seems, as already mentioned, in times of the high pressure of utilisation especially on alpine rivers due to the waterpower industry and traditional fisheries exceedingly necessary.

The quality and quantity of the genetic loss and/or introgression in native brown trout populations by stocking or habitat loss as well as the preservation of habitat structures in alpine river systems will be of great importance, especially with regard to long-term management and conservation concepts. Moreover, alpine river systems can operate as prospective refugium for many aquatic organisms, whose ecological benefit improves constantly. All this should be grasped in the course of the implementation of the WRRL even more intensely and be discussed integrative in cooperation with the fishing beneficiaries and other interest representatives as well as governments and nature protecting organisations.

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Conference Volume | 5th Symposium for Research in Protected Areas
10 to 12 June 2013, Mittersill | pages 227 - 230

Frogs in the city: problems of research and conservation of amphibians in Lobau (Vienna, Donau-Auen National Park)

Günter Gollmann, Heimo Schedl, Daniel Philippi, Walter Reckendorfer, Andrea Waringer-Löschenkohl

Abstract

Lobau is part of the floodplain of the Danube River in Vienna. Due to river engineering, hydrodynamics are constrained and vary greatly among different sections. We synthesize results of recent surveys of amphibians, highlighting the challenges for research and conservation. Habitat availability and abundances may differ markedly between years. Population studies spanning several years are urgently needed. Reproduction of amphibians often is highest in temporary water bodies. Extreme dynamics may be disadvantageous, however, as quickly drying ephemeral pools become reproductive sinks and major floods may bring fish to formerly fish-free waters. Lobau is still home of viable populations of several endangered amphibian species. To secure or even improve their situation, habitat management should increase ground water levels and maintain or enhance water level dynamics. Restoration efforts aimed at increasing connectivity of water bodies must take great care to avoid deterioration of amphibian breeding habitats.

Keywords

population dynamics, distribution, habitat restoration, floodplain, wetland

Introduction

Riverine floodplains are highly dynamic habitats. For amphibian populations, recurrent changes in water levels are important factors determining habitat quality and availability.

Lobau is part of a floodplain of the Danube River in Vienna, and part of the Donau-Auen National Park. Due to river engineering, hydrodynamics are constrained and vary greatly among different sections. In connection with measures to improve flood protection, management options to improve the ecological conditions have recently been analysed; the goals of fostering hydromorphic dynamics and conserving existing macrophyte-rich habitats can hardly be achieved at the same time (Reckendorfer et al. 2012).

We synthesize results of recent studies that were carried out at different spatial and temporal scales, aiming to address the following questions:

Which challenges for research on amphibians are posed by the dynamics of the habitat?
Does this area achieve the aim of protecting biodiversity, judged by the status of amphibian populations?
How can habitat management secure or improve the situation of endangered amphibian species?

Figure 1: Records of *Triturus dobrogicus* (yellow dots), obtained in surveys on 62 days from 7 April to 25 September 2009 (© H. Schedl).

Methods

Standard methods applied in all studies included visual and auditory surveys and dipnetting. Because spawn and larvae of water frogs (*Pelophylax* spp.) cannot be determined to species, they were pooled. For mapping the distribution of *Triturus dobrogicus* in 2009 also bottle-traps and torch surveys were used. In mark-recapture studies, *Bombina bombina* were individually registered by photographing their ventral patterns.

Results

Distribution

Intensive surveys in 2009, a wet year, showed that *Triturus dobrogicus* occurred in 39 water bodies throughout Lobau, in 23 of which evidence for reproduction (eggs or larvae) was found (Fig. 1). In a few locations where this species was recorded in the 1990s no newts were observed; formerly stagnant pools had been converted into flowing channels inhabited by fish. During these surveys, *Rana arvalis* was observed in 11 water bodies, *Pelobates fuscus* in 18 locations; most of these sites (8 and 14, respectively) were also inhabited by *T. dobrogicus* (Schedl et al. 2009).

Seasonal abundance patterns

Seasonal abundance of amphibians varies greatly, especially in temporary water bodies. Whereas several species enter water mainly for breeding, and are terrestrial during most of their activity period, *Bombina bombina* are largely aquatic also as adults. In large temporary pools with strong variation in water level the number of observed toads fluctuated greatly throughout a season (Fig. 2). On 11 July 2008, when the water level had decreased rapidly, not a single individual was detected at the study site. Many toads returned later when it started to rain heavily. At very high water levels, capture probability decreased due to increased flight distance and mobility of the toads in free water bodies.

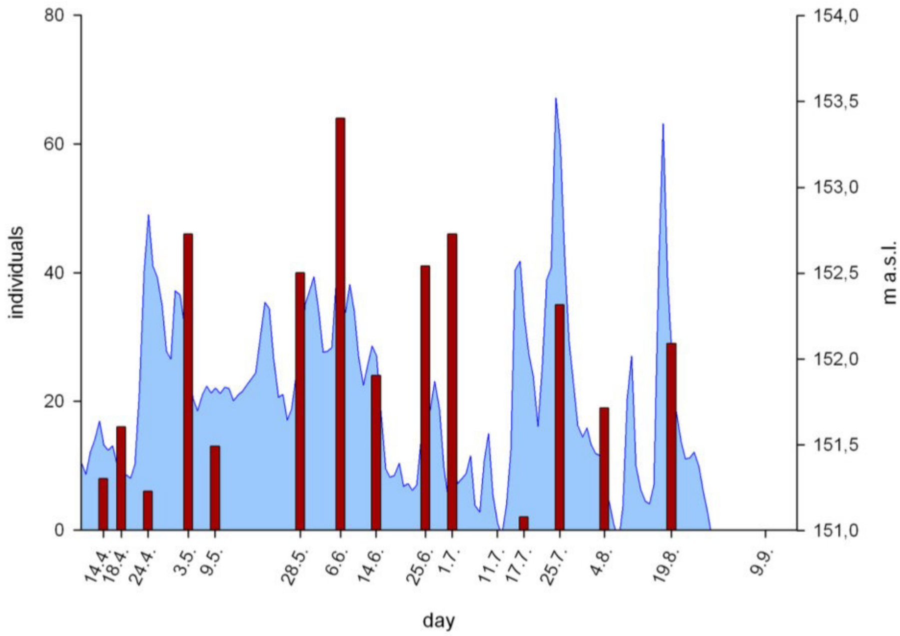

Figure 2: Captures of *Bombina bombina* (red bars: number of individuals, metamorphs not included) over the activity season in 2008 at a spawning site in Obere Lobau. Since this habitat is situated next to the river, the water level of the Danube (blue contour: meters above sea level) correlated strongly with the water levels of the spawning ponds (© D. Philippi).

Variation among years

The number of species that were recorded with comparable methods and sampling effort varied greatly among study years (Fig. 3). Note that the presence of eggs and/or larvae ("reproduction" in Fig. 3) does not always mean successful breeding. Spawning sites may dry before the larvae complete metamorphosis, floods may bring fish to formerly fish-free water bodies where they deplete amphibian larvae (detailed observations in Schedl et al. 2009). For several species, reproductive success was high in temporary pools that had been dry in earlier years.

Population dynamics

At a study site in Obere Lobau, 181 individuals of *Bombina bombina* were captured on 2 May 1997. At the same site, 13 individuals were encountered on 11 April and again on 21 May 2007, with two individuals present in both samples, resulting in an estimated population size of 64 (using Chapman's modification of the Petersen estimate).

At another site, only five males were heard calling in 2007 (and none captured), but in 2008, a year with a higher water table, population size was estimated as above 500, based on mark-recapture analysis of 392 individually registered toads. Beside these recapture studies on *Bombina*, the only quantitative data on populations available are spawn counts of *Rana dalmatina*.

Discussion

Habitat dynamics, especially the low predictability of water level changes in the floodplain, poses challenges for research on amphibians. Variation in habitat availability causes changes in abundance, and thus detectability of species, within (Fig. 2) as well as between years (Fig. 3). Therefore, studies must span several years to provide reliable information on distribution, habitat use and population structure. For most species, almost nothing is known about the patterns and extent of their movements in the floodplain (i.e. migrations and dispersal).

The Danube crested newt, *Triturus dobrogicus,* is a species with high conservation priority. It is included in Annex II of the Habitats Directive and listed as endangered (EN) in the Red List of Austria (GOLLMANN 2007). Our data show that it is still widespread in Lobau, but they do not suffice for estimates of population size. The large overlaps of its distribution with that of rarer species, *Pelobates fuscus* and *Rana arvalis*, suggest that *T. dobrogicus* can be regarded as an umbrella species in conservation of the amphibian community in the floodplain. Further investigations on population dynamics of this species are needed to allow assessment of its conservation status.

The fire-bellied toad, *Bombina bombina*, is also listed in Annex II of the Habitats Directive. Abundance and breeding activity are strongly influenced by water level dynamics (Fig. 2). The decline (from 1997 to 2007) observed at our first study site may have both general and local causes: Severe flooding in late summer of 2002 and the drought of 2003 probably affected many amphibian populations in Lobau. Observations of breeding success at several sites, and the widespread occurrence of subadults and adults in 2009, demonstrate that population recovery was possible. Locally, *B. bombina* and other amphibians may be impaired by the introduction of fish to a permanent water body during the flooding in 2002.

In order to increase water levels and intensify surface water exchange in Lobau, a water enhancement scheme was initiated in 2001, leading to higher water levels and reduced temporal variability in the backwater system (WEIGELHOFER et al. 2011). Whereas increased water levels are certainly beneficial for amphibians, higher connectivity of water bodies may be harmful for most species, because fish enter their breeding habitats. The high reproductive success observed in temporary water bodies suggests that habitat management allowing strong water level fluctuations may often be favourable for amphibian populations.

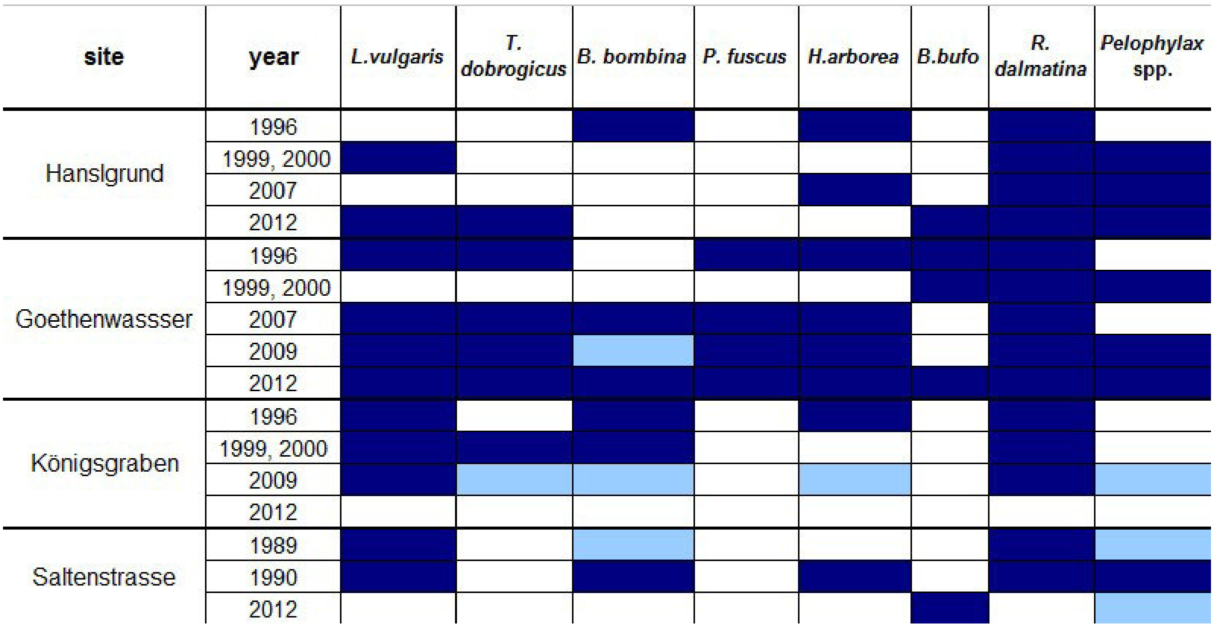

Figure 3: Variation of species composition at four study sites, based on at least two surveys per year (in April and June). Dark blue: reproduction, light blue: only adults found, white: no record. In 2012 the "Königsgraben" was dry (Waringer-Löschenkohl 2013). Data from the years 1996 and 1999/2000 were collected by C. Baumgartner (unpubl.). (© A. Waringer-Löschenkohl).

Conclusions

Population studies spanning several years are urgently needed to allow a profound assessment of the status of the endangered amphibian species in Lobau. In the absence of population data, the wide distributions of most species suggest that viable populations are still present. Nevertheless, long-term trends towards terrestrialization will ultimately lead to a decline in these habitats. Therefore, restoration measures sustaining overall habitat dynamics and diversity are needed but must take great care to avoid deterioration of amphibian breeding sites.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 231 - 236

Research of Lepidoptera fauna as one of the basis for the biodiversity management in the Kozjanski Park

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Abstract

In the Kozjanski Park, a total of 1027 Lepidoptera species, including 25 protected species, 38 red list species and 7 Natura 2000 species have been recorded since 2003. As these were more or less just occasional observations we estimate that the Lepidoptera fauna is presented here with more than 1.500 Species. Already this number indicates the importance of Kozjanski Park for the protection of rare and protected species, although their scope is relatively small protected area of 260 km^2, but very important and rich on the biodiversity. The area is a kind of refugee for many rare and endangered species of plants and animals. Park is also a part of Unesco Biosphere Areas (Kozjansko and Obsotelje). As many butterflies and moths species are strictly seasonal and prefer only a particular set of habitats, they are good indicators in terms of anthropogenic disturbance and habitat quality. They are also represented with many ecologically specialized species, which are highly sensitive even on the smallest ecological changes in habitats. As the Lepidoptera fauna can represent the past and current status of the preservation and use of the habitats, we used this knowledge, in combination of species ecology, food plants and the life cycle in combination of represented species and also other groups, to prepare the most suitable management plan for long term preservation of biodiversity in the Kozjanski Park. The management plans will cover the most important types of habitats represented in the area of Kozjanski Park and its surroundings.

Keywords

Lepidoptera, Fauna, Slovenia, Kozjanski Park, Biodiversity, Protected areas, Research, Protected species.

Introduction

Kozjanski Park is the largest regional park in Slovenia, situated in the south east of Slovenia, north of Zagreb. The largest, and with Kozjaski Park the oldest one in Slovenia, is Triglav National Park, which covers Julian Alps with the highest peaks, where nature is in this sense more or less protected from direct human impact. Kozjanski Park covers an area of 206 sq. km, with an extensive area of typical ecosystems and landscape where a large part of the original nature has been preserved (Kozjanski Park 2013). The human influence in the area is still traditional extensive agriculture, mostly dry meadows, partly pastures and old traditional meadow orchards on the hills and slopes, with the leaf forests on the edges. This traditional maintained grassland vegetation is very rich, with many interesting floristic elements. Interesting are also climate elements, which influence the area. Three different climate characters are connected in the area: Alpine, Pannonian and partly Sub Mediterranean, which additionally enrich the biodiversity of the small area.

According to the national zoogeographical regionalization the area belongs to two big zoogeographical regions: subalpine and subpannonian zone. The area is characterized by the hilly, wooded, grassy, agricultural area with a relatively small settlement. The highest peak is Oslica in the north, with 860 m and the lowest Figarjev Bridge at Sotla River with 151 m a.s.l in the south. The percentage of forests is 48 %. The average annual rainfall is 1060 mm, and the average annual temperature is 9.5^{o} C (Kozjanski Park 2013).

According to Barborič & Zmrzlikar (2010) the land use hasn't changed significantly from the 18th century till now. There were some fluctuations in land use according to the different periods where it was more forest or meadows, depending on different importance of livestock or agriculture and the last two world wars. In general the area of grassland and the vineyards has increased all the time. The area of forests has decreased, except the last two decades, when the livestock is again in the crisis. The area of orchards increases or decreases in different time periods. These facts show that the nature was maintained more or less in the same way during the last 3 centuries.

Since the Lepidoptera are very good adapted and specialized group of insects on different habitats and plants, we can use them as bioindicators from different perspectives. On the composition of Lepidoptera fauna, we can reconstruct the composition of plant species from the area, the habitat types, the climate conditions and the preservation of the area on the long term scale.

The aim of our study was the overview of Lepidoptera biodiversity in Kozjanski Park as such and to estimate the qualitative diversity on different localities and habitat types, to identify the best-preserved sites inside the park according to present fauna. On this sites the long term preservation management, suitable for vegetation and fauna should be applied. This means the same extensive use of meadows and forest glades, with one mowing yearly, without heavy machinery and rotation machines. Parts of clearings, forest edges and old forest stand should also apply more restrictive protection measures, especially parts in Natura 2000 areas. Habitats with the highest biodiversity are particularly important in terms of preserving this treasure with the long-term sustainable management of the area, which cannot remain without human management. Since the whole area, from an economic point of view cannot be strictly protected, we want to identify the best-preserved areas of the park, based on flora and Lepidoptera fauna in which more strict and sustainable management should be implemented. In other parts of meadows and extensive old orchards sustainable land use should be applied, supported by agricultural subsidies. Such areas, with preserved nature will be interesting for nature lovers and tourists, from which the locals may have an additional source of income to keep the locals in the area and preserved nature on the long term.

Methods

Day and night time observation of Lepidoptera fauna were carried out form 2003 till 2012. The observations lasted from early spring until late autumn at different intensity, depending on resources and time. The research cost was partly financed by Kozjanski Park, the other part were voluntary observations.

For the monitoring we selected representative habitat types from the area, in which we applied the same kind of monitoring: transect method for the day time observations and the UV light collecting. Nocturnal fauna usually represents 90 % of Lepidoptera fauna living in the area, so our monitoring was mainly focused on the night active Lepidoptera species. For the nocturnal active moths we used specially designed UV light tents with the halogen super actinic UV TLD light source inside the pyramidal shape tents and sugar baits in spring and the autumn. As species came to the light tents, we identified them and estimated the specimens number of each species. The majority of all species were identified in the field. Species, which could not be identified on the spot, were collected in few specimens for later identification and setting for the collection. The number of the day flying species and their abundance we estimated with the transect method. Some species were also focused searched according to their special behavior or living niches (Psychidae, Gracillariidae, Tineidae, Coleophoridae and others). Species were identified based on long-term experience, comparative collection, different literature and partly with barcoding and other setting techniques. Literature data were also considered if they were available (MAČEK 1999).

Field and literature data were entered in the specially designed database for estimation of faunistical and other ecological data. We used the database to monitor the species composition for different habitats, abundance of the groups and each species, population dynamics of each species, host plans of the fauna and each species and the special ecological needs of each species. The data evaluation was prepared by the same database and application called Popis (GOMBOC & SELIŠKAR 2009).

Systematics, species names and statistics in the article follow FAUNA EUROPAEA (2006).

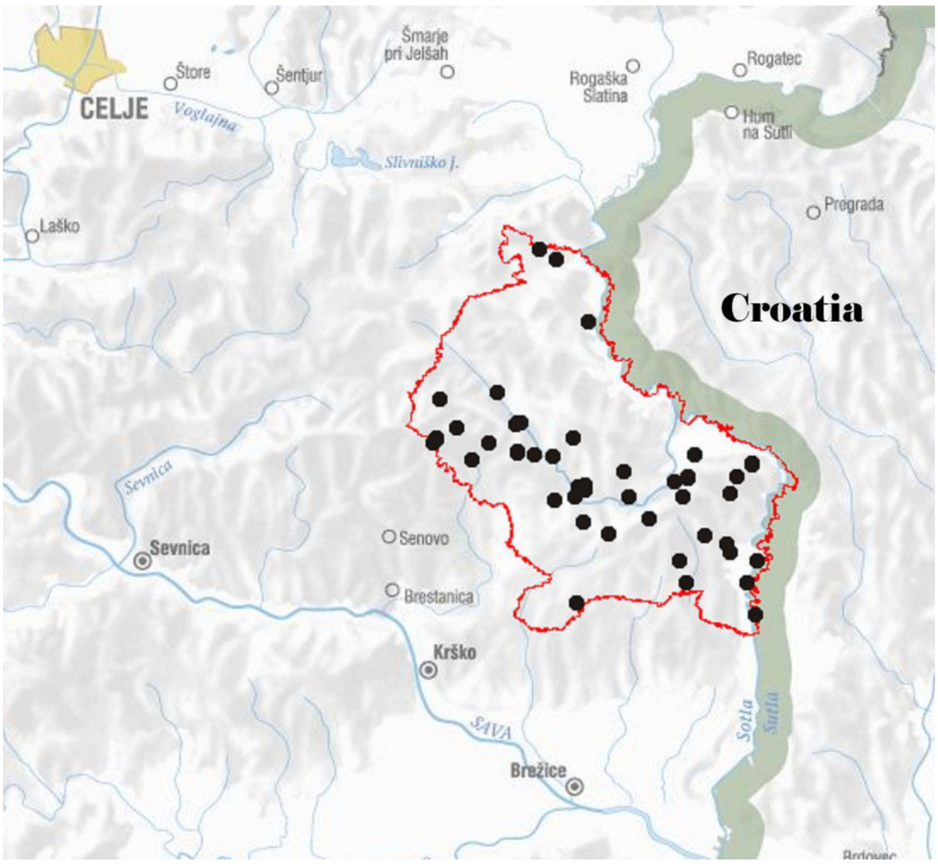

Figure 1: The area of Kozjanski Park, with Lepidoptera monitoring localities.

Results

The Lepidoptera fauna of Kozjanski Park is very rich on species and diverse according to different habitats. Already in the first year of monitoring 542 Lepidoptera species were recorded in 7 observation days (19.6.-28.6.2003). The maximum species numbers during night observation were recorded on 16th of August 2011 – 214 species (Podsreda, W slope, forest clearing, succession) and on 23th of June 2003 – 186 species (Bistri Graben, valley of the stream), 24th of June 2003 – 185 species (Vetrnik, dry meadows), 17th of August 2012 – 177 species (Gradišče, sand pit). These numbers show that the fauna is very reach in different habitat types and during the whole summer season.

All together 1027 Lepidoptera species were observed and identified in Kozjanski Park until the end of 2012. Smaller part of the material has not been estimated yet. This is 29 % of all known Slovenian Lepidoptera fauna, with 3600 known species (Carnelutti 1992a, 1992b, Gomboc & Lasan 2006, Lesar & Govedič 2010). 85 species belong to butterflies and 942 to moths. All together 149 field observations were carried out, where all together 5129 field records were collected of 28874 specimens observed in the field. Figure 1 shows the localities where field observations were carried out.

The family with the highest species number was Noctuidae, with 226 species. Follows Geometridae, with 214 species, Tortricidae 114, Crambidae 66, Nymphalidae 46, Pyralidae 40, Gelechiidae 32. More detailed proportions are shown on figure 2.

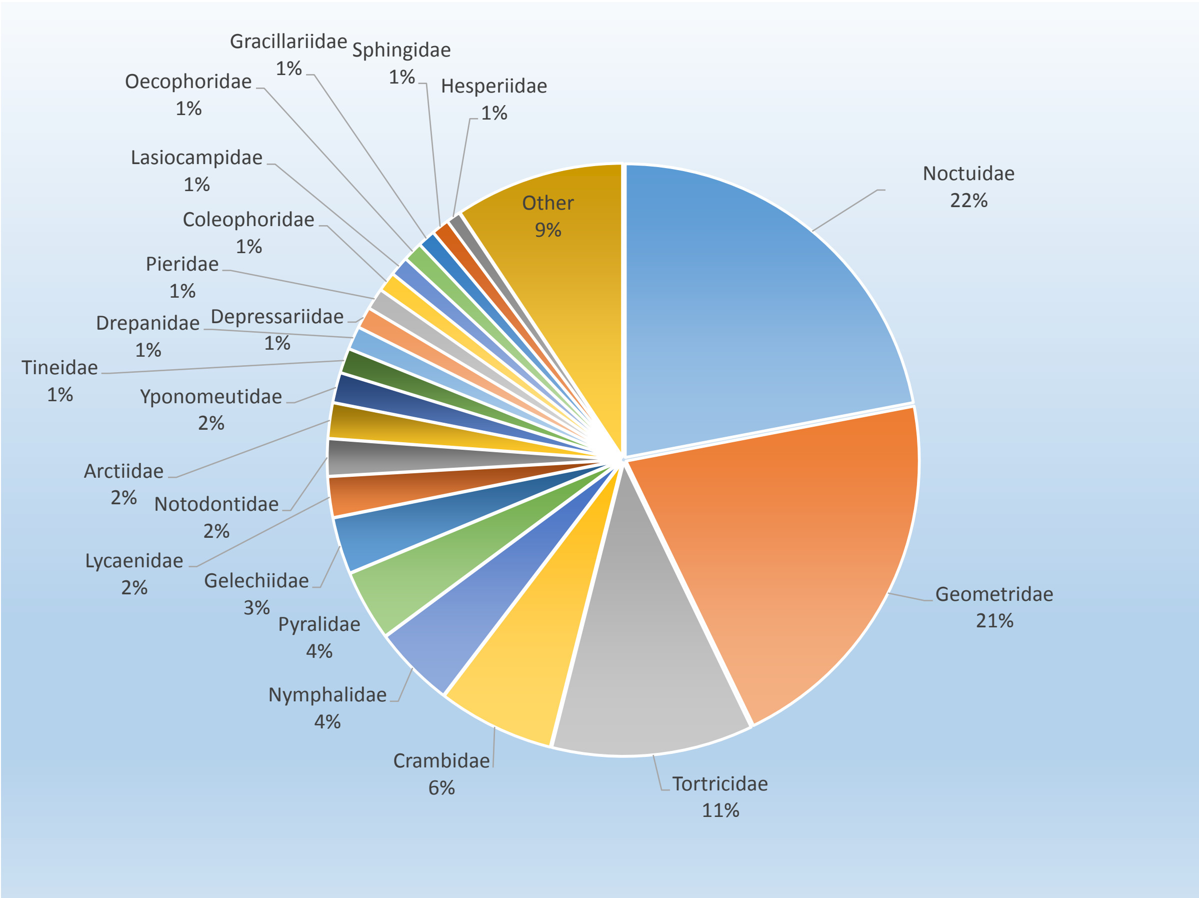

Figure 2: The proportion of Lepidoptera species shown by families.

The area of Kozjanski Park is also important for protection of protected and endangered species. Since 2012 7 of 13 in Slovenia present (Čelik et. al. 2005) Natura 2000 Lepidoptera species have been confirmed in the area. Most of these species are well preserved in the area and builds strong populations, as *Euplagia quadripunctaria* and *Euphydryas aurinia*. 25 protected species of 196 present in Slovenia (Uradni list RS 2004) have been found in the area, mostly dry grassland and wetland species. Also 38 of 219 (Uradni list RS 2002) endangered red list species have been confirmed till now.

Very interesting were some findings of rare and unexpected species even in higher numbers, like *Atethmia ambusta* (Denis & Schiffermüller, 1775), *Euchalcia modestoides* Poole, 1989, *Dichagyris nigrescens* (Hofner, 1888), *Dichagyris signifera* (Denis & Schiffermüller, 1775), *Agapeta largana* (Rebel, 1906), *Fulvoclysia nerminae* Koçak, 1982, *Scardia boletella* (Fabricius, 1794), *Eilema lutarella* (Linnaeus, 1758), *Eupithecia alliaria* Staudinger, 1870, *Eupithecia gueneata* Millière, 1862, *Macaria artesiaria* (Denis & Schiffermüller, 1775) and many others even Mediterranean species. Some alpine-coline species have been found on the lowest altitudes in Slovenia, as for example *Euchalcia variabilis* (Piller & Mitterpacher, 1783) and *Hepialus humuli* (Linnaeus, 1758) at 160 m a.s.l. at the Bistrica and Sotla river.

Table 1: List of protected Lepidoptera species found in Kozjanski Park (in bold are Natura 2000 species)

Species	Family
Atethmia ambusta (Denis & Schiffermüller, 1775)	Noctuidae
Atethmia centrago (Haworth, 1809)	Noctuidae
Cataclysta lemnata (Linnaeus, 1758)	Crambidae
Dichagyris signifera (Denis & Schiffermüller, 1775)	Noctuidae
Eilema pseudocomplana (Daniel, 1939)	Arctiidae
***Eriogaster catax* (Linnaeus, 1758)**	Lasiocampidae
Eucarta amethystina (Hübner, 1803)	Noctuidae
***Euphydryas aurinia* (Rottemburg, 1775)**	Nymphalidae
***Euphydryas maturna* (Linnaeus, 1758)**	Nymphalidae
***Euplagia quadripunctaria* (Poda, 1761**)	Arctiidae
Eurhodope rosella (Scopoli, 1763)	Pyralidae
Hemaris tityus (Linnaeus, 1758)	Sphingidae
***Leptidea morsei* (Fenton, 1882)**	Pieridae
Limnaecia phragmitella Stainton, 1851	Cosmopterigidae
Luperina testacea (Denis & Schiffermüller, 1775)	Noctuidae
***Lycaena dispar* (Haworth, 1802)**	Lycaenidae
Metachrostis dardouini (Boisduval, 1840)	Noctuidae
Metachrostis velox (Hübner, 1813)	Noctuidae
Parnassius mnemosyne (Linnaeus, 1758)	Papilionidae
Perizoma lugdunaria (Herrich-Schäffer, 1855)	Geometridae
***Phengaris alcon* (Denis & Schiffermüller 1775)** = Maculinea rebeli (Hirschke, 1904))	Lycaenidae
Scopula subpunctaria (Herrich-Schäffer, 1847)	Geometridae
Xanthocrambus lucellus (Herrich-Schäffer, 1848)	Crambidae
Zerynthia polyxena (Denis & Schiffermüller, 1775)	Papilionidae
Zygaena ephialtes (Linnaeus, 1767)	Zygaenidae

As the area is open to the corridor of migrant species, not far from the Sava River, many migratory species can be found in the area. Migrant species were especially common during the long heat season 2012 that lasted from end of June until September. Migrants which were recorded in the area are *Helicoverpa* armigera (Hübner, 1808), *Heliothis peltigera* (Denis & Schiffermüller, 1775), *Nomophila noctuella* (Denis & Schiffermüller, 1775), *Rhodometra sacraria* (Linnaeus, 1767), *Spodoptera exigua* (Hübner, 1808), *Trichoplusia ni* (Hübner, 1803), and *Euchromius ocellea* (Haworth, 1811), which was for the first time observed in Slovenia (Gomboc & Klenovsek, 2013). In addition, non-native alien species were observed in the area, mainly Gracillariidae.

According to the results the most important sites for Lepidoptera fauna in Kozjanski Park are dry meadows on Oslica and Vetrnik Plato, south dry slopes of Kozje Peč near Orešje and Svete Gore, western slope of Stare Svete Gore near Podsreda, and some succession habitats as sand pit near Gradišče, forest clearing near Podsreda and even some extensive used agricultural habitats as extensive orchards and vineyards, where also almost 200 species can be recorded during one night observation.

Discussion and conclusion

Monitoring results of Lepidoptera fauna in Kozjanski Park were surprising in the number of species found in the area and species richness of different habitats even in not very intensive monitoring and rather few field datasets. As shown in figure 2 the proportion of some families is rather low according to the expectations, like Tortricidae, Gelechiidae and others, therefore much more species are expected in the area of Kozjanski Park. We estimate that at least 1500 Lepidoptera species are present in the area of Kozjanski Park. We can confirm this also with the field observations as each observation brings additional species to the known fauna. We expect further findings of protected and red list species, especially with more focused monitoring of these species. Until now, these records have been only occasional findings during the random monitoring.

As shown in numbers the area of Kozjanski Park is very rich in Lepidoptera diversity even in agricultural areas like orchards and vineyards if they are extensively used. The area is already a part of the Unesco Biosphere areas (Kozjansko and Obsotelje). According to our long-term experience of Lepidoptera monitoring in whole Slovenia, our opinion is, that this is one of the richest areas in Lepidoptera fauna, like some other hot spot areas on south slopes of Trnovski Forest, Nanos, Slavnik and Julian Alps.

Monitoring results show that fauna here is still well preserved and can remain preserved on the long term if extensive sustainable use of land will continue. The problem is that the agriculture in the area gets intensified on one hand or land is left to nature when old people die without successors. The problems are intensive pastures of cattle and wild deer, which in short grazed vegetation and causes terracing of steep terrain, thus accelerating soil erosion. Also use of heavy machinery for hay harvesting became more critical in the last years. All these problems are consequences of bad economic situation in today agriculture in Slovenia, where small farms cannot survive on long term. This should be taken in to the account that the management of the park area should be a compromise of economic survival of resident population and long term preservation of biodiversity. There are a few possibilities how this can be achieved even with low cost if there will be a compromise on site of agricultural subsidies for protected areas, Park management staff on management plan and promotion of the area and touristic possibilities of the area in sense of complementary business on farms and other local tourist facilities. This strategy has already been partly implemented, so tourists are already discovering the charms of Kozjanski Park and this trend seems to increase significantly in the near future. The park should be ready also for these new trends to help local residents to benefit also from this point of view.

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Conference Volume | 5th Symposium for Research in Protected Areas, 10 to 12 June 2013, Mittersill | pages 237 - 242

Sediment storage quantification and postglacial evolution of an inner-alpine sedimentary basin (Gradenmoos basin, Schober Mountains, National Park Hohe Tauern, Austria)

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Abstract

This study investigates the postglacial evolution of the Gradenmoos basin, a glacially overdeepened, semi-closed sedimentary basin in the central Gradenbach catchment (32 km², 1920-3283 m, Schober Mountains, National Park Hohe Tauern, Austria). The infill architecture and postglacial evolution of the basin as well as sediment storage volumes and associated rates of rockwall retreat (RR) are reconstructed using a multi-method approach, comprising field surveying (terrestrial laserscanning, geophysical prospection, core drilling), lab analyses (stratigraphic and palynologic analyses, sampling and radiocarbon dating), as well as GIS and 3D modelling. Surface, subsurface and temporal data indicate a complete and undisturbed sedimentary record archived in the basin since Younger Dryas deglaciation approx. 11 ka BP. After glacier retreat a former lake in the basin could be proved lasting for *ca.* 7500 years. We observed a heterogeneous spatio-temporal infill pattern of the lake followed by moor formation after lake disappearance since 3.5-2.5 ka BP. Total sediment storage within and surrounding the basin amounts to almost 20 x 10^6 m³. Volumetric and temporal data, however, resulted in comparatively low rates of postglacial RR (up to 520 mm/ka) despite of steep slope gradients and coarse and blocky weathering conditions in the associated rockwall source areas.

Keywords

Late and Postglacial, Holocene, Gradenmoos Basin, Lake Infilling, Sediment Storage, Rockwall Retreat

Introduction

Postglacial denudation (D) and rockwall retreat (RR) in alpine environments is often investigated using the sediment budget approach that relates sediment deposition in landforms and sinks to contributing source areas and a time-span of erosion. In this regard, the age, scale, and closeness of an investigated denudation-accumulation-system (HINDERER 2012) controls the observable time period, accuracy, and reliability of the results to be expected. However, the large range of published values of alpine D and RR might be based on variable spatial scales investigated, variable environmental and topographic conditions, and different ways of sediment storage quantification. Quantification approaches range from simple visual estimation to geometrical modelling, drilling, coring, and detailed geophysical surveying (e.g., COSSART & FORT 2008; CURRY & MORRIS 2004; HOFFMANN & SCHROTT 2002; KUHLEMANN et al. 2001; OTTO et al. 2009; TUNNICLIFFE & CHURCH 2011). The analysis of large-scale systems, such as perialpine lakes or large valley fills (e.g., HINDERER 2001; MÜLLER 1999), yields averaged rates of postglacial D since variable rates through time and the degree to which specific source areas contribute to D remain unknown. Few small-scale studies focused on intermediary sediment storage using geophysical techniques and GIS modelling (HOFFMANN & SCHROTT 2002; OTTO et al. 2009; SCHROTT et al. 2003). Remaining uncertainties comprise (1) the quantity of evacuated sediments since deglaciation, (2) initial amounts of glacigenic till deposits underneath present-day sediment storage landforms, and (3) the absolute timing of deglaciation. Detailed small-scale sediment budget studies within (almost) closed systems might close these gaps and improve our understanding of postglacial landscape evolution in alpine environments. Pleistocene glaciations and lateglacial oscillations frequently created overdeepened basins effectively trapping sediments until present. These basins facilitate such studies as they interrupt catchment connectivity and often archive a complete postglacial stratigraphic record. In view of that, we investigate the glacially overdeepened Gradenmoos basin (subcatchment size: 4.1 km²; basin floor elevation: 1920 m, Schober Range) in order to reconstruct the infill history of the basin and to quantify RR within the steep surrounding cirques using a multi-method approach (field surveying, lab analyses, GIS and 3D modelling). More details on this study are given in GÖTZ (2012) and GÖTZ et al. (2013, accepted).

Study Area

The Gradenbach catchment (32 km²) drains the central part of the eastern Schober Mountain Range to the east into the river Möll and belongs to the National Park Hohe Tauern (NPHT) (Fig. 1, map 1-3). The area is climatically well shielded due to its inner-alpine location with relatively continental climatic conditions, at least within valley bottom locations (climate station Döllach: precipitation: 826 mm/a, temperature: 6.1 °C, http://www.zamg.ac.at). South of the Penninic Tauern window formations and the Matrei Zone, the Palaeozoic 'Schober Range lithology' (mainly mica-schist, amphibolite) is characterised by intense, coarse and blocky weathering. The Schober Mountain Range, and particularly the Gradenbach catchment, shows a strong glacial signature with several cirques, hanging valleys, and a stepped longitudinal profile due to tectonics, glacial overdeepening effects, and rockfall damming. In the context of a cascading system (OTTO et al., 2009; SCHROTT et al., 2003), the catchment is structured into five subsystems (I-V) largely decoupled from each other (Fig. 1, map 3). The glacially overdeepened Gradenmoos basin corresponds to subsystem III, is the most pronounced sink in the catchment, and is sharply delineated up- and downstream the Gradenbach creek (length NE-SW: 1 km, width SE-NW: 100-250 m, subcatchment size 4.5 km²). Sediment storage landforms in subsystem III can be differentiated in primary (e.g., talus sheets; created beneath rockwalls by weathering and rockfall), secondary (e.g., debris cones; created by degradation of primary deposits located above) and tertiary deposits (e.g., floodplain; created by fluvial reworking of secondary deposits). The basin facilitates the study as (1) it effectively trapped sediments after deglaciation (output might be restricted to dissolved and small amounts of suspended load), (2) sediment storage can be accurately assessed due to spatial scale, (3) single landforms can be assigned to clearly delimitable rockwall source areas (four cirques, C1-C4, Fig. 1, map 3 and 4), and as (4) it is not affected by human impact until present (protected area, NPHT).

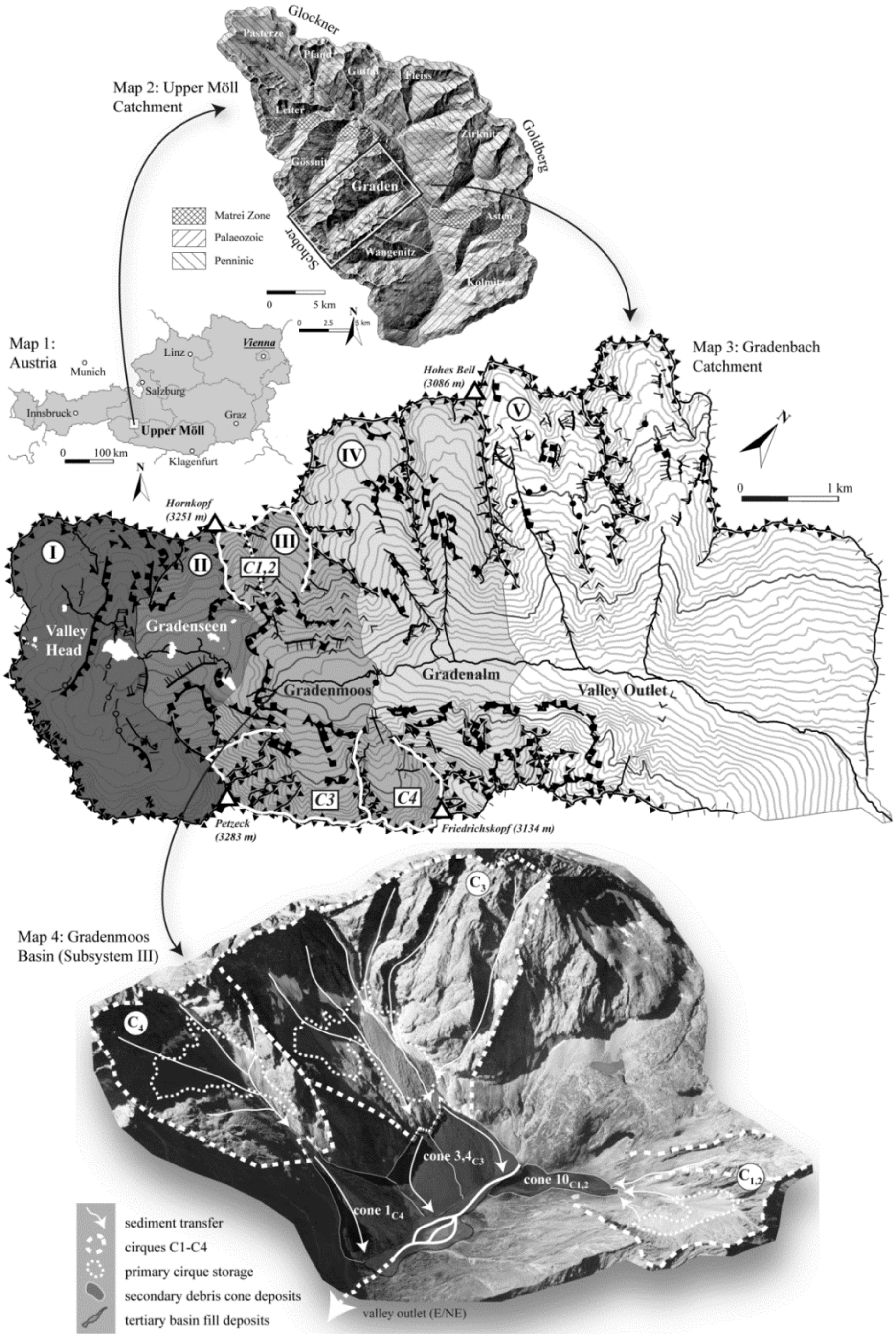


Figure 1: The Gradenmoos basin (4.5 km²; map 4) in the Gradenbach catchment (32 km²; map 3) as a part of the upper Möll catchment (423 km²; map 2) within Austria (map 1). Map 2 additionally shows major geologic units. Map 3 illustrates five subsystems (I-V) and four cirques (C1-C4) within subsystem III. Map 4 indicates source areas (cirques C_1-C_4), areas of primary talus storage within the cirques, secondary debris cones (1, 3, 4, 10), and tertiary basin fill deposits in the Gradenmoos basin (subsystem III).

Methods

Methods are just briefly described here; more details can be found in GÖTZ (2012) and GÖTZ et al. (2013, accepted). First, we mapped the catchment with a focus on sediment storage distribution and landform coupling. Some steep cirques and hanging valleys were mapped remotely using orthophotos, LIDAR data and derivatives (shaded relief and slope grids). Debris cones, talus sheets and cones, glaciers and rock glaciers, moraines, alluvial fans and plains, complex valley fill deposits, in-situ weathered regolith, as well as lakes and peat-bogs have been differentiated. Remaining areas refer to bedrock. We supplemented this dataset by qualitative (e.g., vegetation coverage, rounding, sorting) and quantitative (e.g., slope, area) attribute data resulting in a digital landform inventory, which enables to quickly visualise various geomorphological information.

We additionally assessed the present-day basin topography using terrestrial laserscanning (TLS). Six spatially distributed scan positions covering the entire basin resulted in a point cloud of *ca.* 60 x 10^6 points. During data processing (e.g., registration, 2.5D filtering, elimination of vegetation), the point cloud was homogenised to 4 points/m^2 and reduced to *ca.* 14.5 x 10^6 points.

Subsurface information is based on core drilling and geophysical prospection comprising electrical resistivity tomography (ERT), ground-penetrating radar (GPR), and refraction seismic (RS). Thickness of water-saturated alluvial deposits in the central and distal basin was assessed in greatest detail by ERT (13 survey lines 3.2 km total survey length) and a number of core drillings reaching bedrock several times. To detect bedrock depth beneath surrounding hillslope deposits, six additional GPR and RS surveys have been carried out (115-420 m length). Survey locations are shown in Fig. 2.

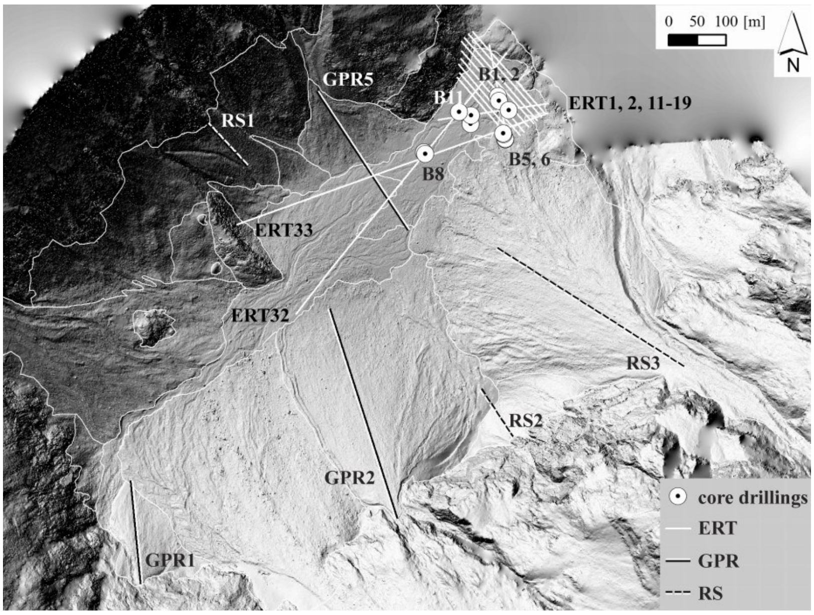


Figure 2: Locations of core drillings, resistivity (ERT), ground-penetrating radar (GPR), and refraction seismic (RS) surveys in the Gradenmoos basin based on hillshaded TLS data (spatial resolution: 50 cm).

Based on mentioned bedrock data derived from TLS, drillings, ERT, GPR, and RS, we interpolated bedrock surfaces in a GIS using different spline algorithms. Single 3D landform volumes were modelled afterwards by means of surface and bedrock meshes.

Temporal information was obtained through stratigraphic analyses and radiocarbon dating of 21 samples taken from the sediment cores (AMS ^{14}C-dating, carried out at CEDAD laboratories, University of Salento, Italy). Presented dates correspond to average values within the 2□ probability range. The core B2 was additionally analysed palynologically with a spacing of 20 cm.

To obtain postglacial sediment storage, landform volumes were reduced by an assumed layer of pre-Holocene basal till covering the entire basin with a mean thickness of 1.85 m as derived from the drillings.

Postglacial RR is based on the equation

$RR = SV * \rho s / (\rho b * A * T)$

where *SV* is the landform volume, *A* is the source area (cirques C1-C4, Fig. 1, map 3 and 4), and *T* is the time since deglaciation. RR is further based on a bedrock density *(ρb)* of 2.8 g/cm^3 and a porosity of sediment *(ρs)* of 2 g/cm^3 according to literature values.

Results and Discussion

ERT models show a sharp increase in resistivity representing the bedrock interface. Sediment thickness successively increases towards the central basin from 5-10 m (ERT11) to 15 m (ERT19). Bedrock edge in the central basin is provided by ERT32 and ERT33. ERT 32 shows an increase to 23 m at metre 130 (verified by B11) before dropping to a maximum depth of 55-60 m. Bedrock depths derived from core drillings (B1, B2, B11) agree with this data and determine the local bedrock resistivity to 2 k□m. Fig. 3 illustrates selected tomographies and core drillings in a 3D scene. GPR and RS data indicate sediment thicknesses of 30-35 m beneath debris cones 3 and 6 and up to 65 m beneath cone 1 (Fig. 1). Smaller talus sheets surrounding the basin reach 10-15 m.

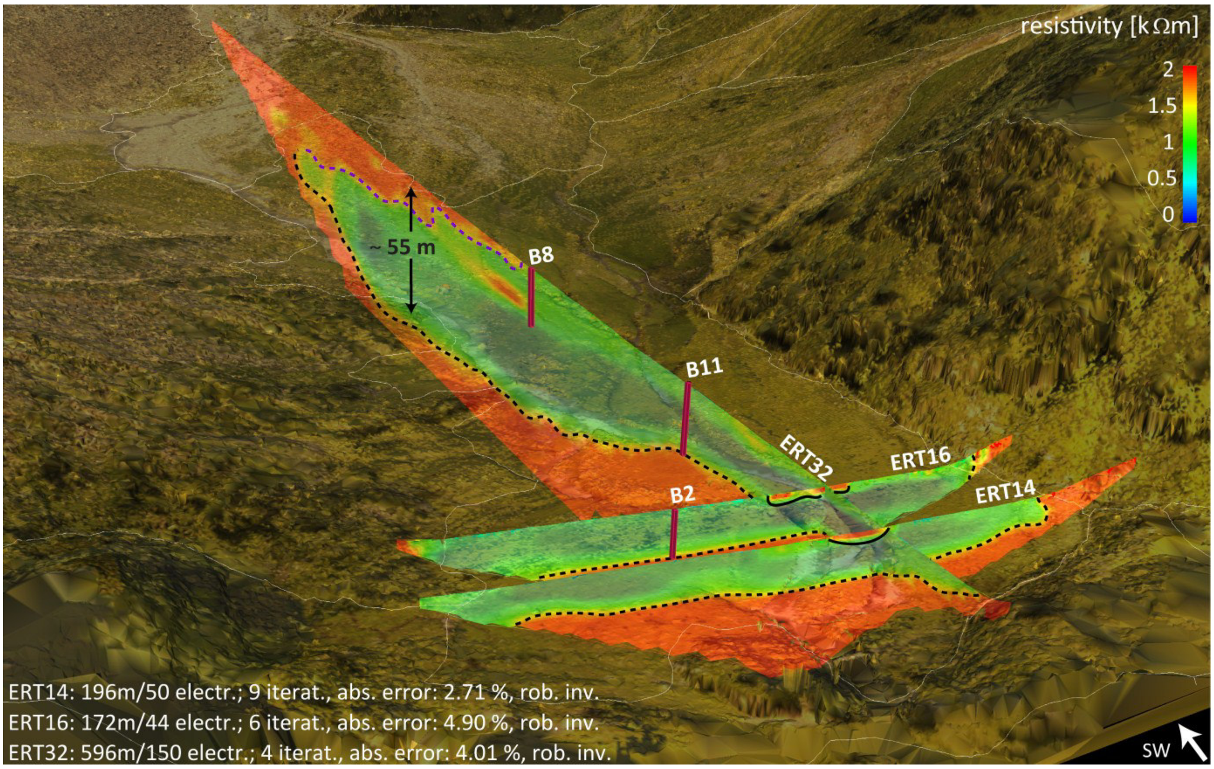
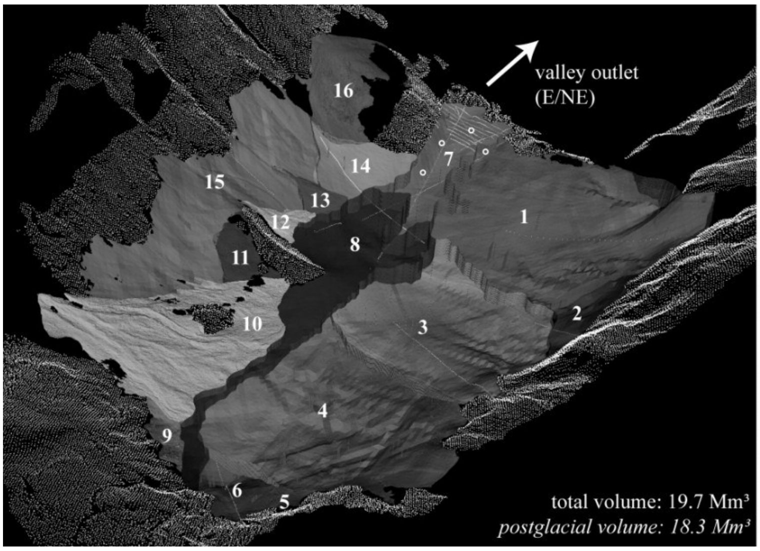


Figure 3: Selected ERT models and core drillings intersecting a TLS-based surface mesh with true colour information. Dashed lines represent bedrock edge (black) and coarse-grained deposits overlying the fine-grained basin fill (purple). Solid black lines delimit channel deposits showing higher resistivities. Drillings are indicated red. Survey/inversion parameters and measures of model fit are given lower left (data inversion: Res2DInv). For scale see Fig. 2.

Three core drillings reached bedrock (B1: 12.3 m; B2: 12.6 m; B11: 23 m) and provide a stratigraphy covering the entire Holocene. Above bedrock edge, a layer of basal till (average thickness: 1.85 m) is characterised by brownish colour, isolated pebbles in a fine matrix, and the absence of organic matter and pollen. Large sections between basal till and the lowest layers of peat near the surface show mainly clayey-silty, partly laminated deposits fading upwards to slightly coarser grain sizes. Subsequently, numerous layers of peat appear in the uppermost sections of the sediment cores above 1.75 m (B1, B2), 3.21 m (B11), and 4.27 m (B8)

Derived from these subsurface data as well as GIS and 3D modelling, total sediment storage within and surrounding the basin amounts to 19.7 x 10^6 m^3 whereas the postglacial volume is reduced by 8 % to 18.3 x 10^6 m^3. Around 70 % of sediments are stored in three debris cones (Fig. 4, Nr. 1, 3, 4) and another 15 % correspond to the central alluvial basin fill (Fig. 4, Nr. 7, 8).



land-form [nr]	total volume [10^6 m^3]	postgl. volume [10^6 m^3]	mean thickness [m]
1	6.26	5.97	40.28
2	0.26	0.24	19.08
3	3.90	3.71	37.11
4	3.67	3.46	32.19
5	0.01	0.01	4.19
6	0.32	0.29	22.52
7	1.21	1.15	32.79
8	1.91	1.80	31.28
9	0.03	0.02	5.90
10	0.50	0.35	6.22
11	0.03	0.01	3.46
12	0.04	0.03	6.85
13	0.13	0.12	23.20
14	0.60	0.56	29.43
15	0.63	0.47	7.45
16	0.17	0.08	3.59

Figure 4: Volumes and thickness of 3D landforms (Nr. 1-16). For scale see Fig. 2.

Rockwall retreat is derived from these volumes. A most realistic scenario (incl. approximates of intermediary cirque sediment storage and shares of tertiary basin fill deposits, Fig. 1, map 4) provides RR rates of 160 mm/ka (C1/2), 360 mm/ka (C3), and 520 mm/ka (C4), if true 3D rockwall source areas are taken into account. Planimetric 2D rockwall source areas in contrast result in significantly larger rates of 260 mm/ka (C1/2), 610 mm/ka (C3), and 930 mm/ka (C4).

We reconstructed the infill of the basin using complementary surface, subsurface, and temporal information. As sediment thickness is strongly variable, sedimentation rates show a large range as well (0.6-7.3 mm/a) but a general decline towards the distal basin. Basin sedimentation is shown in Fig. 5 together with the core stratigraphies, ^{14}C dates, several isochrones, and sedimentation rates. As already proposed by LIEB (1987), Early-Holocene ^{14}C-dates of the lowest samples above basal till (10375 cal. BP, 9475 cal. BP) indicate that the basin was glaciated for the last time during the Younger Dryas (Egesen oscillation) and that the Egesen glacier effectively scoured the basin. Until 3-4 ka BP a lake could be proved by palynology since *Pediastrum* (a green alga inhabiting freshwater environments) appears above basal till until a depth of 3.60 m within the core B2. In direct subsequence *Equisetum* (horsetail) comes up, an indicator that the lake disappeared. During the presence of the lake, sedimentation remained below 2.5 mm/a within the cores B2 and B11 but provides values of 5-7 mm/a in B8. This pattern indicates that the deepest part of the (central) basin 'had to be filled up' before sedimentation could also increase in the distal basin. If sedimentation rates derived from the cores are compared, a uniformity of the plots and delayed peaks of sedimentation can be observed towards the distal basin. This is interpreted as a fluvially induced 'sedimentary wave' advancing into and finally flattening the basin during lake disappearance between 2.5 and 4 ka BP. The idea is supported by several isochrones and stratigraphic data, where the termination of sand accumulation in B8 agrees with the onset of similar sequences in B2 and B11 (Fig. 5). Moor formation finally started between 2870 a cal. BP (B1, B2) and 2066 a cal. BP (B8). Well agreeing with these data, KRISAI et al. (2006) dated this transition to 2320 a cal. BP (depth: 1.65 m) *ca.* 25 m apart from B1.

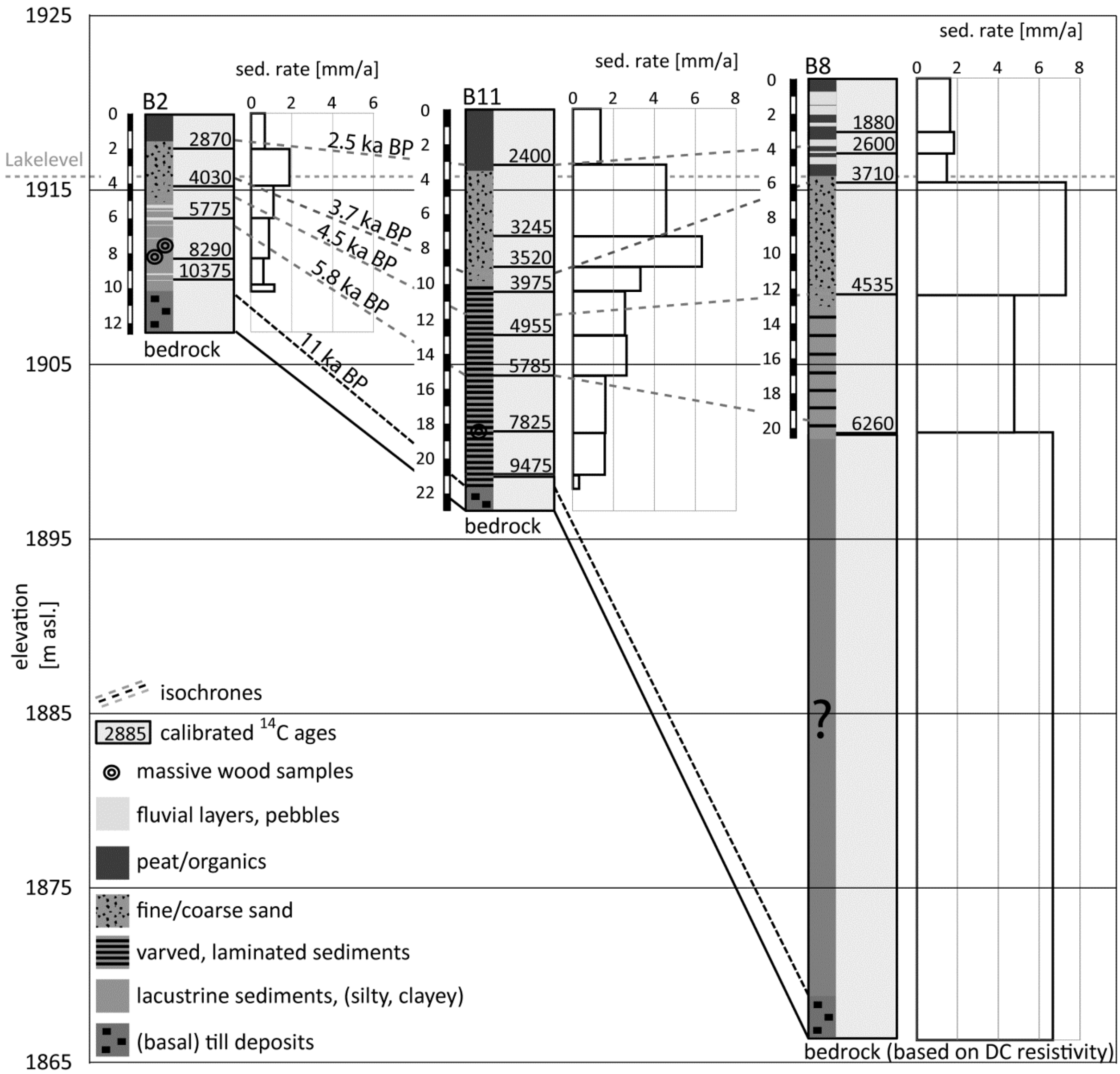


Figure 5: Drilling cores B2, B11 and B8 incl. a simplified stratigraphy, ^{14}C samples, bedrock base, isochrones (dashed lines), and sedimentation rates (for location, see Fig. 2 and 3; basin drainage to the left).

Conclusions

Most important outcomes of this study are as follows.

- Basin deglaciation and the onset of postglacial sedimentation could be determined to 11 ka BP by ^{14}C-dating of sediment core samples. The Younger Dryas (Egesen) glacier seems to have effectively scoured the basin leaving just a shallow layer of pre-Holocene basal till (8 % of total basin storage).
- The sedimentary record is completely preserved due to lake existence after deglaciation for around 7500 years as derived from stratigraphic and palynological data. Output might be limited to dissolved and small amounts of suspended load after lake disappearance.
- The lake infilling progress is interpreted as a 'sedimentary wave' advancing into and finally flattening the basin towards its distal part before moor formation started 3.5-2.5 ka BP.
- Total (postglacial) sediment storage amounts to 19.7 (18.3) x 10^6 m^3. Hillslope storage overbalances the alluvial basin fill by a factor of five.
- Corresponding rates of RR amount to max. 520 mm/ka considering 3D source areas.

Several uncertainties so far not addressed are included this study comprising the approximation of pre-Holocene basal till underneath present-day landforms, the incorporation of primary, secondary and tertiary sediment storages, and the absolute dating of postglacial sedimentation. However, despite of weathering and rockfall prone topographic, lithologic, and topo-climatic conditions, observed rates of RR are comparatively low. Since data is limited and based on different approaches covering a range of scales with different levels of detail, the dataset on alpine RR needs to be extended and knowledge about the factors governing the process (e.g., morphometric parameters, rock-mass strength, freeze/thaw cycles, influence of permafrost) needs to be enlarged. Comparable studies in similar environments but different lithologies might help to better understand the scatter of alpine RR and advance the interpretation of averaged signals of large-scale denudation.

Acknowledgements

Thanks to J. Buckel, J. Bellinger, C. Halla, Prof G. K. Lieb, and numerous students for assistance in the lab and in the field and for perceptive discussions. The Kärntner Landesregierung/KAGIS and the NPHT kindly provided orthophoto and DEM data. This study is part of the ESF EUROCORES programme TOPO-EUROPE. Financial support from the Austrian Science Fund (FWF) [I00156-N19] is greatly appreciated.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 243 - 244

Ecophysiology of filamentous green algae in astatic saline-alkaline ponds

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Nationalparks Austria Science Award 2013

Keywords

algae mats, biomass, desiccation, PAM, Nationalpark Neusiedler See Seewinkel

Abstract

Around forty shallow saline-alkaline ponds are located in the National Park Neusiedler See - Seewinkel. These small, endorheic water bodies are characterised by high nutrient levels and elevated conductivities. Salty ponds are very rare ecosystems in central Europe. Therefore these waterbodies are one of the major subjects of protection in the Nationalpark.

The climate of the region is semi-arid and because of high summer evaporation the water level of the ponds is usually reduced during summer. Some of the salty ponds may even dry out. Every year, dense mats of filamentous green algae develop during springtime, which finally cover large areas of the ponds. These mats are likely to play a key role in the functioning of the ecosystems. Mats of filamentous algae increase habitat complexity: they provide feeding places and refuges from predators thus leading to an increase of macrofaunal diversity (Lauringson&Kotta 2006; Pieczynska et al. 1999). Norkko et al. found a huge abundance of invertebrates of more than 1000 individuals g^{-1} dry mass (DM) in algae mats surpassing even densities recorded for seagrass communities (Norkko et al. 2000). Furthermore, filamentous algae act as a substrate for epiphytes, which serve as a food source for epiphyte grazers (Dodds 1991). Therefore it is likely that the mass occurrence of filamentous green algae in the Seewinkel ponds has a high influence on the ecosystems and increases biodiversity.Moreover filamentous green algae can act as a buffer against a shift to phytoplankton dominance thus maintaining a clear-water state and they account for up to 90% of total primary production in the ecosystem (Gubelit & Berezina 2010; Irfanullah & Moss 2005). In addition to the important effects mentioned above, *Chlidonias hybridus* was found breeding on these mats in the National Park (Dvorak et al. 2010).

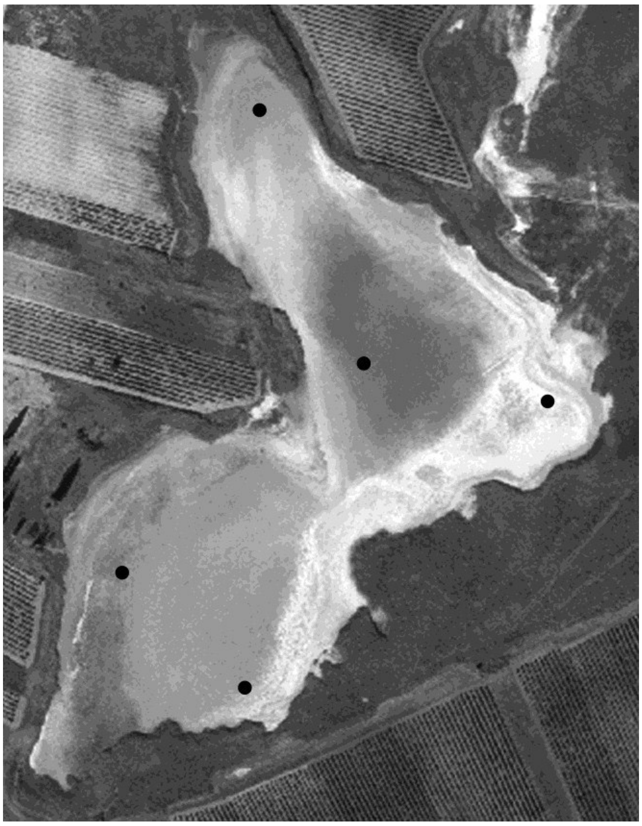

Figure 1: Map of the investigated pond; dots indicating the position of the five mesocosms

In our study we focused on the biomass development and seasonal succession of such algae mats in one of the ponds. The study covered a period between April and September and included also weekly measurements of water chemistry parameters. Moreover we investigated the ability of these algae to cope with desiccation by carrying out desiccation and recovery experiments in the laboratory.

Na^{+} and HCO_3^{-} were the most dominant ions reaching a maximum in the mid of September, when the pond was nearly dried out; phosphorus concentrations indicated hyper-eutrophic conditions. Maximum algae biomass was reached in July, measured in mesocosms, which were installed in the pond. At this time, floating algae mats covered a large part of the pond surface. The high biomass values clearly indicate, that such mass development of filamentous green algae plays an important role in the functioning of the pond ecosystems.

Desiccation and recovery experiments were carried out with vital as well as senescent algae mats in the laboratory using the non-invasive pulse amplitude modulated (PAM) fluorescence technique, which is an excellent tool for getting information of the overall photosynthetic performance of the algae. The vitals as well as the senescent algae showed a very low recovery potential after desiccation. The low ability to regenerate after desiccation is quite surprising because usually specimens occurring in periodically desiccating habitats show quite a high recovery potential.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 245 - 250

Impact of flooding on true bug communities (Heteroptera) on meadows of the Morava River floodplains, Eastern Austria

Marian Gratzer, Wolfgang Rabitsch & Christian H. Schulze

Abstract

Annual flood dynamics represent a determining factor in shaping habitats of lowland floodplains. Terrestrial arthropods of the soil and herb layer are particularly exposed to flooding events. We quantified the impact of flooding duration on abundance, species richness and composition of terrestrial true bug assemblages (Heteroptera) on floodplain meadows in the nature reserve "Untere Marchauen" (Lower Austria) and its close proximity. Heteroptera were sampled by sweep netting on meadows with different flooding regimes ranging from meadows only occasionally flooded by a rising ground-water level to meadows usually flooded for several weeks per year. A total of 11,950 individuals, 5,312 of them adults belonging to 118 species, were collected. Species richness and abundance of true bugs were negatively affected by flooding duration and species composition differed between meadows of different flooding regimes. Our study proved that anthropogenically induced changes in hydrological dynamics of floodplains can have a tremendous effect on richness and structure of terrestrial true bug communities.

Keywords

terrestrial arthropods, species composition, species richness, flooding duration, floodplain ecosystem

Introduction

In floodplains, flood events play a key role in shaping and maintaining the complex mosaic of riparian and associated aquatic and semi-aquatic habitats (Tockner et al. 1998; Hughes & Rood 2003). However, recurrent flooding represents a serious challenge for terrestrial invertebrates and special survival strategies have to be developed to adapt to such conditions. Many species are not able to survive flooding for a longer period of time. Particularly flooded meadows hardly provide any refuge for non-aquatic arthropods. Therefore, the ability to fly, in order to escape from inundation and to re-colonize drying-out areas after the flood, seems to be crucial. Additionally, reproduction strategies or life cycles, synchronized to the likely appearance of flooding events, have been evolved in certain groups of arthropods (Zulka 1999a; Rothenbücher & Schaefer 2005).

In this study, we investigated effects of flooding events on true bugs (Heteroptera). In Central Europe about 1,100 species are known (Günther & Schuster 2000). True bugs inhabit most terrestrial and aquatic habitats and due to their sensitive response to environmental changes, they have a great potential as indicator organisms in evaluating the quality of habitats (Achtziger et al. 2007; Dolling 1991; Morris 1979; Otto 1996; Zurbrügg & Frank 2006).

In Austria about 12,000 animal and plant species live in floodplain areas (Gepp 1985). Today, about half of the European human population lives on former floodplains and the remaining wetlands have been highly modified through construction of locks, levees and dams, through the impacts of farming, gravel mining, timber harvesting, species extinctions, the invasion of alien species and other direct or indirect anthropogenic disturbances (Brinson & Malvarez 2002; Tockner et al. 2009).

Only few studies tried to investigate the impact of flooding events on communities of terrestrial arthropods in floodplain landscapes of the temperate zone (e.g. Nickel & Hildebrandt 2003; Rothenbücher & Schaefer 2005; Truxa & Fiedler 2012). We studied effects of flooding duration on richness and composition of true bug assemblages in meadows of the floodplain of the Morava River in Eastern Austria. Heteroptera were sampled on meadows with different flooding regimes ranging from meadows only occasionally flooded by a rising ground-water level during strong flooding events to meadows usually flooded for several weeks per year. In particular, we tested the following hypotheses:

(1) Abundance and species richness of terrestrial true bug assemblages are declining with flooding duration due to a resulting high mortality of many species not adequately adapted to this disturbance. Furthermore, flooding causes a reduction of plant biomass production (Pezeshki 2001). This can correspond to a decline in vegetation height and structural diversity (Morris 2000). Hence, flooding is expected to diminish food supply and microhabitat diversity for true bugs (e.g. Zurbrügg & Frank 2006; Rabitsch 2007). Both should additionally decrease richness and abundance of true bug assemblages.

(2) We expect that flooding events represent a selective force with the potential to structure true bug assemblages by promoting species which are better adapted to this disturbance. Consequently, species composition is expected to differ distinctly between meadows with a different flooding regime.

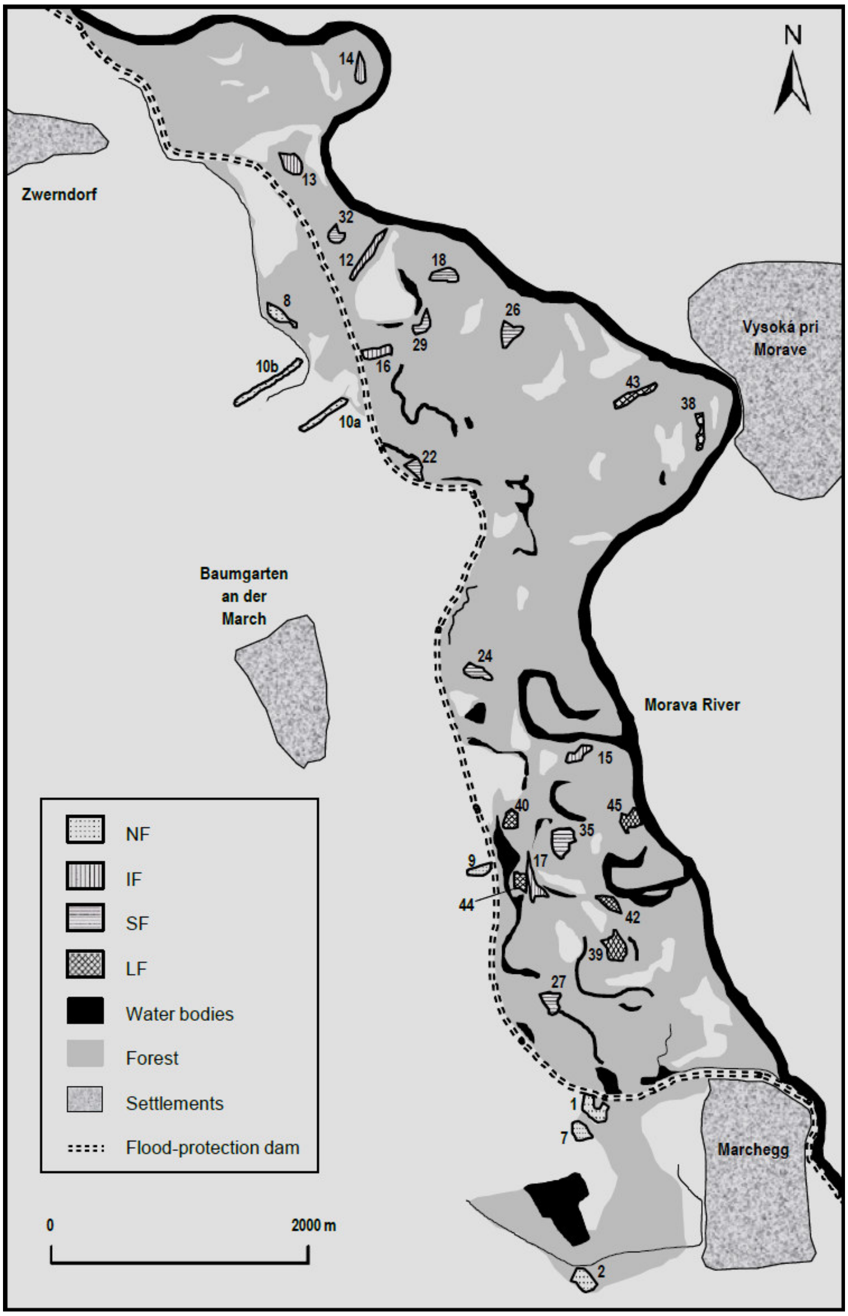

Figure 1: Study area and sampled meadows. Meadow types: NF – non-flooded meadows, IF – infrequently (not annually) flooded meadows, SF – meadows annually flooded for a short period of some days, LF – meadows annually flooded for a longer period of some weeks. Sampled meadows are indicated by code numbers.

Methods

<u>Study area and study sites</u>

Fieldwork was conducted in summer 2010 and spring 2011 in Lower Austria on meadows located in the nature reserve "Untere Marchauen" (48°18′31″N, 16°53′34″E) and its close proximity (Fig. 1). The reserve along the Morava River covers an area of 1,166 hectares (WWF Österreich 2012). Meadows account for 160 hectares of the total area (WWF Österreich 2012). The area west and south of the nature reserve is dominated by cropland. The lowland river Morava is characterized by a simple flow regime with a maximum runoff in April (Zulka & Lazowski 1999). Despite several river engineering measures, especially in the mid of the 20th century, the dynamics of annual flooding events are still a determining factor for the different habitats along the Morava (Zulka 1999b).

Selected study sites were hay meadows (size: 1-3 ha) inside or just outside the nature reserve. Meadows inside the nature reserve are periodically flooded. The selected meadows outside the dam are not directly influenced by flooding but can be affected by rising groundwater level during strong flooding events. According to their annual duration of flooding, the studied meadows were classified as non-flooded (NF) meadows, infrequently (not annually) flooded (IF) meadows, meadows with annual flooding for a short period of some days (SF) and meadows annually flooded for a longer period of some weeks (LF). Six to eight meadows were selected per meadow type resulting in a total of 28 study sites (Fig. 1).

Sampling of true bugs

On each meadow true bugs were sampled once in July 2010, August 2010, May 2011 and June 2011, respectively. A sampling unit consisted of 300 sweep net samples, roughly evenly distributed over the meadow area, per sampling date. The sweep net method is commonly used to assess true bug communities of meadows (ZURBRÜGG & FRANK 2006; TORMA & CSÁSZÁR 2012).

Table 1: Results of one-way ANOVAs testing for differences of number of individuals (log (x) transformed), and recorded species between meadows with different flooding regime. Results remained significant after controlled for false discovery rate (FDR) (Benjamini & Hochberg 1995).

Dependent variable	**One-way ANOVA**	**FDR-adjusted *p***
Individuals	$F_{3,24} = 14.04$, $p = 0.001$	**0.003**
Recorded species[1]	$F_{3,24} = 13.24$, $p = 0.001$	**0.003**

[1] only adult specimens considered

Data analysis

Because our study had a focus on effects of flooding on true bugs occurring on meadows, we excluded all exclusively arboreal species from our analyses. For all calculations on species richness only adult true bugs which could be identified at the species level were considered.

One-way ANOVAs were calculated to test for effects of flooding regime on total abundance and species richness. To approach a normal distribution of data, log (x) transformations were used. Least significance difference (LSD) tests were calculated to test for significant differences of variables between meadow types. All results of one-way ANOVAs listed in Tables 1 were controlled for false discovery rate (FDR) (BENJAMINI & HOCHBERG 1995). FDR-adjusted *p*-values were calculated by a spreadsheet program of Pike (2011). Species accumulation curves were calculated using the program PAST (HAMMER et al. 2001).

Analyses of similarity (ANOSIM; number of permutations: 999) were calculated with Primer v5 (CLARKE & GORLEY 2001) to test for differences in true bug species composition between meadow types. Similarity of species composition was quantified by Bray-Curtis similarities (calculated using square-root transformed abundances). Similarity relationships between true bug assemblages of the sampled meadows were visualized in a two-dimensional plot using non-metric multidimensional scaling (NMDS). A stress value of <0.20 was considered as appropriate for displaying similarity relationships (CLARKE 1993).

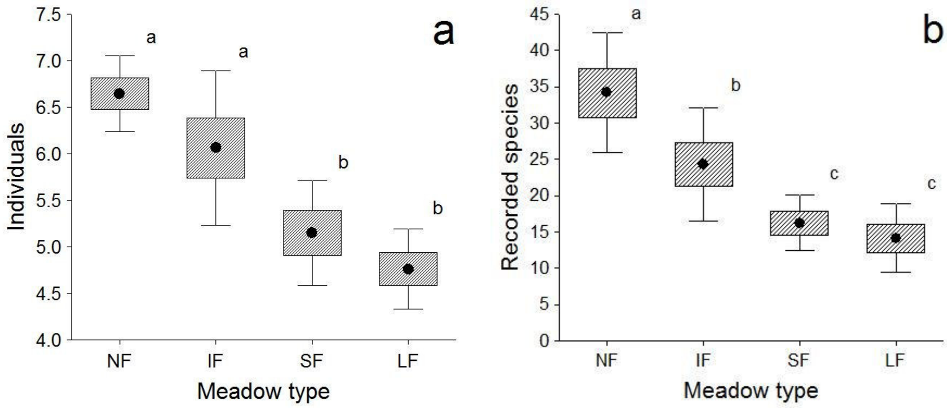

Figure 2: (a) Mean number of individuals (log (x) transformed) and (b) species ± SE (box) and 95% CI (whiskers) sampled on meadows with different flooding regime. Different letters indicate significant differences (LSD tests). Meadow types: NF – non-flooded meadows, IF – infrequently (not annually) flooded meadows, SF – meadows annually flooded for a short period of some days, LF – meadows annually flooded for a longer period of some weeks.

Results

A total of 11,950 individuals, of that 5,312 adults belonging to 118 species, were sampled. Only 15 individuals of 9 arboreal species, which were excluded from all subsequent analyses, occurred in our samples. True bug abundance was significantly affected by meadow type (Table 1). NF and IF meadows showed higher abundances than meadows characterized by longer flooding durations (Fig. 2a). The mean number of species recorded per study site decreased from NF sites to IF sites and, further, to meadows flooded for longer durations (Fig. 2b).

Species accumulation curves for samples pooled on the level of meadow types indicate significant higher species richness for non-flooded meadows compared to all other three meadow types, which apparently were characterized by relative similar species richness as indicated by similar shapes of their species accumulation curves and a strong overlap of the associated 95% confidence intervals (Fig. 3).

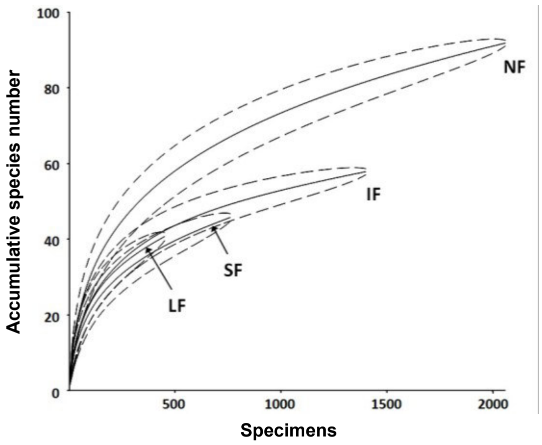

Figure 3: Species accumulation curves ± 95 % CI (dashed lines) for four different meadow types: NF – non-flooded meadows, IF – infrequently (not annually) flooded meadows, SF – meadows annually flooded for a short period of some days, LF – meadows annually flooded for a longer period of some weeks.

The similarity relationships (quantified by Bray-Curtis similarities) between species assemblages of the sampled meadows are visualized in a NMDS plot (Fig. 4). Dimension 1 can be interpreted as the flooding duration. NF meadows (predominantly plotted in the right part of the graph) are clearly separated from LF meadows (segregating in the left half of the graph), while the two other meadow types IF and SF are plotted in-between these two extremes (Fig. 4). A significant effect of flooding regime on true bug species composition was indicated by a one-way ANOSIM (global r = 0.32, p = 0.001). Pairwise tests to detect differences between meadow types achieved a significant level for the comparisons between NF and SF as well as LF sites and between LF and IF sites (Table 2).

Discussion

Disturbance caused by flood immediately reduces diversity, abundance, and biomass of the soil macrofauna. The effect becomes stronger with the duration of flooding (PLUM 2005). The survival rate of species without special physiological adaptations, like certain annelids or insect larvae, is very low. For other groups the only way to respond to flooding is by active or passive movement, by re-colonization or reproduction from resistant stages (PLUM 2005). Accordingly, our study showed a negative impact of flooding events on true bug communities. Both abundance and species richness on meadows decreased with increasing flooding intensity. The species accumulation curves calculated for the four meadow types indicate that on a larger spatial scale non-flooded meadows were characterized by a higher species richness. In addition, a reduced structural heterogeneity and diversity of the herb layer may have been contributed to this pattern (MORRIS 2000; SCHWAB et al. 2002). Although we did not conduct a vegetation mapping on the sampled meadows, we noticed, that NF and IF sites were characterized by a higher herb layer density and plant species richness, which should correspond to a higher plant biomass and a higher structural heterogeneity. Higher richness at non-flooded compared to flooded sites was also found for grasshoppers and spiders (ROTHENBÜCHER & SCHAEFER 2005; KATUŠIĆ 2008). The latter group also showed a higher abundance in non-flooded grasslands (KATUŠIĆ 2008). However, it appears that these patterns cannot be generalized. Remarkably, terrestrial beetles studied in a floodplain forest in south-eastern Australia showed an opposite response. Abundance, species richness and biomass were greatest at sites flooded for the longest period of about four months. Spiders maintained a similar abundance, species richness and biomass at flooded sites (BALLINGER et al. 2005).

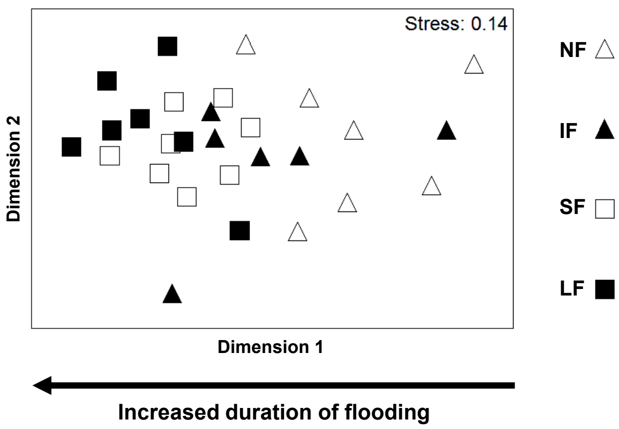

Figure 4: Similarity relationships between species assemblages of meadows with different flooding regime visualized in a NMDS-plot based on Bray-Curtis similarities. Meadow types: NF – non-flooded meadows, IF – infrequently (not annually) flooded meadows, SF – meadows annually flooded for a short period of some days, LF – meadows annually flooded for a longer period of some weeks.

Our data show that the composition of true bug species assemblages was significantly affected by flooding duration. Similarly, differences in the inundation duration of riparian habitats are affecting species composition of spider and ground beetle assemblages (BONN et al. 2002; GERISCH et al. 2006). In contrast, a high similarity of species composition between flooded and non-flooded sites was found in grasshoppers on floodplain meadows along the river Elbe (Germany), possibly because most of the species survived the flooding period in the egg phase (FISCHER & WITSACK 2009). Also many planthopper and leafhopper species can tolerate flooding in the egg stage during winter (ROTHENBÜCHER & SCHAEFER 2006). A follow-up study has to identify which factors are responsible for the high sensitivity of true bug assemblages against flooding in the Morava floodplains. Perhaps, the phenology of hydrological conditions plays an important role.

Table 2: ANOSIMs testing for differences in species composition between meadow types (NF – non-flooded meadows, IF – infrequently (not annually) flooded meadows, SF – meadows annually flooded for a short period of some days, LF – meadows annually flooded for a longer period of some weeks). Significant differences printed bold.

Pairwise comparisons of meadow types	*R*	*p*
NF vs. IF	0.124	0.090
NF vs. SF	**0.625**	**0.001**
NF vs. LF	**0.705**	**0.003**
IF vs. SF	0.109	0.112
IF vs. LF	**0.250**	**0.024**
SF vs. LF	0.077	0.204

Conclusion

Our study proved that flooding does not only affect abundance and richness, but also has an impact on species composition of true bug assemblages. Therefore, river restoration measures changing the hydrological dynamics of adjacent floodplains do not only affect diversity of terrestrial arthropods but also have a significant impact on species composition. Hence, a declined hydrological dynamic of floodplains causing a loss of habitat heterogeneity on a landscape level will most likely result in a decrease of beta diversity and consequently a decline of regional true bug species richness.

Acknowledgements

The study was done in collaboration with the WWF Österreich and we especially want to thank Mag. Bernadette Strohmaier and Mag. Gerhard Neuhauser, who provided important information about the study area. Questions concerning the plant communities of the study area were kindly answered by Ass.-Prof. Dr. Luise Schratt-Ehrendorfer. The Land Niederösterreich granted all necessary permits to sample true bugs in the protected area "Untere Marchauen".

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 251 - 252

The Biodiversity Database of the Hohe Tauern National Park as a base for research and management: distribution of threatened species in the national park, based on butterfly data

Patrick Gros

Abstract

A survey was conducted on the spatial distribution of threatened butterfly species in the Hohe Tauern National Park by means of the national park's database maintained at the "Haus der Natur" museum for natural science and technology in Salzburg. It led to the insight that butterfly species of conservation interest especially occur in edge areas of the national park, often finding habitats close to the national park, yet outside of the legal borders. As these habitats are cultivated, it is essential to stop the intensification of farming spreading inconspicuously even within the national nark boundaries, and to target conservation measures at these habitats, even if just outside the legal borders.

Keywords

biodiversity database, distribution, Hohe Tauern National Park, hotspot, threatened butterfly species

Introduction

The biodiversity database of the Hohe Tauern National Park contains nearly 300 000 records on animal and plant species. Apart from the general documentation of biodiversity the focus is directed towards species of conservation interest. Butterflies are a well-known group of organisms, information on their ecology and conservation status are readily available. Furthermore, their spatial distribution is known, even at small scale. This makes it possible to evaluate their distribution in the Hohe Tauern region. We aimed to delimit hotspots for threatened butterflies in the Hohe Tauern National Park, in order to highlight sensitive areas for the corresponding species as a background information for management measures.

Study area

The geographic area covered is the region of the Hohe Tauern National Park, comprising a core and a buffer zone (together ca. 1 800 km²), as well as an area outside the national park including those municipalities in Salzburg, Tyrol and Carinthia, which share a part of the Hohe Tauern National Park (Figure 1). The study area thus covers a natural spatial unit and is not confined to legislative boundaries such as the borders of the national park.

1. **Hohe Tauern National Park core zone**
2. **Hohe Tauern National Park buffer zone**
3. **Municipalities**: area outside the national park including all municipalities sharing a part of the National Park

Figure 1: The three zones of the Hohe Tauern region considered in this survey

Methods

The biodiversity database is maintained at the "Haus der Natur" museum for natural science and technology in Salzburg. Database management and data entry is carried out by a small team of biologists specialised in the taxonomy and ecology of vertebrates, invertebrates and plants and with in-depth knowledge of informatics.

The main software used in the project is "BioOffice", a software package designed for the documentation of biodiversity data. The database program is based on a Microsoft SQL server and a client software with integrated GIS functionality.

Record sets on threatened butterflies documented in the database were queried and analysed with respect to their spatial distribution, whereby we firstly only distinguished between the three zones of the national park (see Figure 1).

The conservation status of butterflies follows the Austrian red list (Zulka 2005).

Results

128 butterfly species were recorded in the study area. 54 of them are considered as being threatened at a national level. All these threatened butterfly species are known in the area outside the national park including all municipalities sharing a part of the national park (zone “municipalities”). On the other hand, only 35 of these threatened butterfly species have been recorded in the buffer zone and 28 in the core zone of the national park.

The most endangered species (categories “critically endangered”, “endangered” and “vulnerable”, N = 20) are almost exclusively found outside the borders of the national park. In the core zone only 4 species have been recorded for the “vulnerable” category, 23 species occurring here are considered as “near threatened”. Most of the latter are alpine specialists: they have a restricted geographical range, but are currently not threatened by human activities (e. g. *Boloria napaea*, *Polyommatus eros*). The buffer zone occupies an intermediate position (Figure 2). Thus most species occurring in the national park are not threatened. The few species threatened at a higher level occur mostly in the buffer zone. An example is the Large Heath (*Coenonympha tullia*), which settles in the national park only in low altitude fens.

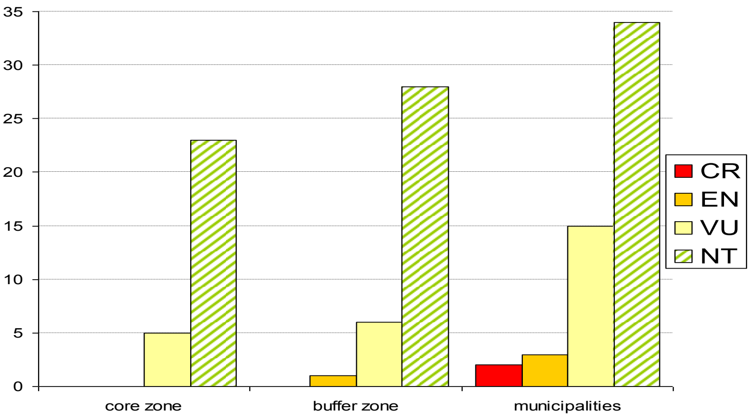

Figure 2: Threatened butterfly species in the three different zones of the area studied. Categories of threat (after ZULKA 2005): CR – critically endangered; EN – endangered; VU - vulnerable; NT - near threatened

Discussion

Butterfly species threatened at national level occur mostly in the transition zone between the area of the Hohe Tauern National Park and its surroundings (in our case the zone “municipalities”).

The uncultivated core zone of the national park is home to only a few threatened species, most of which are alpine species with a restricted geographical range, but which are widespread throughout European mountainous region. Thus with respect to butterflies the role of the core zone of the national park as a refuge for threatened species is limited: only few habitats are likely to sustain populations of more highly endangered butterfly species there (e. g. dwarf shrub habitats in case of species such as *Colias palaeno* or *Agriades optilete*).

In the national park, more highly endangered species find refuge mostly in the buffer zone, with a preference for cultivated grassland. Of crucial importance are traditionally used pastures and fens very low in nutrients. As such sites are a limited resource, even within the national park, it is essential to target conservation measures at these habitats, for example by promoting their traditional management. It is essential to stop the intensification of farming spreading inconspicuously even within the boundaries of the national park!

On the other hand, we were able to show that most of the nationally threatened butterfly species find habitats close to the national park, but outside of its legal borders. This situation is changing very rapidly, also due to the intensification of farming. Hence efforts must be made to save these habitats, even though they are outside the protected zone. We have to take responsibility for these refuge habitats, because populations of (inter)nationally threatened species occurring there have to be considered as an important reservoir. The national park within its current legal borders cannot act as a safeguard for these species, as they do not occur there naturally (or are very scarce) for ecological reasons. Therefore we have to keep our focus also on habitats just outside the legal borders.

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Conference Volume | 5th Symposium for Research in Protected Areas | 10 to 12 June 2013, Mittersill | pages 253 - 256

Comparative fish stock assessment at the Johnsbach brook and the Enns River within the course of the EU LIFE-project "Conservation strategies for woodlands and rivers in the Gesäuse Mountains“

Agnes Hahn (nee Kammerhofer)

Abstract

In the course of the EU LIFE-Project “Conservation strategies for woodlands and rivers in the Gesäuse Mountains“ (2005-2009) revitalization programs were implemented at the Enns River and the Johnsbach brook. Fish stocks before and after the implementation of the project were compared to investigate the program´s efficiency for fish in biomass, density and species assemblage. Despite the realized revitalization program, fish stocks of the Johnsbach brook declined slightly between 2005 and 2009 whereas at the Enns River stocks stayed constant.

In addition, migration obstacles in the Johnsbach brook were investigated to assess the barriers’ potential for successful fish passage. Measurements at the obstacles were compared to previously published data on jumping and swimming capacity of different fish species. Our results show that fish passage, especially for bullheads and juvenile salmonids, is still problematic in every part of the Johnsbach brook containing such obstacles.

Keywords

Nationalpark Gesäuse, EU LIFE-Project, river restauration, Enns, Johnsbach, fish migration

Introduction

This LIFE project (LIFE05NAT/A/78) was conducted from 2005 to 2009. The project aimed to open the connection between the rivers Enns and Palten and thereby establish highly dynamic areas where changes of flow directions depending on water levels became possible. Furthermore, the LIFE project involved the reconnection of a silted back water (Lettmair-Au), and the adaptation of existing obstacles in the Johnsbach brook. The studied stretch of the river Enns ranges from the estuary of the river Palten in Selzthal into the centre of the National Park Gesäuse where the Johnsbach brook discharges into it on the right bank. For the current study the river Enns has been further divided into two sections, i.e. (i) upstream Gesäuse and (ii) Gesäuse.

Materials & Methods

Fish stock assessment

In order to assess the fish ecological state 2009 fish stocks in the study areas were collected by electro-fishing whereby different forms of this method were used depending on the size of the water body. Results of the 2009 operations were compared to results of operations conducted prior to the LIFE implementations.

Assessment of the fish ecological status

The current ecological status of a water body is, in addition to chemical and physical components, determined by the composition of the biocoenoses within it, whereby fish biomass, density and species assemblage are playing a significant role. Based on these data, a deficit analysis is created. This shows to what extent the current state of a river deviates from the river-type specific model which corresponds to the "high ecological status" thereby determining in what way implementations need to be set in terms of water quality, morphology, hydrology and water continuum. In the current study, the nomenclature of Haunschmid et al. (2006b) was used to calculate the current status based on a data matrix resulting in five classes from 1 to 5. A fish ecological status of 1 (class limits 1.0 to <1.5) represents the reference state and therefore the "high ecological status" regarding fish biocoenoses. Class 2 (class limits 1.5 to <2.5) thus corresponds to the "good ecological status". Results worse than class 2 (class limits from 2.5 and above) imply an insufficient state and thus demand action from an ecological perspective.

By applying this method, four components are assessed to characterize fish resources. These are (i) fish biomass (kg / ha), (ii) species composition (number of river-type-specific species, ecological guilds), (iii) the fish area index (distribution of river-type specific fish species) and (iv) the population structure with special emphasis on the abundance of juvenile individuals.

Obstacle assessment at the Johnsbach brook

In the course of fieldwork in September 2009, an assessment of 27 obstacles in the Johnsbach brook was carried out by measuring the flow velocities and drop heights from water level on the obstacle to water level underneath

(Δh). The aim was to evaluate possibilities of successful fish passage by comparing the obtained physical characteristics of obstacles to previously published data on the swimming and jumping capacity of the most abundant fish species in the area, i.e. bullheads, adult brown trout and grayling as well as their juvenile stadiums.

In order to examine the conditions of flow velocities and drop heights at a low water level, and to include the evaluation of further conducted implementations (carried out October 2009) further assessments of obstacles were conducted in December 2009.

Table 1: Classification of obstacles in the Johnsbach brook as surmountable (green, +), potentially surmountable (yellow, (+)) or not surmountable (red, -) for all native species. In December 2009 the obstacles 1.1c to 1.1k were not measured due to weather conditions.

		September 2009				December 2009			
Section	Obstacle	bullhead	juvenile salmonids	adult grayling	adult browntrout	bullhead	juvenile salmonids	adult grayling	adult browntrout
1	1a	-	(+)	(+)	(+)	+	+	+	+
1	1b	+	+	+	+	-	(+)	+	+
1	1c	+	+	+	+	-	-	(+)	(+)
1	1d	+	+	+	+	-	+	+	+
Mouthregion		-	(+)	(+)	(+)	-	-	(+)	(+)
1	1e	(+)	(+)	+	+	+	+	+	+
1	1f	-	(+)	+	+	-	-	+	+
1	1g	+	+	+	+	-	-	+	+
Section 1 total		-	(+)	+	+	-	-	(+)	(+)
1.1	1.1a	-	-	-	-	+	+	+	+
1.1	1.1b	-	-	+	+	-	-	+	+
1.1	1.1c	-	-	+	+				
1.1	1.1d	-	-	-	(+)				
1.1	1.1e	-	+	+	+				
1.1	1.1f	+	+	+	+				
1.1	1.1g	-	-	+	+				
1.1	1.1h	(+)	(+)	+	+				
1.1	1.1i	-	+	+	+				
1.1	1.1j	-	+	+	+				
1.1	1.1k	+	+	+	+				
Section 1.1 total		-	-	-	-	-	-	+	+
2.1	2.1a	(+)	(+)	+	+	-	-	+	+
2.1	2.1b	-	+	+	+	-	-	+	+
2.1	2.1c	-	+	+	+	-	(+)	+	+
2.1	2.1d	-	(+)	+	+	-	-	(+)	+
2.1	2.1e	-	+	+	+	-	-	+	+
2.1	2.1f	-	+	+	+	-	-	+	+
2.1	2.1g	-	-	+	+	-	-	+	+
2.1	2.1h	-	-	+	+	-	-	(+)	(+)
2.1	2.1i	-	-	+	+	-	-	+	+
Section 2.1 total		-	-	+	+	-	-	(+)	(+)

Results & Discussion

Johnsbach brook - fish stock

Across the entire study area, a total of 189 fish, representing five different species, were caught in the Johnsbach brook. These were 163 brown trout - *Salmo trutta* (86.2%), 14 bullheads - *Cottus gobio* (7.4%), 5 rainbow trout - *Oncorhynchus mykiss* (2.6%), 4 sparctic char - *Salvelinus fontinalis x umbla* (2.1 %) and 3 grayling - *Thymallus thymallus* (1.6%). Bullheads were caught exclusively in the mouth region of Johnsbach brook (Section 1A). Overall, a distance of 1971 m was fished with an average width of 9.1 m. The average of all sections results in an abundance of 10.31 Ind./100 m or 112.37 Ind./ha, and a biomass of 0.67 kg/100 m or 7.26 kg/ha.

The majority of the captured brown trout range within the size class 151-200 mm. The second most abundant size class is 101-151 mm, followed by the classes 201-250 mm and 51-100 mm. The classes 0-51 mm and >250 mm are present only sporadically.

Johnsbach brook - Evaluation of fish ecological status

The required "good ecological status" according to the EU WFD was achieved in five of the six sections within the Johnsbach brook. These five sections (1, 1.1, 2, 2.1, 3) are all classified as strongly bedload carrying, so that the minimum target of fish biomass of 50kg/ha does not apply. Only in Section 4 ("upper tunnel"), the "knock-out criterion" biomass does apply, since in this area the sediment transport is no longer dominant, therefore leading to an insufficient result concerning the fish ecological status in this section. In all sections except section 1 a further adaptation to the reference condition was applied by changing the status of *C. gobio* from dominant species to rare species.

Johnsbach brook - Comparison 2005 and 2009

In section 1 both biomass and abundance has dropped significantly from 12.9 kg/ha and 474.4 ind./ha in 2005 to 6.42 kg/ha and 220.16 ind./ha in 2009. The allochthonous species *O. mykiss* appeared absent from this section in 2009. In both years bullheads were detected only in the mouth region below the first obstacle.

Section 2 showed a biomass of 13.0 kg/ha in 2005, while during 2009 only 11.93 kg/ha. However, the number of species increased in this section from two to three species as an adult grayling with 390 mm was caught.

In section 3 a total biomass of 42.6 kg/ha was recorded in the year 2005 while in 2009 a biomass of only 6.59 kg/ha was observed. In both years, brown trout was the only species present in this section, which is characterized by particularly high flow rates. It is noteworthy that greatly increased flow rates were observed in this section at the time of the 2009 assessment.

Section 4 showed in both years good results compared to the sections downstream. In 2005 a higher biomass was detected (33.7 kg/ha) than in 2009 (19.83 kg/ha). This section of the Johnsbach brook shows good potential for fish stock as the slope and the sediment transport are lower. However, only brown trout could be recorded. Apparently the barriers in the lower sections seem to act as a major obstacle for all other fish species to access this area.

Johnsbach brook - Obstacle assessments

Results for individual obstacles and fish species are summarized in table 1. Bullhead and grayling are undoubtedly limited in their upstream migration. In the case of the brown trout, the effects are less crucial. However, the consequences of continuum interruptions should not be underestimated even for this species. GOSSET et al. (2006) studied the effects of barriers on migration and reproductive behaviour of brown trout and showed that due to barriers large parts of upper river sections were not used as reproduction sites. The authors stress that this situation may very possibly have a direct negative effect on the survival and the genetic variability of the population. Our results indicate that the current situation in the Johnsbach brook allows for migration of adult brown trout and thus potentially enables utilization of upstream regions as spawning habitat for this species.

Migration distances of brown trout during the spawning season may vary but as the minimum distance was 20km (ZITEK et al. 2007 and references therein) a migration to the upper part of the 13.5 km long Johnsbach brook seems to be quite likely. Even apart of the spawning season migration of brown trout up to 122 km were found in various studies (ZITEK at al. 2007 and references therein), showing that a continuum of all water stretches seems essential not only at the time of spawning migration .

Grayling require even more attention, since they don’t show the same capacities in jumping and swimming compared to brown trout. Furthermore, grayling are less able to adapt to changes in spawning conditions and are thus especially susceptible to interference from obstacles that are passable only at certain conditions (OVIDIO et al. 2007). OVIDIO & PHILIPPART (2002) stress that fish that get to a transverse structure, usually immediately try to overcome this. Does this first attempt fail they often undertake a downstream drift by several meters to wait for better conditions (flow, temperature), sometimes for several weeks. Especially for grayling this behaviour often has serious consequences as the optimum conditions at the target spawning areas could be missed during these waiting periods. Repeated attempts to overcome an obstacle may result in an increased energy challenge and as a consequence the fitness of the individual fish may be reduced and the spawning success may be minimized. Also the risk of injury increases with the number of attempts to pass a barrier. (OVIDIO & PHILIPPART, 2002).

It is doubtful whether the Johnsbach brook can serve as a permanent habitat for grayling. However, the value of such water bodies as spawning habitats should not be underestimated. Grayling are known to cover distances of up to several kilometres (NYKÄNEN 2004, ZITEK et al. 2007 and references therein) during spawning migration. Optimal conditions for grayling reproduction were observed in the Johnsbach brook some 13 km upstream of the mouth and the continuum is therefore desirable especially in the light of the increasingly limited grayling spawning grounds in the Enns river.

Also the bullhead is a species that could find suitable habitats in the Johnsbach brook. The conditions may vary considerably depending on the annual amount of discharge and sediment transport but it seems reasonable to assume a good potential for stable bullhead populations in individual years. According to UTZINGER et al. (1998), *C. gobio* is a very well suited indicator organism for the amount of continuum interruptions within a water body. At the time of the fish stock assessment in September 2009 bullheads could only be found in the mouth region - a finding in agreement with the supposed discontinuity as suggested by the results of the assessment of the physical properties of the obstacles. Whether the additional implementations carried out in October 2009 will result in an improved situation for bullheads remains to be assessed.

The small number of fish caught in September 2009 indicates that the existing barriers still have a strong impact on the fish fauna. However, it should be noted that in the course of this study no telemetry was carried out, therefore statements about the possibility to overcome obstacles are merely based on comparisons with values from the literature. Furthermore, it must be emphasized that the implementations carried out in the framework of this LIFE project took place only shortly before the current evaluation. Final steps were even implemented after the fish stock assessment 2009. Especially these adaptions achieved a significant improvement most notably in the mouth region (section 1, obstacle 1a) and at the webcam (section 1.1, obstacle 1.1a). Long term effects remain to be assessed but the implementations conducted during the LIFE project certainly lend hope for a development towards a further improved continuum in the Johnsbach brook.

Enns river - fish stock

In the Enns river a total of 1005 fish were caught in 2009 (549 individuals upstream Gesäuse and 456 individuals in the Gesäuse itself). *S. trutta* was the most abundant species in both sections, i.e. 45.9% in total, followed by *T. thymallus* with 22.9% and *C. gobio* with a total of 19.8%. The allochthonous *O. mykiss* accounted for 6% of the total catch.

In addition, the following native species were detected: chub (*Squalius cephalus*), Danube river lamprey (*Eundontomyzon vladykovi*), minnow (*Phoxinus phoxinus*), perch (*Perca fluviatilis*), Gibel carp (*Carassius *gibelio*), pike (*Esox lucius*), Danube salmon (*Hucho hucho*), nase (Chondrostoma nasus) and roach (Rutilus rutilus). All caught Danube salmon are most likely the result of recent restocking. Two further non-indigenous species were detected: brook trout (*Salvelinus fontinalis*) and sparctic char (*Salvelinus fontinalis x umbla*).

Enns river - Evaluation of fish ecological status

The assessment 2009 indicated an insufficient fish ecological status in both studied sections of the river Enns. The status of the section upstream Gesäuse was found to be class 4 (4.0), resulting mainly from a lack in biomass. By ignoring the biomass criterion and also adding all species reported by an additional structure assessment performed in 2007/2008 (WIESNER et al. 2010) a value of 3.22 could be achieved. Despite the failure of achieving a good ecological status in this stretch an increase in the detected species number needs to be positively emphasised. The assessment of the section Gesäuse likewise resulted in a bad fish ecological status, largely due to a substantial lack of biomass. Not taking into account the biomass, the required good ecological status could only just be reached with a value of 2.49.

Enns river - Comparison 2006 and 2009

Comparing the values of biomass and abundance of individuals in the Enns river between the year 2006 and 2009, no significant differences can be identified. In 2006 in the section upstream Gesäuse grayling accounted for the major part of biomass, whereas in 2009 it was brown trout. In 2009 *O. mykiss* was caught in lower numbers both in biomass and abundance compared to 2006. In the section Gesäuse the total numbers in biomass and abundance remained stable, but in 2009 the grayling accounts for a larger share than in the previous study and thus dominates now together with brown trout. Also, the proportion of rainbow trout has increased compared to 2006 in the section "Gesäuse".

Already in the course of the pre-monitoring in 2006, a severe deviation of the fish ecological status was determined in both studied sections of the Enns river, thus only reaching an insufficient condition according to the WFD (WIESNER et al. 2008). Although stocking of brown trout and Danube salmon took place between 2006 and 2009, only an insufficient fish ecological status was calculated at the post-monitoring due to low biomass and the incomplete composition of species. Taking into account additional data (fish stock assessments in specific structures, stocking actions of missing species) the potential for improvement may be recognized. However, a sustainable improvement can only be achieved by further habitat enhancement. Also for the recovery of populations of existing species, this step is a prerequisite. In the case of the Upper Drau river, which was similarly affected by regulation, a first success in terms of stock recovery became apparent only after 10 years of intensive restoration (personal communication G. UNFER and C. WIESNER, 2010).

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 257 - 264

Beyond the inventory - Change detection at the landscape level using aerial photographs in four protected areas of the Alps

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Abstract

Long-term monitoring is a key task for any national park. Therefore, a set of monitoring programs has been established by ecologists in the last decades to observe changes of different ecological processes. However, monitoring change at the landscape level has lagged behind because of the cost-intensive investments to be made and also because of the lack of a meaningful framework to detect and measure change as well as store data at this scale. Documenting change of the landscape could give insights into processes which were not expected by experts and therefore no specific monitoring system was implemented.

The four national parks Berchtesgaden, Hohe Tauern, Gesäuse and the Swiss National Park have recently developed a framework to fill this gap in their monitoring system. Based on aerial image comparison and on a formerly defined interpretation key from the Interreg IIIB project HABITALP, the working group has developed the necessary workflow and tools. The group has also expanded the existing inventory based on aerial photographs to a change detection data set which allows quantifying change at the landscape level in the protected areas.

Fields denoting change were added to the existing interpretation key and the data model from HABITALP based on two different time series of aerial photographs. Current technology allows for a comparison between the two stereoscopic images and the detection of thematic and geometric changes. The system was trialed in test areas of all four national parks. Resulting maps allow for a detailed insight into change of the main habitat types, as well as several smaller, often not immediately obvious, changes in the landscape over time.

Keywords

landscape change, long term monitoring, detection, aerial images, aerial image interpretation, data model, digital photogrammetry

Background

Nature conservation is a key task of large protected areas in general and national parks in particular. This includes absolute protection of the landscape and species, as well as tolerating and accepting natural processes and ecological disturbances. The latter is followed by changes in landscape structures or unpredicted succession of species. A precise monitoring with long-term perspectives is indispensable to differentiate between natural processes and anthropogenic influences, provide facts when conflicts occur and document change over time (Margules & Pressey 2000).

The monitoring systems established in protected areas in the last decades allow for observation of change on small-scale plots of flora and fauna (Lockwood & Worboys et al. 2006). However, change at the landscape level - one of the key elements for large protected areas - has been largely neglected so far. Mainly cost factors and missing meaningful conceptual models for protected areas prohibited a systematic documentation of change at landscape scales in national parks. Moreover, a lack of methodologies has prevented managers from investing in these approaches. There are different requirements in protected areas compared to other regions, where human impacts such as, sheeting, or drainage mainly need to be documented. Common data models documenting change often do not know terms such as abandoning, restoring or natural succession. But these types of change must be included if an area-wide analysis in a conservation area is to be successful.

Increasingly, these analyses have to provide quantitative evidence. Special definitions are needed for a planar quantification. It is of crucial importance to know the quality of the data in terms of their positional and thematic accuracy and completeness with respect to the question to be answered - is something changing or not? Otherwise, there is a risk to document erroneous spatial boundaries instead of true change (Haller 2011). In addition, there is no prior experience of a meaningful time period between two recordings to detect changes in natural landscapes.

Thanks to increasingly more powerful remote sensing systems, new methods have been developed, which allow for a more differentiated view of the earth's surface and identification of conditions. If the condition is not the same as the previous time, something has obviously changed in between - but what?

This question was also the challenge of this project: First, the spatial and temporal resolution had to be chosen so that the usually slow pace of change in national parks could actually be recognized. Secondly, the issue of what types of change should be recognized had to take into account the needs of all four national parks and their specific environmental and management conditions. This was the starting point of this project, entitled "Change check of the Habitats of the Alps".

Aims and objectives

During the Interreg III project HABITALP, the basic methodology (using CIR aerial images), as well as the semantics of the landscape inventory, were developed (HALLER 2006; LOITZ 2006). At the time, the adaption of the theoretical framework could only be tested in the Nationalpark Berchtesgaden (Germany) due to missing time series of aerial images in other partner regions.

In this follow-up project "Change check Habitalp"- CC-HABITALP, it should be investigated whether this method meets the key requirements for detection of changes in the various national parks in the Alps. The four national parks Hohe Tauern (NPHT; A), Gesäuse (NPG; A), Berchtesgaden (NPB) and the Swiss National Park (SNP; CH) have been working on five priority objectives:

- Identification of space-related (landscape ecology) parameters which are important to the parks
- Elaboration of the semantics of change based on the mapping of space-related parameters
- Developing the logic of the interpretation key which considers the possibilities of different types of aerial images
- The creation of a technical and operational framework and tools for area-wide mapping
- Test the framework and tools on concrete examples in test areas in the four national parks and with different aerial image material (e. g. color-infrared (CIR), normal colours (RGB) and panchromatic (pan)).

CC-Habitalp should deliver the base for future work in the individual national parks.

Results

<u>Interpretation methodology</u>

We used Stereo Analyst for ArcGIS Desktop in versions 9.3 and 10.0. Therefore, all aerial photos had to be digital, and an aerial triangulation had to be present. The procedure enables the interpreter to compare the two image pairs of the default time series with the existing inventory, and to detect and correct errors. In a second step, the interpreter searches for changes in the landscape according to the defined key. Changes in geometry are followed by splitting polygons and thematic changes are recorded in the attribute table.

Basically, only the aerial visible elements can be evaluated. However, because the national parks already have many other data and therefore knowledge of the landscape, the use of these data is desirable to enhance the knowledge of possible processes. The same goes for any local knowledge of the interpreter.

Figure 1: Used infrastructure

<u>Data</u>

A set of aerial images for each protected area was prepared. Taking into account the effort involved, this can be seen as a major output of the project. The basic methodology generally requires very high spatial resolution (15-20 cm ground resolution) and CIR images in the spectral range of 400 - 900 nm. However, for the SNP and the NPG, panchromatic images were also used to allow for retrospective analysis. Moreover, for NPHT and the NPG, RGB-images for the years 2003 and 2009 were used (Table 1).

Table 1: Aerial area-wide images prepared for digital photogrammetry in the four national parks Gesäuse (NPG), Hohe Tauern (NPHT), Berchtesgaden (NPB) and the Swiss National Park (SNP)

	NPG	NPHT	NPB	SNP
Aerial pictures series 1	2003	1998	2003	2000
Spectral range	RGB	CIR	CIR	CIR
Pixel resolution	25 cm	17 cm	17 cm	20 cm
Aerial pictures series 2	1954	2009	2009	1946
Spectral range	PAN	RGB	CIR	PAN
Pixel resolution	30 cm	28 cm	20 cm	50 cm

Interpretation key and data model

The fundamental conceptual model of the interpretation key and associated guidelines were developed and described in HABITALP (LOITZ 2006). However, this so-called "universe of discourse" has been modified to include the aspect of ongoing processes. This has been included in the coding, and new directives for interpretation have been developed. The data model has become of vital importance. A data model is a generalized custom representation of data that reflect the real world. Since the entire workflow had to be developed from image interpretation through to the actual data in ArcGIS 9.3 and 10.0, the technical data model was constructed as an ESRI-geodatabase (Figure). Essentially, the key is based on the elements of HIK-2 (DEMEL & HAUENSTEIN 2005). Further developed, HIK-CD (Version 1.1.3) includes not only an inventory of one time series, but also the data structure of the second time level, as well as the associated process information.

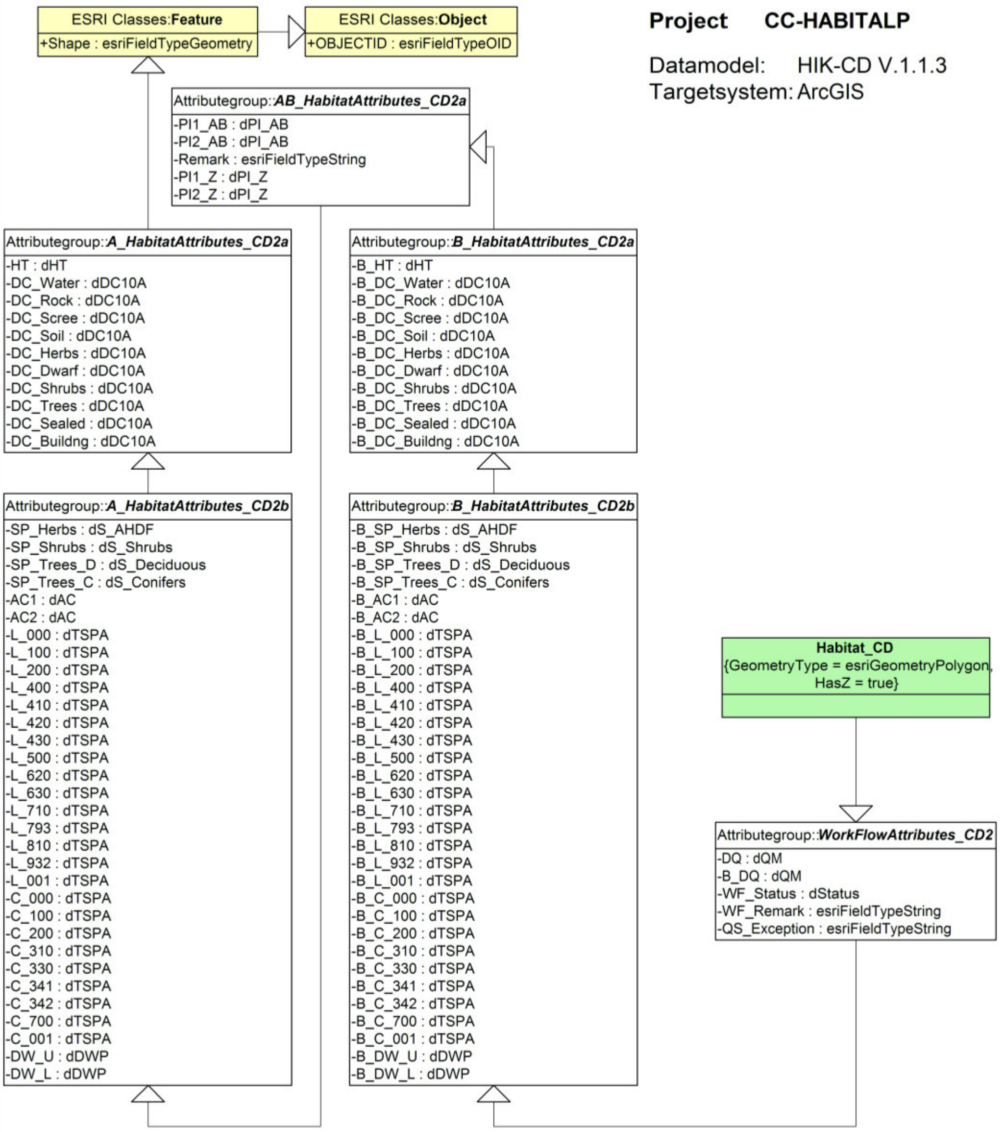

Figure 2: UML-data model of HIK-CD (Version 1.1.3)

The structure an subjects of the interpretation key and thus the contents of the database can be explained simplest with some examples (Figure 3 and 4). In 1998 object A was in the upper part a forest dominated by *Pinus mugo ssp. mugo* (80%) and some deciduous trees (20%) and a total canopy closure of 80%, the ground vegetation was grass (degree of cover 80%) and only few scree, the lower part was an alpine meadow crossed by a gravel road. In the meantime a mudflow covered the area so that in 2009 the area is covered by nearly 100% scree. Thus the originally straight flowing river (object B) was forced aside and dammed, so that the alpine meadow with no trees and dwarf shrubs (lower part of object B) was flooded and partially covered by sand. In the middle of the river exists a riverine sediment area. Object C is also an alpine meadow, but carrying medium sized rocks and *P. mugo* shrubs. No significant change could be detected here.

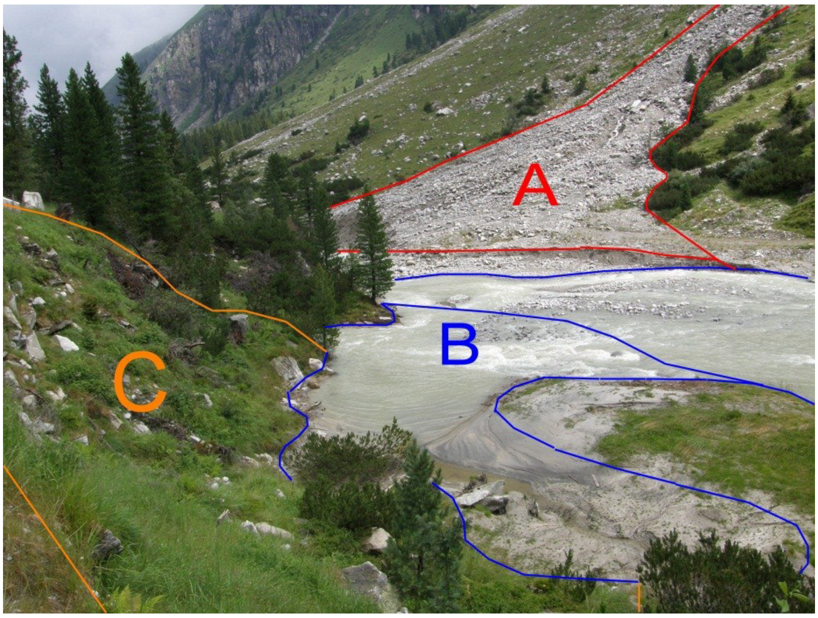

Figure 3: Part of the landscape in the Obersulzbachtal of the Nationalpark Hohe Tauern (Austria) with the focus on three Objects.

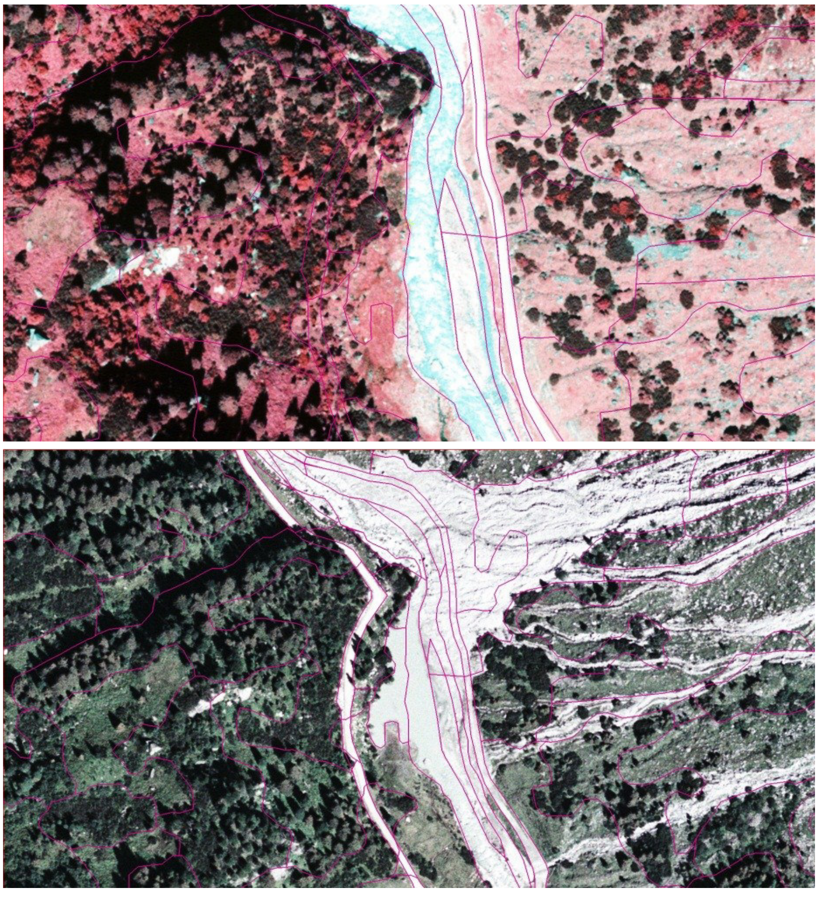

Figure 4: Aerial Images of the cut-out of the Obersulzbachtal as in Figure 3, taken in 1998 (above) and 2009 (below) with the delineation after the change detection process.

Test area interpretation

In each of the national parks, a test area between 12 and 16 km² was selected and mapped according to the proposed method and interpretation of the key. In order to test as many of the habitats and changes occurring in the four protected areas as possible, the test areas were selected in different habitats within each area. Together with different image material and time gaps between the photographs, we gained a detailed view of advantages and limitations of the selected method.

The shortest time interval is shown on the images in the NPB, for which the best imagery was available. Thematically, the test mapping concentrated on rocky, karstified limestone with grasslands and pine shrubs *Pinus mugo ssp mugo*. Dynamics in forests were mainly dominated by European bark beetle *Ips typographicus*.

The greatest difference between images, both with respect to time span (between 1946 and 2000) and quality of the pictures, was seen for the test area of the SNP. Nevertheless, in the upper Val Mingèr, only natural changes were captured, as this area has been fully protected since 1914. Land changes of 7.62% in the main habitat types of key HIK-CD were detected here, particularly in the degree of mixing of forest, but also in rubble and debris surfaces. The dynamics of an avalanche path is shown in Figure.

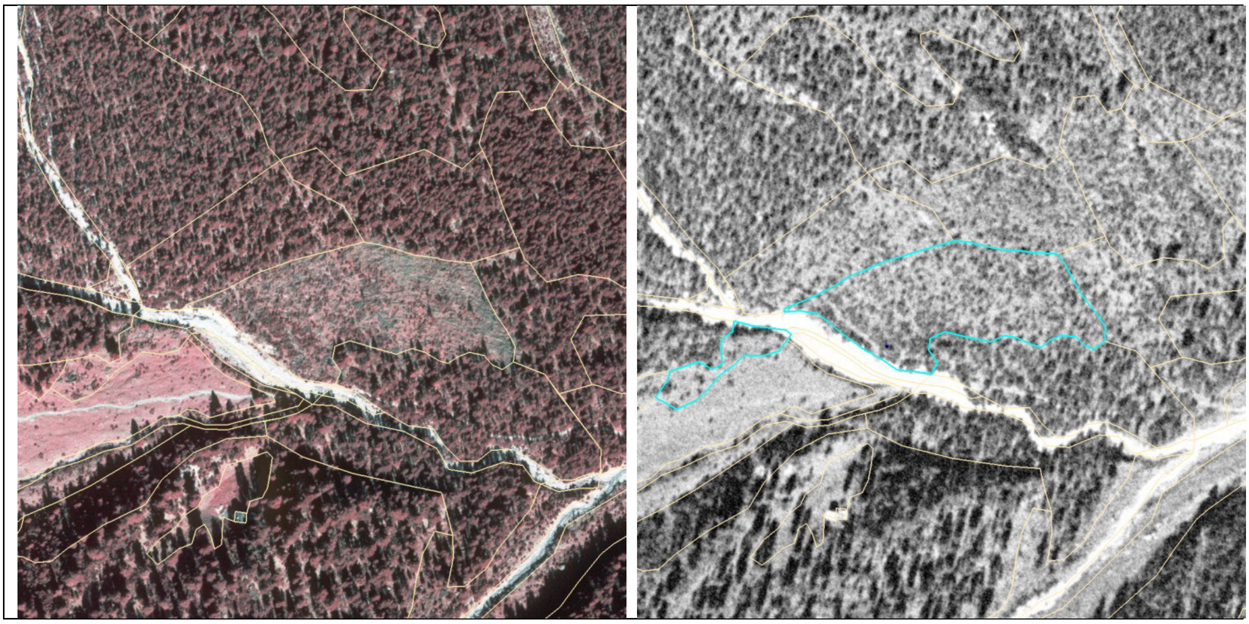

Figure 5: In 2000 (left), all mapped forest left in Val Mingèr in the SNP appeared approximately evenly distributed and organized. A look back at the picture from 1946 (right) shows that the current avalanche area around the trees at that time was much smaller (b). Presumably, these are the consequences of an even larger avalanche event before 1946. Larger amounts of dead wood - which should also be seen in the picture from 1946 - are missing. Along with historical information, this indicates that it was removed in 1900 before the establishment of the Swiss National Park, possibly along with other wood uses.

Changes were also evident in retrospect in the NPG. By contrast to the SNP, the first series of aerial photographs was taken some 40 years before the park was founded. Therefore, we found many signs of landscape utilization by comparison to images from 2003, especially in pastures and woodland. A focus was set on detecting changes within avalanche tracks. Avalanche events and a frequent used forest road, together with the natural forest growth and forestry measures, led to changes in many objects between 1954 and 2003.

The mapped area in the NPHT was 13.07 km², within which 998 different landscapes could be detected. Figure shows the areas where relevant landscape changes were identified and measured. These make up 6% of the total area. Changes happened due to avalanches, debris flows or mountain stream dynamics, but also due to natural forest growth and rock glacier or glacier dynamics. The glaciers also show the limitations of the methodology: the method is of little use for precise monitoring of glaciers, since it was often not able to define whether the glacier still existed under scree or snow. Although mass changes are visible and measurable on the aerial photographs, they would have to be precisely captured in an additional process. Human-induced changes such as forestry operations and construction activities, or derelict buildings, are also visible in the images.

Conclusions

The interpretation key based on experiences and results from the Interreg III project HABITALP was named HIK 2.2.2. Basically, the method allows for detection of changes (ΔH) at the landscape level in accordance with requirements of the national parks. Within in the CC-HABITALP framework, landscape changes could be detected and recorded at different time intervals (Δt). ΔH can be detected over an interval of 6 years or of 55 years. HIK-2 was already holistic and homogeneous at the spatial and thematic resolution, and the change detection interpretation key was developed and completed according to this principle. Particularly in terms of definitions and tools against the inventory key HIK-2, significant progress has been achieved.

Longer intervals naturally favor detection of changes in the landscape and allow the use of aerial photos from other spectral ranges. If the time interval is short, the use of CIR aerial images is highly recommended. However, short time intervals require very high spatial resolution and accuracy of aerial images and the base inventory. It is expected that even small-scale changes can be detected and recorded by potential users. Moreover, results are expected within a shorter time frame than with longer intervals, which also increases pressure on interpreters.

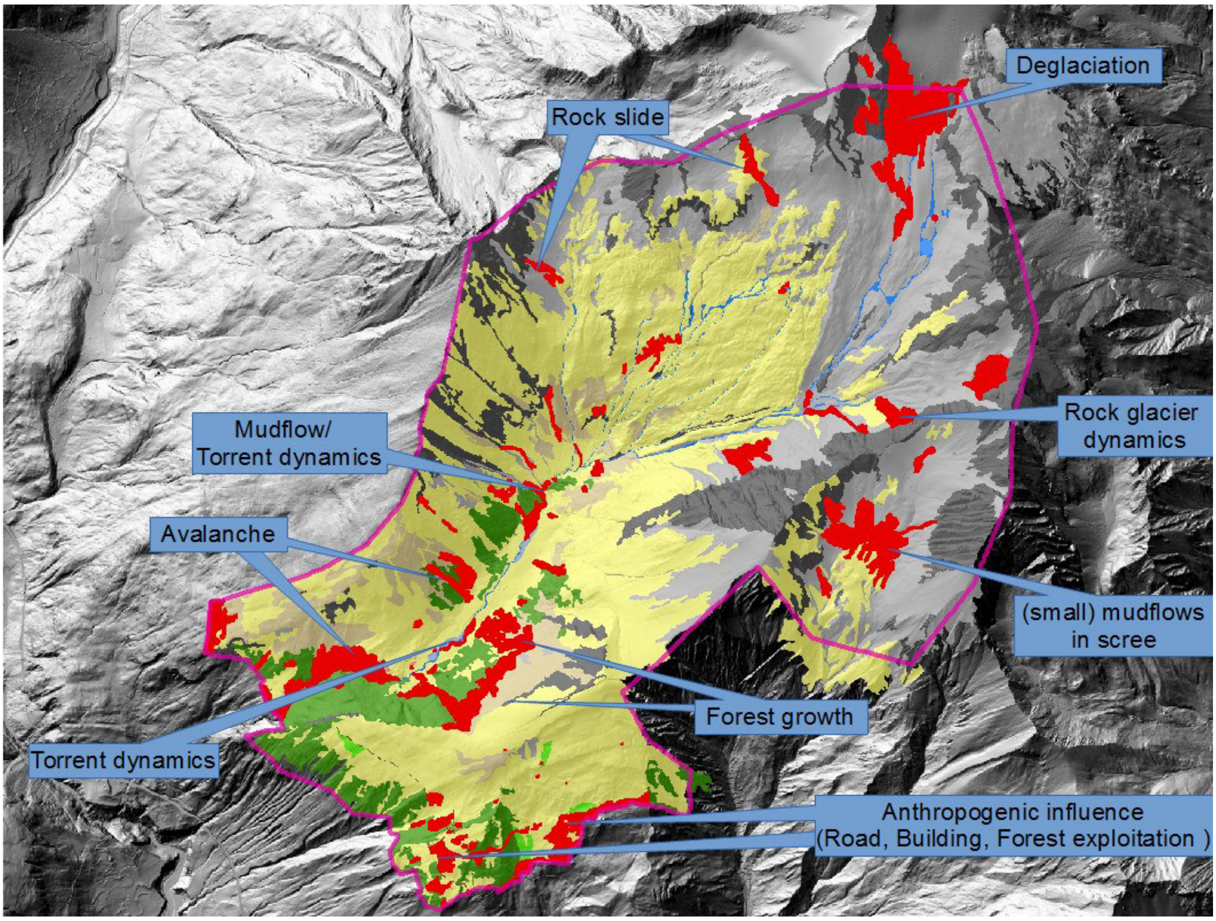

Figure 6: Changes and process information on the Steiner Alm in Nationalpark Hohe Tauern

A homologous base inventory based on HIK-2 resp. HIK-CD is central to all inventories of change. Only if the starting material meets the high demands of thematic and spatial accuracy can changes in the defined habitats be properly quantified .

On the other hand, long time intervals have their pitfalls, as the test mapping in the NPG and the SNP showed. Especially in the NPG, forest areas managed in the period before the establishment of the national park were difficult to interpret if the time interval covered 50 years. It is possible that old changes were masked by new events already . The two recorded time readings can thus hardly be traced to ongoing succession of the area.

The SNP has worked with very old pictures from the 1940s. The difficulties experienced in the NPG were not an issue here due to the very slow and natural development. On the other hand, limited detectability of changes due to the relatively poor panchromatic imagery with a resolution of 0.5 m and the geometrical distortion of aerial material was evident.

Based on these experiences, we recommend time intervals of 10 - 20 years for aerial image-based change detection in the national parks of the Alps. The precise interval depends on the soil type and plant growth of an area. Only if the time interval is relatively long (> 15 years) normal color and panchromatic images can be recommended.

The mapping scale has frequently been discussed. With ground-pixel resolutions from 17cm to 50cm we approved an overall reference scale of 1:5'000. This means zooming in to a scale of 1:800 - 1'000 to reasonably detect and map changes. However, there is also an economic aspect: the smaller the area of change to be detected, the greater the effort.

Estimates of cost are essential for a comprehensive inventory in the national parks. We divided effort into two sections: in a first phase, the quality of the first inventory was checked and corrected. This included the transformation of the 2-D inventory of HABITALP into 3-D by using a high resolution terrain model (DTM; $\Delta z \leq$ 1m) in the NPB, NPG and NPHT. This so-called homology was achieved depending on the quality of the first inventory. Once the basic inventory is of good quality, we expect as a first guideline a 2 km² mapping capacity per day per person. Additional GIS-data is helpful, but does not increase the daily output. Field verifications are not within this time estimation, but are highly recommended, since they allow additional statistical testing of interpretation and improve the interpreter's familiarity with the area.

Outlook

The project has demonstrated that the detection of landscape change using aerial photographs is still a viable method. However, the demands are considerable. Moreover, exchange of ideas and reciprocal verification of results are an essential element in a long-term application to gain comparable results between different protected areas. It is also important to support the interpreters with technical tools and support to ensure optimal quality and productivity. Since the development is complicated, a common application is highly recommended and should be the aim in future. Moreover, we should invest in analysis and visualization of this complex content demonstrating change in landscapes over time.

Apart from the protected areas involved in the project HABITALP, only few other protected areas have base mapping available which was performed with the key HIK-2. There is no obligation in Alpine countries to use this key in protected areas and to capture the landscape and its changes over time. Therefore, it would now be important for that key to invest in a political breakthrough. This could be followed by setting up a steering group for amendments, which reviews new ideas and useful additions to the existing code.

The development of remote sensing will continue. We assume that the spatial and spectral resolution will increase in the future at the same cost base. The information gained will be beneficial for this method, but must be integrated into this framework and be processed using appropriate infrastructure.

Acknowledgements

We thank the management authorities of the four participating national parks Berchtesgaden, Gesäuse, Hohe Tauern and the Swiss National Park for the financial support and man power in this project.

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Conference Volume | 5th Symposium for Research in Protected Areas, 10 to 12 June 2013, Mittersill | pages 265 - 268

Health effects of alpine waterfalls

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Abstract

Traditionally, numerous beneficial health effects have been attributed to waterfalls in various regions of the world, including areas around waterfalls in Austria. In most cases, the folk memory describes mitigating effects concerning respiratory diseases.

During a three-year field campaign we monitored five different waterfalls in the Hohe Tauern National Park and revealed a specific environment around different waterfalls. Breakup of small water droplets in the waterfall forms a specific nano aerosol comprising mainly negatively charged intermediate ions, which are assumed to trigger a variety of biological effects.

In randomized, controlled clinical studies, we addressed the question, whether the specific environment of different waterfalls provides beneficial effects on:

A) pediatric allergic asthma (Krimml waterfall, n=54, Hohe Tauern National Park Salzburg)

B) stress-immunology and burnout prevention (Gartl waterfall, n=102, Hohe Tauern National Park Carinthia)

C) lung and heart physiology, mucociliary clearance (Krimml and Gartl waterfall, n=450)

In *asthma bronchiale*, exposition to the aerosol of the Krimml waterfall significantly reduces the expression of pro-asthmatic and inflammatory cytokines, and induces immunological mechanisms leading to an improved sustainability of the positive effects on lung function and asthma symptom score compared to a control group. Exposition to the Gartl waterfall in combination with hiking in the Hohe Tauern National Park induces significantly higher antibody titers to cholera vaccine and significantly reduces stress compared to two control groups. Furthermore exposition to alpine waterfalls significantly accelerates the mucociliary clearance rate, alters lung physiology and has systemic effects on different parameters of the cardiorespiratory system.

In summary, we found and characterized positive health effects of waterfall aerosol on the human immunology and physiology thus providing a new health rationale for protecting alpine areas and their invaluable water resources.

Keywords

Waterfall, health, allergy & asthma, stress & burn-out

Introduction

Thanks to its natural environment, Austria is lucky enough to possess a multitude of healing climate regions with health promoting potential. A highlight among the various natural health resources of Austria is the Hohe Tauern National Park, with its still largely unexplored and untapped climate therapy and health tourism possibilities. The protected water resources within the Hohe Tauern National Park in particular offer entirely new health aspects with the Krimml Waterfall (Salzburg) and the Gartl Waterfall (Carinthia) being particularly noteworthy (HARTL et al. 2010).

As of December 1st, 2009, 50% of the Austrian population lives in urban areas (STATISTIKAUSTRIA 2012). And the European trend exceeds the situation in Austria by far: in Germany for example, 85% live in cities and agglomerations like the Ruhr, the Rhine-Main conurbation or the city cluster of Wiesbaden/Mainz/Frankfurt/Offenbach (UNITEDNATIONS 2007). This enormous lack of “natural experience” in industrialized countries is accompanied by a change of people’s way of life (lack of exercise, crowding stress), in some cases with environmental health risk factors such as smog and fine dust. Known consequences are lifestyle diseases such as allergies and asthma, cardiovascular diseases, diabetes mellitus type 2, obesity, certain forms of cancer, skin diseases and the resulting mental disorders (GODFREY & JULIEN 2005; SCHOTTENFELD et al. 2013). For the treatment of these chronic illnesses and lifestyle diseases, the focus of medical science is being placed more and more on natural health resources as preventive and therapeutic remedies (KOCH et al. 2004). Against the backdrop of the increasing development pressure applied on the sensitive mountain regions by energy suppliers and ski companies, the protection of alpine water resources also becomes an important medical measure (HARTL et al. 2010; KÖHLER 2012; ÖSTERREICHISCHERALPENVEREIN 2009; RIEDL 2009).

The medical effective agent of alpine waterfalls

A particularly valuable unique feature of the Hohe Tauern National Park, in terms of the healing climate, is the nano-aerosol, the nanometer-sized reparable atomized water droplets of alpine waterfalls. The charged nano aerosol is formed within micro seconds after the ionization of primary ions, due to hydration and cluster ion formation processes. Waterfalls mainly produce negatively charged ions, referred to as Lenard ions. As a result of the aerosolized water hitting the ground, the droplets created in the waterfall form dipoles with a negatively charged surface. Due to the waterfall wind, the negatively charged particles, atomized by thermophoretic processes, drift away from the waterfall, whereas the positively charged droplets quickly sink to the ground. This causes surplus of negatively charged air ions in the proximity of the waterfalls, which can be of the order of several 10.000 ions/cm3 air (KOLARZ et al. 2012). It is remarkable, that each waterfall has its own physical signature and different waterfalls thus have different effects on human physiology (KOLARZ et al. 2012; PARTS et al. 2007). In recent years we have conducted research on the physiochemical properties of waterfall aerosol and the physiological effect the aerosol of alpine waterfall have and its effect on allergic asthma and stress/burnout prevention in a series of randomized controlled clinical trials.

Physiological effects of waterfall aerosol on the human body

What is it that makes the waterfall climate so special? How far is a space in open countryside different from a place close to a waterfall? What effects does a waterfall have on human physiology and the respiratory tract after just a few minutes? On behalf of the Hohe Tauern National Park we investigated these questions in a randomized clinical crossover study with 60 test persons, using the results to create a "health map" of the Krimml Waterfalls. In comparison, to a control location in the open countryside of Krimml proximity to the waterfall creates a parasympathetic tonus (a relaxed state characterized by calmness and relaxation). The heart rate slows down and the better synchronization of abdominal and thoracic breathing as well as deeper inhalation improves blood circulation in the lungs. Overall, the transport of oxygen in the blood is facilitated, increasing oxygen saturation. A parameter of key importance for those suffering from asthma, the nitric oxide exhaled (FeNO) was particularly reduced on the orographic right side of the Krimml Waterfalls.

Allergies and asthma

Asthma and allergic rhinitis are among the most common chronic diseases worldwide. Since the 1950s, the prevalence (susceptibility to the disease) of allergies and asthma in Western Europe has increased drastically; now one third of the Austrian population suffers from allergies and 11 % of children are affected by allergic asthma. The allergy and asthma rate increases as communities adopt a Western lifestyle and become urbanized. According to current estimates, another 100 million people worldwide could be suffering from asthma by 2025 (BACHERT, LANGE & VIRCHOW 2005; BOUSQUET et al. 2005; EDER et al. 2006; EDER & VON MUTIUS 2004).

In a series of preclinical studies in a mouse model of asthma we evaluated the waterfall aerosol effect of three different alpine waterfalls (Gartl waterfall, Hohe Tauern National Park Carinthia, Krimml Waterfall Hohe Tauern National Park Salzburg, Stuibenfall Ötztal, Tyrol). Each individual waterfall is characterized by a specific physicochemical signature – and just the Krimml waterfall induced a bettering of lung function and an antiallergenic immunprofile in this controlled, placebo free mouse model of allergy and asthma. As a result of these preclinical studies we examined the Krimml waterfall aerosol's effect on clinical, functional, molecular and immunological parameters of allergic asthma in the human system: In an asthma camp, 54 patients aged 8 to 14 with mild and moderate bronchial asthma were tested on the effects of waterfall climate therapy on allergic asthma in a controlled randomized study setup and with completely identical living, housing and nutrition conditions (GAISBERGER et al. 2012).

For a period of three weeks, the children were divided into two groups. Every day both groups spent an hour outdoor exposition, the waterfall group close to the waterfall, the control group 6 kilometers away. Pulmonary function, breathing gas exhaled and two blood samples were tested and a combined symptom and medication value was determined.

Over the three weeks of exposure, the waterfall caused an anti-allergic and anti-asthmatic immune response in the young asthma patients. This positive and balancing immune modulation (reaction of the immune system) is characterized by a change in the ratio of allergic/anti-allergic biochemical messengers, the induction of anti-inflammatory messengers as well as the production of anti-allergic regulatory T-cells, and is specific to the waterfall - the control group did not show as many beneficial effects, especially not on a long-term basis.

- Only exposure to the waterfall improves pulmonary function by 30 % with a measured effective duration of at least two months.
- Even four months after exposure, the asthmatic symptoms of the "waterfall children" are still considerably alleviated compared to the control group.

This highly relevant data from a medical and health economy perspective (GAISBERGER et al. 2012) was used as the basis for the health tourism project Hohe Tauern Health, offering the benefits of the Krimml Waterfalls in combination with specialized anti allergenic hotels as a therapy option, which can already be booked by patients from all over Europe suffering from allergic asthma (www.hohe-tauern-health.at).

Stress and Burnout-prevention in the Hohe Tauern National Park

Stress is an omnipresent part of life and a stressful event causing hormones such as cortisol or adrenaline flushing our body and triggering a "fight and flight" response. Modern lifestyle, when everything from crowding in big cities, high-pressured jobs and busy traffic can keep the organism in an alarm state called chronic stress (NAKATA 2012). This affects people of all ages, genders and circumstances and can lead to a major psychological and physical health issue going along with high susceptibility to anxiety, depression, heart disease, metabolic syndrome, cancer and other concomitant medical phenomenon's of modern civilization and urbanization (ZACHARIAE 2009; GODBOUT & GLASER 2006).

The Gartl waterfall in the community of Grosskirchheim in the Hohe Tauern National Park in Carinthia produces a remarkable high concentration of negative air ions (>20.000 ions/cm3) compared to other waterfalls in the Eastern alps (KOLARZ et al. 2012). We have studied the effect of a daily 1h exposition in the particulate Gartl waterfall microclimate in combination with six hiking tours in the Hohe Tauern National Park in a randomized, controlled clinical study (n=102) with patients suffering from chronic stress. We have chosen a vaccination model using cholera vaccine for conducting this psychoneuroimmunological research in the intersection of climate therapy, behavior, neuroendocrine functions, immune response and health (PHILLIPS 2012). Daily exposition at the Gartl waterfall in combination with hiking in the Hohe Tauern National Park induces significantly higher antibody titers to cholera vaccine and significantly lower psychological and physiological stress levels compared to a non - intervention control group and a "hiking alone" group. Thus using the Gartl waterfall in connection with hiking tours in the protected Hohe Tauern National Park area as medical remedies boosts immune function via reduction of stress by acting on the hypothalamic-pituary-adrenal axis and their succeeding endocrine and immune pathways (HARTL et al. 2010).

The medical and psychological evidence is now the gateway for the development of health tourism products and prospective boost for regional added value in the Hohe Tauern National Park, Carinthia.

In summary, alpine waterfalls produce a distinct environment characterized by a negatively charged nano-aerosol. This specific microclimate acts on the human physiology and immunology and offers new therapeutic remedies for allergy and asthma and for chronic stress and burnout prevention. This scientific and medical evidence provides a new health perspective for relevant diseases of civilization and is a powerful argument for the protection of alpine areas and their invaluable water resources.

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Conference Volume | 5th Symposium for Research in Protected Areas | pages 269 - 274
10 to 12 June 2013, Mittersill

Implementing a long-term monitoring site focusing on permafrost and rockfall interaction at the Kitzsteinhorn (3.203 m), Hohe Tauern Range, Austria – A status report from the MOREXPERT project.

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Abstract

The research project MOREXPERT („Developing a Monitoring Expert System for Hazardous Rock Walls“) has initiated a new long-term monitoring site focusing on bedrock permafrost and rockfall interaction. The project's primary objective is the development of an expert system for the stability assessment in high-alpine rock faces. For this reason a state-of-the-art monitoring system has been established at the Kitzsteinhorn (3.203 m). The monitoring comprises various methods that allow the acquisition of combined information on subsurface, surface and atmospheric conditions: Five deep boreholes deliver temperature data from depths of up to 30 m. More than 40 spatially distributed temperature loggers provide information on near-surface thermal dynamics. Two permanently installed ERT profiles (Electrical Resistivity Tomography) are used to derive quasi-continuous information on ground temperatures. In order to detect changes occurring at the surface terrestrial laserscanning is carried out. Atmospheric conditions are monitored at six different weather stations.

Keywords

climate change adaptation, mountain permafrost, natural hazards, rockfall

Introduction

Within this contribution we explain the motivation and scientific basis of the research project MOREXPERT. Moreover, we discuss the applied methods, the monitoring design and the relevance of our study site in an international research context. Permafrost potentially reacts very slowly to external change. Thus, long-term data series are essential for a thorough understanding of permafrost evolution. Establishment of the Kitzsteinhorn monitoring site has started in October 2010. Given the relatively short period of time, long-term data series are not available for the Kitzsteinhorn site yet. Therefore no extensive discussion of measurement results (e.g. borehole temperatures) is found within the present contribution.

Motivation and Objectives

Over the last decades and centuries many mountain regions have experienced significantly increased frequentation for settlement, employment and transportation purposes. The European Alps were particularly affected by this development. In addition, recreational use has taken on greater importance, which is illustrated by millions of tourists, who visit the Alps and its protected areas every year. This development makes instability of rock faces in high mountain areas an increasingly important risk factor man and infrastructure, especially within the context of recent warming trends in the Alpine region (Gruber et al. 2004). Numerous rockfall events in the Alps suggest an increasing occurrence of gravitational mass movements due to rising temperatures in recent years. During the hot summers of 2003 and 2005 a large number of rockfall events were triggered from steep bedrock areas affected by permafrost. In several cases massive ice was visible in the exposed detachment zones (Gruber & Haeberli 2007). However, long-term field data/observations on the complex relationship between rock temperatures and the occurrence of rockfall events are rare. This lack of data serves as one of the primary incentives for establishing a new long-term monitoring site at the Kitzsteinhorn.

On a theoretical level MOREXPERT therefore aims at an improved understanding of permafrost-related processes operating in high-alpine rock faces. On a technical level the project targets the development of a robust monitoring system that resists the harsh environmental conditions of high mountain environments. In order to support risk management strategies MOREXPERT will furthermore develop an expert system for slope stability assessment in steep bedrock. The expert system is considered to be a transferable good-practice guide that can be applied to potentially hazardous rock faces in other areas. It will contain operating procedures and working routines as well as recommendations for required data resolutions and efficient data analysis.

State of Mountain Permafrost Research

Permafrost is defined as ground that remains at or below 0°C for at least two consecutive years (Brown et al. 1998, IPA). Mountain permafrost research is a young scientific discipline whose systematic beginnings date back to the 1970s (Barsch 1973; Haeberli 1975). Academic research of mountain permafrost has experienced a marked upswing in recent decades for several reasons. Permafrost (degradation) has major implications for the occurrence of debris flows, rockfall events or even large-scale rock avalanches. Furthermore, mountain permafrost has been recognized as a major technical challenge for the successful realization of construction projects in high-mountain environments (Bommer et al. 2010). Recently, particularly the occurrence of potentially permafrost-related rockfall events has garnered the attention of researchers. Numerous laboratory experiments have confirmed that permafrost warming or thawing in steep bedrock causes a significant alteration of rock mechanical properties and ice mechanical properties (Mellor 1973;Davies et al. 2000; Krautblatter et al. 2012). In order to foster long-term research on mountain permafrost evolution the projects Permafrost and Climate in Europe (PACE), the Swiss Permafrost Network (PERMOS) and the Longterm Permafrost Monitoring Network (PermaNET) have initiated permafrost monitoring sites in the European Alps. Particularly high mountain peaks in the western Alps (e.g. Schilthorn, Matterhorn) have been instrumented for continuous monitoring of permafrost. In Austria, extensive permafrost monitoring with deep boreholes and geophysicshas been limited to the research site located at Hoher Sonnblick (3.106 m).

Study Site

The study site is located at the Kitzsteinhorn (3.203 m), Hohe Tauern Range (Fig. 1). The monitored area encompasses the entire summit pyramid of the Kitzsteinhorn, covering an elevation difference of more than 300 m and an area of approximately 3.5 ha. Due to its topographical features (no neighbouring summits, pyramidal shape) the Kitzsteinhorn is particularly well-suited for the investigation of the influence of aspect and elevation on ground thermal conditions.

Regarding it geology the Kitzsteinhorn primarily consists of calcareous-micaschists. Stress release and intense physical weathering resulted in the formation of an abundance of joint sets with large apertures. The pronounced retreat of the Schmiedingerkees glacier in recent decades led to the exposure of oversteepened rock faces, which are frequently affected by minor rock fall events (Hartmeyer et al. 2012).

The study site extends across the Kitzsteinhorn skiing area and the Hohe Tauern national park. The tourism infrastructure existing within the study area (cable car, ski lifts) provides easy access and convenient transportation, an essential prerequisite for the establishment of an extensive long-term monitoring program. The west ridge of the Kitzsteinhorn is crossed by a tunnel ("Hanna-Stollen"), which allows the acquisition of thermal information from depths of up to 80 m.

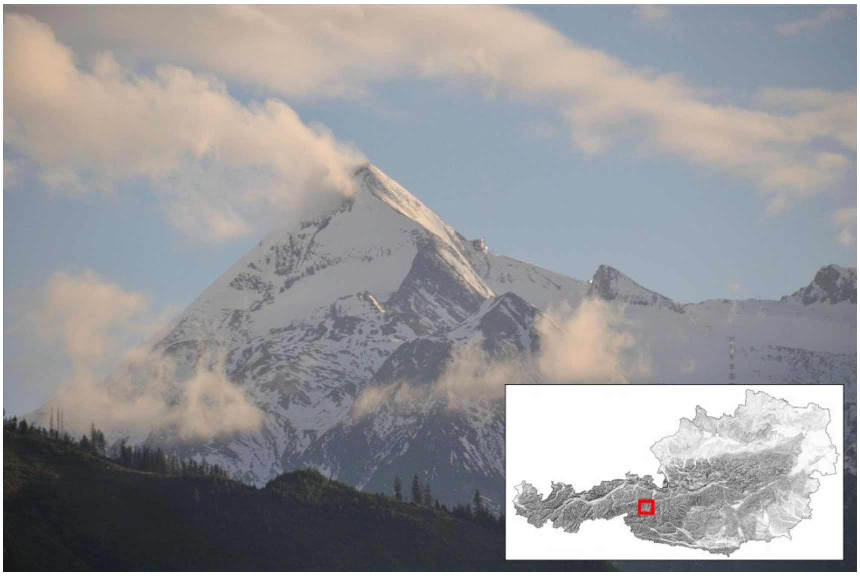

Figure 1: The study area of the MOREXPERT project is located at the Kitzsteinhorn, Hohe Tauern Range, Austria (© Markus Keuschnig/Günther Prasicek).

Applied Monitoring Methods

Subsurface Monitoring

Temperature Measurement in Boreholes

In order to investigate subsurface temperatures five boreholes with depths between 20 and 30 m were drilled (Fig. 2). The boreholes were created by rotary drilling using air flush to avoid contamination of frozen ground with water. The drillings were conducted perpendicular to the terrain surface. All boreholes are instrumented with an innovative temperature measurement system that has been developed within the MOREXPERT project. It consists of a special polyethylene casing with non-corrosive brass segments at the designated depths of the temperature sensors. The specific design of the thermistor chain which is inserted into the casing allows the temperature sensors to establish direct contact with the brass segments. The utilized temperature sensors are Pt100 thermistors with an accuracy of +/-0.03°C. Due to the high thermal conductivity of the brass segments this newly developed solution enables significantly improved thermal coupling between the sensors and the surrounding rock and is therefore able to deliver highly representative temperature data. The new system has been designed and manufactured by the Austrian company GEODATA.

Figure 2: Air flush rotary drilling at the Kitzsteinhorn west face (© Ingo Hartmeyer)

In Addition to 12 UTL (Universal Temperature Loggers) in loose material, more than 30 shallow boreholes have been drilled to investigate near-surface temperatures up to a maximum depth of 80 cm (Fig. 3). For temperature measurement within these shallow boreholes a new methodological strategy for near-surface rock temperature measurement has been developed (KEUSCHNIG et al. 2012). Every drilling site consists of two shallow boreholes with depths of 10 cm and 80 cm. In order to enable a small drilling diameter (18 mm) and therefore minimize the extent of the drilling works, iButtons® are used for temperature measurement. The iButton® is a miniature temperature logger that integrates a battery, a computer chip, a real-time clock and a temperature sensor in stainless steel can. The present study represents the first time that iButtons® are applied for temperature measurement in bedrock. The integrated digital thermometer measures temperature with a resolution of 0.0625°C, accuracy is ±0.5°C.

Figure 3: Drilling of a shallow borehole for near-surface rock temperature measurement at the Kitzsteinhorn south face (© Ingo Hartmeyer).

Electrical Resistivity Tomography

During ERT measurements an electric current is injected into the ground using two electrodes. The resulting voltage difference is recorded at two potential electrodes. Repeated measurements with changing electrode configuration provide a dataset of the apparent subsurface resistance. The underlying resistivity distribution can then be calculated through inverse modelling (HAUCK & KNEISEL 2008).ERT is well-suited to distinguish between frozen and unfrozen subsurface regions as a marked increase of electrical resistivity occurs at the freezing point of water-containing materials such as moist rock or soils (SASS 2004).

For monitoring purposes, ERT measurements are repeated at specific time intervals using the same survey geometry. Thus, temporal and spatial permafrost variability can be resolved (HILBICH et al. 2008). Rock faces are well-suited for the quantitative interpretation of ERT data as bedrock usually has a relatively homogenous constitution and an accurately defined pore volume. However, joints and fractures represent distortions that potentially alter the subsurface electrical field considerably (KRAUTBLATTER et al. 2010).

Surface Monitoring

Terrestrial Laserscanning

Terrestrial Laserscanning (TLS) creates highly accurate, three-dimensional images of the scanned area. By sweeping a laser beam over a defined scene, a laser scanner is able to record millions of data points. TLS allows an accurate quantification of changes in geometry and volume in steep terrain over distances of several hundreds of meters (KENNER et al. 2011).

All scans are performed using a Riegl© LMSZ620 (Fig. 4), georeferencing is carried out with differential GPS data. Object distance varies from 50 to 500 m. Data processing is performed using the software Riscan Pro. Final registration of TLS data is carried out by means of multi-station-adjustment.

Figure 4: Terrestrial Laserscanning below the Magnetköpfl (© Ingo Hartmeyer)

Crackmeter

Marked changes in joint aperture frequently point to imminent rockfall events. Joint apertures will be continuously monitored in two localities (Magnetköpfl and cable car summit station) using crackmeters. A crackmeter consists of two anchors installed on opposite sides of the joint and a wire that is fixed between the anchors. Changes in distance between the anchors is measured and recorded by a data logger. Instrumentation with crackmeters currently is in the planning stage.

Atmospheric Monitoring

Knowledge of meteorological variables is crucial for the understanding of future permafrost development. Six weather stations are located within the study area or in its direct vicinity (< 2 km away), permitting continuous observation of external forcing of ground thermal conditions. At the weather stations, which are located at altitudes between 2.400 m and 2.940 m, air temperature, radiation, humidity, wind speed, wind direction, snow height and precipitation are recorded.

Monitoring Implementation

In the preceding chapter the applied methods were introduced. Spatially distributed measurements of near-surface rock temperatures (shallow boreholes, depth: up to 80 cm) and temperature measurements in large depths (deep boreholes, depth: up to 30 m) allow a very precise characterization of the ground thermal regime. Moreover, the introduced combination of methods allows the additional acquisition of surface and atmospheric information. Thus, changes occurring at the surface (e.g. rockfall events) can be directly related to potential subsurface changes (e.g. deepening of active layer), which potentially represents an important step towards the coupling of warming and destabilization trends in steep bedrock.

Even in a relatively small study area like the Kitzsteinhorn summit region it is necessary to define specific monitoring hot spots which are provided with a particularly high instrumentation density. A rough rockfall impact assessment served as basis for the definition of monitoring hot spots. The assessment delivered three comparatively homogenous monitoring scales: the cable car summit station, the Magnetköpfl and the Kitzsteinhorn summit pyramid (Fig. 5).

An occurrence of a rockfall event at the highly frequented cable car summit station would have serious consequences for visitors, employees and the infrastructure itself. Thus, the highest possible monitoring density has been chosen for the immediate surroundings of the station. Here, temperature measurements in deep and shallow boreholes are carried out in combination with ERT surveys. In order to additionally monitor surface changes TLS and crackmeter measurements are conducted.

The second monitoring scale is represented by the Magnetköpfl (2.950 m), a minor neighbouring peak of the Kitzsteinhorn. It is significantly less frequented than the summit station and therefore warrants a reduced monitoring density. Nonetheless, due to the existence of infrastructure and the regular presence of tourists in its direct influence, extensive monitoring has to be carried out in its vicinity. At the Magnetköpfl a high number of shallow boreholes have been drilled and an automated ERT-array (operated by the 'Geological Survey of Austria') has been installed to survey ground thermal conditions. Crackmeter measurements will be carried out to observe joint aperture development.

The Kitzsteinhorn summit pyramid features no infrastructure and is rarely frequented. Probability of harm to man and/or infrastructure as a result of a rockfall event is very low. Monitoring density at this scale level is reduced to spatially distributed measurements of near-surface rock temperatures and TLS campaigns that do not cover the entire summit pyramid due to its size.

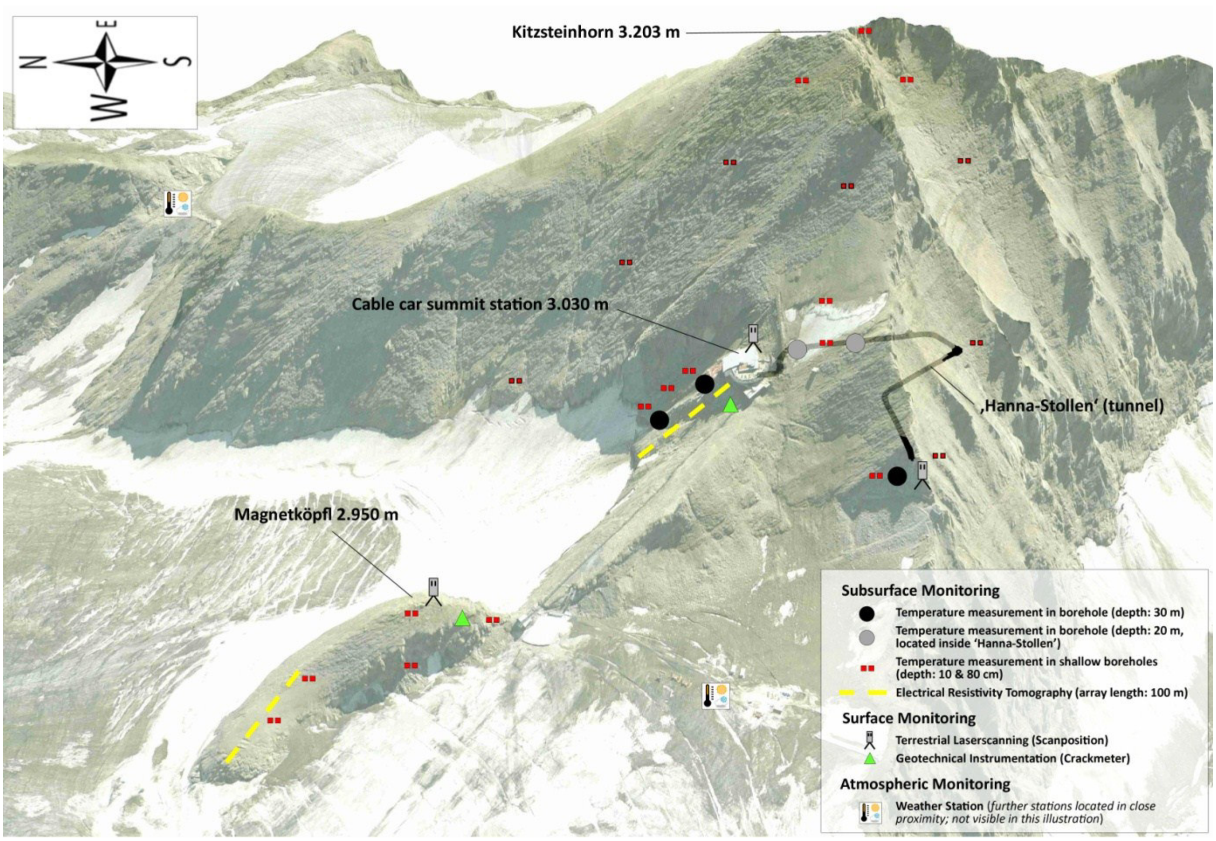

Figure 5: Monitoring installations at the Kitzsteinhorn (© Ingo Hartmeyer)

Acknowledgements

The research project MOREXPERT is supported by several private companies and scientific partners. The authors want to particularly thank Gletscherbahnen Kaprun AG, Geoconsult ZT GmbH, Geodata GmbH, Geolog 2000

Fuss/Hepp GdbR, University of Salzburg, Technical University of Munich, Z_GIS – Centre for Geoinformatics, ZAMG - Central Institute for Meteorology and Geodynamics and the Salzburg Research GmbH for financial, material and intellectual support.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 275 - 278

How restoration measures can affect biogeochemical cycles in protected floodplain areas along the Danube River

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Abstract

Floodplain ecosystems have a strategic role in biodiversity aspects in intensely used catchments and can provide multiple functions and services of importance for human well-being. Especially floodplains in the vicinity of urban areas can be areas of conflicting interests, as it is the case in floodplains in the Danube Nationalpark downstream Vienna. The alteration of riverine landscapes has led to increasing efforts in water management, also concerning rehabilitation and restoration activities, especially in areas of high nature value. The Lobau within the city limits of Vienna for example has undergone severe changes by mainly altered ground- and surface water connectivity and urban development in the last 20 to 100 years which result in various alterations including changes in biogeochemical cycling. In order to estimate the effects of different management options related to conservation and restoration and compare the situation in restored and degraded floodplain systems, nutrient dynamics as key ecosystem properties and functions are analysed. We demonstrate that principles of hydromorphological dynamics control potential greenhouse gas emissions and the nutrient status in the water column and sediment compartments and these can be used as proxies to assess environmental changes in floodplain systems. Changes in hydromorphology as introduced by restoration measures may stimulate nitrogen turnover and can even reduce greenhouse gas emission of nitrous oxide compared to degraded floodplain systems. The results clearly show that increasing hydrological connectivity can impact various ecosystem properties and ecosystem services and these effects have to be considered in a sustainable management approach of highly valuable areas, such as protected areas and national parks.

The example of the Nationalpark Donau-Auen showcase the importance to focus research efforts on remaining intact ecosystems and present the positive impacts of continuous research efforts for improved understanding of river-floodplain systems in general and the value of specific insights for local management decisions.

Keywords

river restoration, large river, nitrogen, nutrient, Nationalpark

Introduction

Floodplains are providing a multitude of ecosystem service, which are of key importance for river systems, acting as biogeochemical hot spots of nutrient cycling and carbon processing. As central sites of nutrient transformation, floodplains can prevent river and even coastal eutrophication (RICHARDSON 2004) and the accumulation of toxic compounds such as heavy metals in their sediments also contribute to these purification effect. In terms of carbon cycling, floodplains play a major role in the recycling and removal of soluble organic carbon released from terrestrial ecosystems (BATTIN et al. 2008).

River regulation severely impacts the ecology and morphology of the river system, including the adjacent floodplains. The majority of floodplains have been lost and with them the associated ecosystem services they provide. These anthropogenic effects can drastically change the structure and function of microbial communities, and also affecting the control and cycling of carbon and nitrogen in rivers (HEIN et al. 2004). Depending on the composition and their activity, these biological units can increase the nutrient spiraling, especially that of nitrogen. Areas of high nutrient cycling activity are found in regions and subsystems coupled with high hydraulic retention - for example, in riparian zones, wetlands, and floodplains. The speed and efficiency of carbon and nitrogen cycles are, along with the composition of the present microbial community, significantly shaped by three principles: the hydro-morphological conditions (e.g. the hydrologic network of streams), the frequency and duration of sediment-river water contact, and hydrological extremes such as high- or low-water phases.

Interventions such as an altered flow regime, or a modification of the river landscape structure, or the interaction between landscape elements leads to changes in the biogeochemical processes, as well as causing a temporal shift of metabolic processes and therefore has a larger impact on nutrient transport and retention.

The presented research summarizes results on the effects of changed surface water exchange on whole ecosystem processes in selected floodplain areas of the Nationalpark Donau-Auen, one of the last remnants of riverine floodplains along the Upper Danube.

Key questions have been how a change in connectivity impact nutrient cycling, expecting a biogeochemical activation following restoration measures. The research was performed in the national park area as these areas one of the last to study the effects under less constrained environmental conditions and furthermore, the results can be used to optimize future measures in this very sensitive stretch.

The article provides a summary of results and more details, especially technical information, can be found in the references cited.

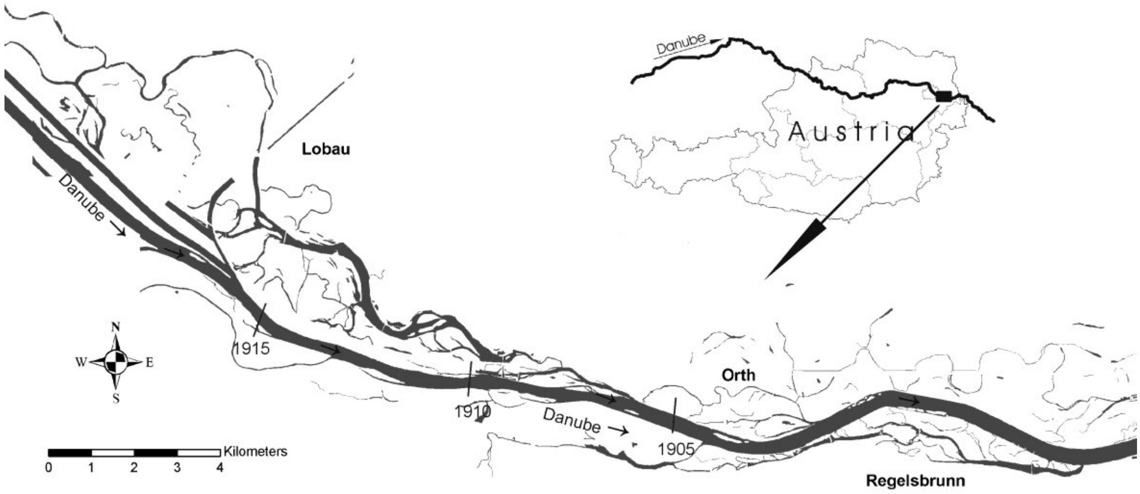

Figure 1: Selected floodplain areas along the Danube River east of Vienna. Insert: location in Austria.

Study Site

The two floodplains, Lobau and Orth, are within the boundaries of the Alluvial Zone National Park, located downstream of the city of Vienna, Austria (Fig. 1). In this area, the Danube River is a 9th order river with a drainage basin of 104 000 km². The flow regime has an alpine character with variable and stochastic patterns (regulated low discharge = 915 m^3s^{-1}, mean discharge = 1930 m^3s^{-1}, annual flood discharge = 5300m^3s^{-1}, 30 year max. flood discharge = 9340 m^3s^{-1}). Following the major regulation scheme in 1875, the Danube River was confined between flood protection dams, thus the main channel was disconnected from the adjacent floodplains.

The Lobau floodplain covers an area of approximately 23 km². As no significant restoration measures have been undertaken within the Lobau floodplain, it is not integrated within riverine flow and in this study, considered as an altered and degraded floodplain based on the altered surface water exchange. Aside from ground-surface water exchange and a controlled small water intake, the primary water exchange with the main channel takes place through an artificial 5m wide breach in the flood levee in the Lobau's south-eastern end (HEIN et al. 2006).

In contrast, the reconnected and restored floodplain Orth, located downstream of the Lobau floodplain covering approximately 5.5 km², is characterized by very diverse flow conditions following restoration measures to increase the surface water exchange. Some side arms in this system have through-flow conditions just above riverine summer mean flow (2230 m^3s^{-1}), while others are connected only at much higher flow conditions. These changes provide the basis to analyse the effects of frequent periods of flow in the floodplain (HEIN et al. 2004).

Results and discussion

The results are summarized in the references listed in the reference section. These results confirm that an increase of surface water connection with the Danube River improved nitrogen removal capacities in the adjacent floodplains (WELTI et al. 2012 a, b, c). Yet, it is not the hydrological connections alone that control denitrification processes occurring in the floodplains – the specific morphology of the site within the floodplain determines the available carbon sources and creates the optimum conditions for denitrification. In controlled laboratory experiments, we demonstrated that denitrification is controlled not only by the supply of nitrate, but also by the available dissolved organic carbon sources found in the water column. River water, although containing less dissolved organic carbon, has a higher carbon quality during certain time periods, which provided the necessary substrate for denitrification. Denitrification rates were shown to increase in areas where the Danube River regularly flooded. Based on the results of the hydrology and ecology, a model was developed to spot potential areas of denitrification during different discharge conditions and during flooding events TRITTHART et al. 2011, WELTI et al. 2012c).

On the other hand, laboratory experiments clearly showed that the phosphor dynamics in sediments are affected by changes in wetting and drying cycles of riparian zones. A more pronounced phosphorus release from sediments can be observed after complete drying of sediments and following frequent dry/wet cycles. The results are presented in SCHÖNBRUNNER et al. (2012). The implication of changes in phosphorus dynamics are discussed in BONDAR-KUNZE et al. (2009).

The most important finding of this research is the role of restored floodplains on overall biogeochemical cycling and major factors influencing N cycling and N_2O versus N_2 emission and the release of phosphorus. We have shown that restoration, by increasing the frequency of inundation will improve biogeochemical cycling efficiency and reduce N_2O emissions from denitrification compared to decoupled systems. Overall, the research improved understanding of the function of different subsystems within a riverine landscape as well as the role of overall transformation capacity, and biogeochemical interplay within floodplain systems and highlighted the importance to restore ecosystem processes such as biogeochemical cycles for a sustainable development of protected areas. The results can be used for the design of future restoration measures addressing nutrient retention aspects.

Furthermore, the new insights can improve the understanding how complex fluvial landscape react on different measures and what overall changes can be expected, also in line with multiple utilization patterns (SANON et al. 2012). In line with some general topics of the conference, the research presented here points to the important role of Nationalpark areas for continuous research programmes such as LTER programmes to understand changes over long term periods including restoration activities and provide science based information for future management decisions.

Acknowledgements

We thank the Austrian Academy of Sciences (Man and Biosphere Program: "Perspective Lobau 2020: Exploring management options of a heavily used urban biosphere reserve confronted with new urban developments in its neighbourhood considering a restricted potential for ecosystem development"), Austrian Science Fund (FWF) project CanFlood (P19907-B17) and Agrarmarkt Austria (LE 07 – 13 "Gewässervernetzung (Neue) Donau – Untere Lobau (Nationalpark Donau-Auen") for financially supporting the research.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 279 - 284

A review of research on *Pinus cembra* in Austria, with special reference to the conservation of genetic resources

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Abstract

Swiss stone pine (*Pinus cembra*) is restricted to the uppermost subalpine forest belt in the Central Alps, and the Austrian high mountain National Parks are important for this species. Climate change threatens this habitat, as an upslope migration "escape" is often not possible. However, this pattern seems to have recurred throughout the post-glacial history.

We would like to present results from a literature and data survey regarding past and present distribution of the species. A striking feature is that many places mentioned in older literature (ca. 1900) as rare outposts often do not seem to have any more trees. Seed harvest data from the past few decades will be reviewed, as well as the establishment of genetic conservation stands and seed orchards. The role of the Austrian National Parks for conserving *Pinus cembra* will be discussed.

Keywords

Swiss stone pine, *Pinus cembra*, conservation, genetics, National Parks, Austria

Introduction

Swiss stone pine has found admirers throughout the recent centuries (e.g. NEVOLE 1914, FIGALA 1928, FUSCHLBERGER 1928), but has also experienced severe set-backs in these environments. The species occupies the upper zone of mountain forests. Geographically, it is restricted to the inner, continental Alps; "outposts" occur in the Carpathians. The upper limit is given by climatic factors. Additionally, high pastures (*Almen*) have depressed the vertical distribution of of *P. cembra*. Apparently, the species had a much wider distribution during the glacial periods, and must have been in contact with its current sister species, the Siberian pine (*Pinus sibirica*). It has thus retreated to The Alps. The *Hohe Tauern* and *Gesäuse* National Parks (plus Biosphere Park *Nockberge*) thus form important refuges at present. Will they be able to maintain this role in the face of climate change? What measures could prevent such a scenario, and what can protected areas contribute to that goal? We will try and summarize current genetic knowledge on this species, in order to guide management and conservation efforts in this critical phase.

Methods

The past and current distribution of *P. cembra* in Austria was assessed on the basis of a literature survey; the Austrian Forest Inventory; databases of gene conservation and natural forest reserves at the Federal Research Centre for Forest Research (BFW); and our own excursions. During visits, the number of trees at a site was estimated, and the presence of young trees was recorded. Sources for genetic information were also drawn from the literature.

Results

The current distribution of *P. cembra* in Austria comprises much of the Central Alps, which are characterised by a more continental climate, from the Vorarlberg to Styria. It is rarer north of the Lower Inn, Salzach and Enns rivers. The North-Eastern limits are *Totes Gebirge* and *Gesäuse* (Fig. 1). The easternmost stands in the Central Alps are in the *Seethaler* and *Seckauer Alpen*. An isolated outpost is *Petzen* mountain in Southern Carinthia. At a visit in autumn 2012, the number of trees present there was estimated to between 30 and 50. In all this distribution area, the tree species is scattered and fragmented.

The Austrian Forest Inventory lists 15 000 ha of stone pine production forests, two thirds of which are forests with protective functions, all in the elevation class of above 1200 m asl. The Austrian Forest Inventory does not cover, however, typical *P. cembra* stands when they are above the timber line. Information was also gathered from stone pine stands present in gene conservation and natural forest reserves. There are approximately 20 entries in a BFW database. All these stands are well within the main "core" distribution area of the species.

When this actual distribution pattern is compared to reports collected more than 100 years ago (NEVOLE 1914), a number of questions arise. Many "outposts" mentioned by NEVOLE (1914) were communicated to him by correspondents (*'Gewährsmänner'*). Many of the locations are on the outer border of the distribution area, for example *Gamsstein* near Palfau. It may be due to an introduction (JANCHEN & NEUMAYER 1942) and has disappeared. Although direct human intervention by cutting and planting blurs the picture, an in-depth comparison may give a clue as to minimum viable population sizes. For example, NEVOLE (1914) reported of a mysterious decline of stone pine in the *Sabathy* area near Judenburg; today, this is a vigorously expanding population, but only few very old trees are present. Given the discussion in FUSCHLBERGER (1928), FIGALA (1928) and PAMPERL (1929) regarding the usefulness or harmfulness of nutcracker birds (*Nucifraga caryocatactes*), it would also be important to know whether people in former times and in certain areas actively promoted or suppressed this bird. Nowadays it is undisputed that the bird and the tree species are symbionts.

Figure 1: The northeastern-most stand of *Pinus cembra* in Austria: *Wolfbauern-Hochalm*, National Park *Gesäuse* (copyright: B. Heinze).

Genetic research was started in the late 1950ies by Kurt Holzer with the selection of phenotypically superior trees for seed production (HOLZER 1958, 1960, 1961, 1969, 1970, 1974, 1989). A collection of grafts of these trees still exists near Vienna ("*Plantage Tullnerbach*"). The last formal report is by FEUERSINGER (1992). His main conclusions are that given the irregular flowering and seed production, a high number of selected trees is necessary for such a plantation. Graftings from trees from continuous stands below the timber line show better growth. Around the timber line, growth is slightly reduced. Trees retain their characteristics when grafted, even after at least 30 years. At the same time as the collection of the material for the grafts, seeds were collected. The resulting seedlings have been planted at *Tullnerbach* and in *Seethaler Alpen*. Both plantings still exist. For *Tullnerbach*, FEUERSINGER (1992) found out that height growth of offspring from trees immediately above the timber line is reduced. Trees originating from above the timber line retain on average one needle year less, and the needles are shorter, but denser. However, further above (approx. 200 m higher in elevation), growth of certain offspring cohorts is very good again. This may be due to the nutcracker's behavior of caching seeds collected in the lower continuous stone pine belts way above the timber line at places protected from too much snow cover (so that the caches are easy to find in winter). The resulting trees retain the genetic information for somewhat faster growth. In *Seethaler Alpen*, thinning has removed trees, but many still stand there. The area is next to a shooting range of the Austrian army and thus difficult to access. The plantation has developed into a quite uniform stand; there are no immediately apparent growth differences among the groups of trees.

At present, 101 forests have been registered for harvesting purposes (ZWERGER 2011). The majority of these are in the Inner Alps. Forty-seven individual commercial harvests of stone pine seeds have been registered between 1998 and 2011 (data provided by T. Franner, BFW). The sum of all harvested cones is 22 711 kg; single harvests are often approaching 1000 kg. The highest numbers of harvesting operations were in 2003 and 2009. Many of the registered seed harvest stands are never harvested. A large part of these seeds are sown in one particular nursery (Nikolsdorf, East Tyrol). A second seed orchard is officially registered as a harvest entity, owned by the Austrian Federal Forest Company ÖBf, consisting of 53 clones. There are no official records of seeds harvested between 1998 and 2011 (seed that is not commercialised by ÖBf does not show up). According to the manager, there is little demand for the seeds.

With the availability of genetic markers, researchers soon had an interest in this species. Probably the first was SZMIDT (1982) who found unusually high differentiation at isoenzyme gene markers. BERGMANN & HATTEMER (1995) did not find big differences in genetic variation between stone pine and *Pinus sylvestris*. LEWANDOWSKI & BURCZYK (2000) found some evidence for self-pollination, but not for inbreeding among related trees, in a stand in Northern Italy. STEFSKY (2001) analysed such markers in tree stands along different altitudes in *Kötschachtal* in Salzburg (National Park *Hohe Tauern*). The markers were less variable than in other tree species, and no meaningful differences were found among the stands or between old and young trees. BELOKON et al. (2005)

analysed a few population samples from The Alps and the Carpathians. They found slightly elevated differentiation among populations, higher genetic diversity in the Carpathians, and also some evidence for inbreeding.

GUGERLI et al. (2001) compared chloroplast and mitochondrial DNA between Alpine (*P. cembra*) and Sibirian (*P. sibirica*) stone pines; both species were very similar. A nearly complete *P. cembra* chloroplast genome sequence in GenBank (Accession No. FJ899574.1; tree from *Turracher Höhe*) is identical to a *P. sibirica* sequence (Accession No. FJ899558.1). GUGERLI et al. (2009) found a gradual decline of chloroplast DNA diversity from East to West in Switzerland. This fits to the evidence from fossil pollen that The Alps were re-colonized from the South-East. HÖHN et al. (2009) analysed samples from The Alps and the Carpathians and again found higher diversity in the East, despite the isolated character of the Carpathian populations.

MOSCA et al. (2012 a, b) analysed a number of nuclear genes in populations from Northern Italy. Some of the genes showed evidence for being affected by natural selection. There were some signs of geographical clustering of genetic variants. Some variants showed clines when compared to winter precipitation values at the sites where samples were collected.

Discussion

A striking feature of the distribution of *P. cembra* in the Austrian Alps is the abrupt eastern border. The stands in *Seethaler* and *Seckauer Alpen* or at *Turracher Höhe* are among the best, yet east of these, no more stone pine stands can be founds. Why do the trees not extend further east? The elevations of the mountains are lower towards the east, and at lower elevations, spruce (*Picea abies*) and larch (*Larix decidua*) are more competitive. However, this is no apparent clue as to why the trees cannot be found on the next mountain to the east of e.g. *Zirbitzkogel* in *Seethaler Alpen*. Similar thoughts apply to the *Hochschwab* massif, where on the other side of the *Schoberpass* road, very nice stone pine forests thrive in *Seckauer Alpen*.

Former reports often tell of over-exploitation (e.g. NEVOLE 1914). It is likely that at the edges of the distribution range, over-exploitation has led to a critically low density threshold. At present, the few trees at *Petzen* may serve as an example. We observed only very few young seedlings and trees. The next natural stands are tens of kilometres away.

A big obstacle in former times was excessive grazing on the high pastures (*Almen*, NEVOLE 1914). Young seedlings were often browsed by the animals. This resulted in very long regeneration times. Nowadays, grazing is not so much of a problem in general, as the pressure for use of the high pastures is gradually diminishing. This gives *P. cembra* a chance to re-colonise such sites. However, this may take very long, as the build-up of a strong humus layer is a prerequisite for growth. Furthermore, in some areas, high game pressure (tolerated for hunting reasons) is a problem.

Climate changes for The Alps are difficult to predict. While a general warming trend can be assumed continent-wide, it is as yet unclear what exact consequences this will have for subalpine and alpine ecosystems. Will there be more or less precipitation than today – will there be a shift in precipitation between summer rain and winter snow – will there be different temperature trends for summers and winters? Stone pine seems to be very tolerant of “continental” type climate extremes. However, the species’ competitors, larch, spruce and mountain pine, may become even more competitive. In general, an uphill “escape” is often not possible for orographic reasons. This applies especially to the Outer Alps. Under this aspect, the Central Alpine National Parks gain great importance for conservation of stone pine (Fig. 2). Given its overall slow regeneration process, there may be a critical phase in the near future.

Figure 2: A vital stand of P.cembra in National Park Hohe Tauern, where upwards migration seems possible: Stubachtal (copyright: B. Heinze).

At the same time, emphasis should be put on the genetic resources that may get lost in the Outer Alps. Active conservation measures may include the silvicultural removal of competing tree species, the support of any possible local upwards shift in stone pine distribution, and even re-planting. It would be problematic if management concepts prevent such active measures, e.g. in National Park *Gesäuse* where an outpost of stone pine still holds out. If all this is not feasible, the work by Holzer on grafting offers a possible way to conserve the genetic variants from such areas where the species may disappear soon. Such graftings could be a source of seed in the future. Plants from such seed can be translocated to areas where growing conditions remain good for the species.

The current stone pine stands in the northern parts of Vorarlberg, Tyrol and Salzburg, any remaining trees in southern Upper Austria, and the very vital populations in *Seethaler* and *Seckauer Alpen* should thus be constantly monitored for any signs of problems under climate change. Measures should be prepared for the case of such problems becoming apparent.

While the majority of stone pine forests are regenerated by natural means, it is evident that current seed harvest and planting practices do not promote genetic diversity. It would be desirable that seed be collected from all the registered seed stands. The laboratory genetic investigations already indicate lower levels of genetic variation, and a further reduction may cause problems of inbreeding in the future.

GUGERLI et al.'s (2009) observation of a gradual decrease in genetic richness from east to west also fits to BELOKON et al. (2005) and HÖHN et al. (2009). The surprisingly vigorous appearance of the easternmost populations in Styria (*Seethaler* and *Seckauer Alpen*) and the presence of the relict population at mount *Petzen* all point to a centre of genetic richness in Eastern Europe, and that The Alps were colonised from there in the form of a "retreat" during post-glacial warming. The easternmost populations in Austria should therefore receive special attention for conservation.

Conclusions

- An in-depth comparison of the number of sites, and trees at a site, reported previously and present today may give a clue as to a minimum viable population size.
- The altitudinal cline in genetically controlled growth should be taken into consideration for seed harvests.
- The stands on the easternmost edge of the distribution in Austria deserve special attention for conservation, as they are close to former glacial refugia and may still harbour high levels of genetic variation. Additionally, the northern- and southernmost stands should be actively monitored. Problems should be alleviated by silvicultural intervention.
- Decreasing pressure from grazing on high pastures (*Almen*) helps the species, but high game densities and slow regeneration mean that it will take very long for visible effects.
- There are orographic limitations for an upwards "escape" from climate change effects; the Central Alps National Parks are vital for the survival of the species.
- Techniques for the conservation of germplasm (grafting) should be utilized for emergency measures of saving material from extinction.
- Current seed harvest practices should be improved by expanding the range of stands harvested.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 285 - 288

Bird communities in distinctively mixed alpine forests of the Ennstal Alps in the Gesaeuse National Park

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Abstract

Bird communities as an important component of many ecosystems and their special characteristics, such as the good detectability (NIPKOW 1995) or the high autecological state of knowledge (NOWAK 1982), led to considering the following question for this work: which forest inventory parameters (for example the composition of tree species or the amount of deadwood) have an influence on the avifauna of the Gesause's alpine forests? Starting from this question, twelve research sites where spatially set along a gradient of closeness to nature, differentiated by two components: the amount of deciduous wood respectively coniferous wood, and the size of the forest complex. Three bird inventories have been executed by using two different methods (point stop count and line transect count) on these research sites between mid-April and mid-June. The bird data obtained from these surveys were initially analyzed with principal components analysis and subsequently, in combination with forest parameters, in multivariate analysis. Based on the insights gained in these analyses about the effects of forest structure on ornithocoenosis, indicator species for three different characteristics of the Gesaeuse's mixed alpine forests could be derived. After that, the transferability of the results to the practical work in the Gesaeuse National Park, especially the differences between the two mapping methods, were examined. The comparison of the two mapping methods revealed that the line transect count provided significantly more reliable and more descriptive results than the point stop count and that the latter may cause an underestimation of biodiversity in near-natural mixed alpine forests. In addition, targets have been suggested to preserve and promote precious forest structures for ornithocoenosis of the mixed alpine forests in the Gesaeuse National Park.

Keywords

bird communities; ornithocoenosis; avifauna; mixed alpine forest; forest inventory; Ennstal Alps; Gesaeuse National Park; point stop count; line transect count

Introduction

The birdlife is an important component of many ecosystems. Their particular suitability as an indicator with regard to conservation-related planning is partly due to the following characteristics:

- good detectability (NIPKOW 1995)
- high autecology and faunistic state of knowledge (NOWAK 1982) at a manageable species richness
- close relationship to habitat and spatial structures (NIPKOW, 1995) and thus good comparability of population density studies in similar landscape units (STEIOF 1983)
- high sensitivity to environmental changes (STEIOF 1983; RUTSCHKE & KALBE 1980)

This high performance indication of the birds was the decisive reason for using avifaunal studies for the development of the Gesaeuse National Park. Thus in 2000, the breeding bird communities in montane and subalpine regions of the Buchsteingebiet (in the north of the Gesaeuse National Park) were mapped (ZECHNER 2001). Issues related to the change of bird communities along an altitudinal gradient were part of a thesis prepared in 2008 (KLOSIUS 2008). There are also monitorings of selected, for the European nature conservation particularly important breeding bird species (such as Tetraourogallus, Ficedulaparva or different woodpeckers) as part of a LIFE project (LIFE05NAT/A/78) as well as numerous works on various species (especially to Tetraoninae). However, studies regarding the most dominant forest community in the Gesaeuse National Park area, the mixed alpine forest with their locally very diverse characteristic forms, and the ornithocoenosis in these characteristic forests are missing so far. Even natural mixed alpine forest are "refuges of many endangered bird species", such as Tetraourogallus or Dendrocoposleucotos, attribution to the structural diversity of these forests "caused numerous ecological niches" (SCHMIDT 1997). Therefore this work is dedicated to the Gesaeuse's mixed alpine forest and especially considers the following question: which forest inventory parameters (for example the composition of tree species or the amount of deadwood) have an influence on the avifauna of the Gesaeuse's alpine forests? Therefrom indicator species were derived for certain characteristics of mixed alpine forests. Finally, it was considered which bird mapping methods are both feasible for the national park's work/staff and can provide useful results (point stop count or line transect count), taking into account that the areas are difficult to access and completely closed for the public.

Methods

Research sites

Four regions in a potential distribution area of the mixed alpine forests in the Gesaeuse National Park were selected as test areas. First, they are different in actual vegetation as a result of silvicultural use (gradient from near-natural forest to heavily silvicultural used forests). Second, the embedding of the test areas into the alpine landscape was considered (gradient from embedded in large forest complexes to interdependent small forest complexes with other small forest habitat and land use types). The concrete specification of the twelve research sites, the mapping points (100 m radius for the point stop counting) respectively the walking line (200 m belt for the line transect count) was set with special consideration of accessibility and walkability. The numbering of the sites 1 - 12 follows a gradient of closeness to nature which is substantially based on the tree species composition of natural mixed alpine forest. Comparability was ensured by keeping the defined conditions: all areas are at altitudes between 500 and 850 meters above sea level and at southeast facing slopes.

- Area 1 Hagelwald (Sites 1 - 3):

  Fairly inaccessible and thus also by the forestry marginally influenced areas in the northeast of the national park. Characterized by a near-natural mixed alpine forest, which forms an largely closed, continuous forest complex of approx.190 ha (Fagussylvatica 53 %, Piceaabies 22 %, Acer pseudoplatanus 9 %, approx. 10 % woodless).
- Area 2 Gesause-Eingang (Sites 4 - 6):

  A near-natural mixed alpine forest in a small forest complex (70 ha), isolated by spruce forests, in the west of the national park (Fagussylvatica 55 %, Piceaabies 33 %, other conifers approx. 5%; other parameters similar to area 1).
- Area 3 Scheibenbauer (Sites 7 - 9):

  Close to the first, very natural area, a mosaic-like textured area of semi-natural mixed alpine forest and silvicultural used forests (260 ha). Deciduous and coniferous tree species as well as the age of wood are roughly balanced. The stocks are mainly closed and the area is comparatively poor on the amount of deadwood.
- Area 4 Gstatterboden (Sites 10 - 12):

  The Gstatterbodener caldron is one of the formerly intensively used areas in the center of the national park. The proportion of the non-natural, non-native spruce forests (coniferous about 70 %) is accordingly high in this approximately 140 ha forest complex.

Bird inventories

For detecting the bird communities of the different research areas, the point stop count and line transect count method were applied. The principle of the line transect count is to traverse a transect along a predefined route with normalized step speed and to record all acoustically and visually perceived birds (BIBBY et al. 1995). For this work, a continuous route of 900 meters (divided into sub-sections, each 300 meters) was specified in each of the four research areas. In contrast, for the point stop method, all individuals are acoustically and visually counted at defined points. The counting points were directly located on the walking route of the line transect count. This way it was possible to combine both surveys. Each of the twelve research sites was committed three times beetween April and June. To ensure the comparability of the data collected, all surveys were proceeded in the early morning and only on days without strong wind, fog or rain (according to BILCKE 1982; BIBBY et al 1995).

Forest inventory parameters

A large part of basic data for creating the parameter data set to describe the forest habitats could be drawn from existing data sets. Forest data collected by the Steierische Landesforste and the Gesaeuse National Park for a forest management plan represented the central part of the parameter data set. Key parameters were for example: tree species composition, growth class, stage of forest development, tree heights, overall structure, wildlife ecological parameters, deadwood. Data from the Alpine Habitat Diversity project (HABITALP interpretation Key II, see BFN 2002) were used to refine the composition of tree species. In addition, the coverage of the herb and shrub layer on the study areas was recorded with a standard sample method according to CYR & OELKE (1976).

Statistical analysis

The statistical analysis can be divided into three phases. In the first phase, the forest inventory parameters of the twelve study sites were compared. Exploratory and descriptive tests were executed. The H-test according to Kruskal-Wallis resulted in a list of parameters that are significantly different from each other. With the U-test according to Mann-Whitney, the significant differences of the research sites were analyzed. In the second phase, the bird data were examined for similarities. Therefore cluster analysis and correspondence analysis (PCA – Principal Component Analysis) has been executed. To determine significant differences between the research sites, also H- and U-tests were executed. In the third phase, both data blocks were analyzed together to question the relationships between birds and habitat. For this purpose, first the previously executed principal component analysis has been overlaid with the forest parameters and the Spearman correlation to the axes was calculated. Subsequently the bird data was merged with the forest parameters by multivariate analyzes (CCA - Canonical Correspondence Analysis). These three analysis phases were executed separately for both the point stop count data and the line transect count data.

Results

Bird inventories

During the line transect count 42 bird species composed of 887 individuals were mapped. As expected in mixed alpine forests, the most common type was Fringillacoelebs with a share of more than 16 % of the total sum of the individuals, followed by Parusater (14.88 %) and Erithacusrubecula (11.61 %). Especially in area 1 a significantly higher density of individuals was observed (32 species, 263 individuals). Area 4, as the formerly intensively used research area, was about 16 % lower in species richness (30 species) and 7 % lower in individual richness (220 individuals). The least differences were found between area 3 and 4. The point stop count resulted in 29 bird species and 412 individuals. The most common species were as in the line transect count Fringillacoelebs with a share of almost 20% of the total sum of individuals, Parusater (15.29%) and Erithacusrubecula (10.92%). However, comparing the individual research sites, the results of the two mapping methods differ significant. The biggest difference was between the areas 1 and 4 (species turnover of 31%) and 2 and 4 (species turnover of 33%). The cluster analysis confirms the limited precision of the point count data. Only the coniferous dominated areas 3 and 4 were successfully clustered. Also the principal component analysis of the point count data resulted in significantly worse separation of the areas compared with the results of the line transect data (especially in the deciduous woods).

Bird inventories and forest parameters

An overlay of the results of principal component analysis with the forest inventory parameters revealed significant correlations of both mapping methods (e.g. deciduous wood, coniferous wood or the amount of deadwood). The canonical correspondence analysis with the line transect bird data and the forest inventory parameters of research sites resulted in a very plausible outcome: bird species such as Paruscaeruleus, Pyrrhulapyrrhula, Carduelischloris or Sittaeuropaea, with a main distribution in area 1, were unique to the near-natural forests. Turdusviscivorus, Paruspalustris and Dendrocoposleucotos were completely limited to area 1 (single counts). Dryocopusmartius and Phylloscopusbonelli were only counted in area 1 and 2, and also point to near-natural conditions. Other species such as Bonasabonasia, Turdusphilomelos, Regulusignicapillus or Scolopaxrusticola, with the main distribution in area 4, were characteristic of coniferous woods. The canonical correspondence analysis of point stop bird data and the forest inventory parameters came, compared to the line transect analysis, to quite different results. Noticeable is a large dispersion of the counting points in areas 1 and 3, which is the consequence of an insufficient number of samples in the point count method, especially in deciduous rich areas. The statistical analyzes showed how the mapped species react to different habitat characteristics and which forest structures are largely responsible for it. As the most valuable manifestations of mixed alpine forests of the Ennstal Alps in the Gesaeuse National Park, three types could be defined: (1) natural, deciduous and deadwood rich types, (2) natural, clear types, and (3) shrub and herb-rich coniferous-dominated types. Considering existing studies (ZECHNER 2001; SACKL&SAMWALD 1997) and the results of this work, indicator species to these three "target forms" where derived and provide a basis for monitoring programs.

Conclusions

Method comparison

Comparing the two mapping methods, a number of differences was found. The most remarkable difference is the small amount of point count data, especially in the first area. This might be due to the fact that it is easier to detect species in relatively heterogeneous areas with the line transect count method. This is also confirmed by BIBBY et al. (1995). Accordingly, coniferous-dominated, homogenous forests could be comparatively well recorded with the point stop count method. However, surrounding effects (as the near spruce forests in the small, isolated area 2) can hardly be detected with the point stop count method. In addition, a significantly lower number of Sittaeuropaea and rare species have been mapped with the point stop count method. This had an negative influence especially in the species-richness of areas 1, 3 and 4, were for example significant species such as Phylloscopusbonelli, Bonasabonasia or Scolopaxrusticola have been overlooked. A detailed interpretation of the forest data only with the point count bird data, such as the derivation of indicator species, would not have been possible. The results lead to the conclusion that the line transect count method is more appropriate for the heterogeneous forest. Alternatively, a significantly higher number of counting points would be possible, but regarding the accessibility of the research sites it is getting quickly ineffective (too unfavourable data volume/cost ratio).

Indicator species

Due to the consideration of the indicator system for the Gesaeuse region (ZECHNER 2001) and the relations between the different forest "target forms", the transferability of the indicator species system to other mixed alpine forests is possible (see also KOCH 1976; of KLOSIUS 2008). Relatively uncertain is the transferability to mixed alpine forests at lower elevations (<500 meters above sea level) respectively in the Alpine foothills.

Relevance of forest structures

If a forest management in the National Park is necessary at all, it should be done under the model of a near-natural forest management, to help establishing site specific and thus richly structured and natural forests. With regard to the support of bird communities of the Gesaeuse, ZECHNER (2001) already suggested possible management measures. Because of the complexity of forest habitats, it is necessary to find certain parameters that achieve the widest possible impact. Therefore, special attention should be paid to the following forest parameters for the mixed alpine forests in the Gesaeuse national park: tree species composition, herb and shrub layer, wood ages, deadwood and habitat trees.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 289 - 294

Use of Modern Information and Communication Technology in Large Protected Areas

Sabine Hennig, Robert Vogler & Matthias Möller

Abstract

Several management objectives of large protected areas involve information and communication activities. This particularly refers to management actions in terms of recreational use and tourism, environmental education, visitor information, and public relations. However, due to the advance of modern information and communication technologies (ICT), the way we exchange and share information, communicate and catch up on content changed remarkably in recent years. Today, communication processes are strongly linked to the use of Web 2.0 tools running on desktop computers and mobile devices. This offers unique and innovative opportunities for information and communication work in general. Such benefits and challenges of modern ICT are relevant for large protected areas as well and thus should be kept in mind.

But, to what extent modern ICT is used in large protected areas? How do these sites leverage modern ICT for their information and communication activities? The current situation has been investigated, on the one hand, through an online survey of large protected areas in Germany, Austria, and Switzerland. On the other hand, web sites and tools implemented by these sites have been studied. Best practices examples were found, challenges and opportunities became obvious. Based on this, selected application areas of modern ICT in large protected areas are presented in this paper.

Keywords

modern ICT, Web 2.0, information and communication activities, recreational use, environmental education, public relation

Background and research question

Information and Communication Technology (ICT) is progressively embedded in many aspects of our daily lives. Related applications are widely used in business and public administration organizations, as well as for private purposes (URL 1). Meanwhile, (modern) ICT has become a major force of changes in modern societies showing impact on social, economic, and political concerns (SCHNORR-BÄCKER 2004; WORK 2010).

While ICT, in general, encompasses all issues related to enable transmission of digital information between humans, modern ICT refers to the so-called new media, saying the Internet and associated aspects (OECD 2003; SCHNORR-BÄCKER 2004). Modern ICT is closely linked to Web 2.0, which covers a wide range of interactive, dynamic applications allowing for exchange and cooperation between users (ZEW 2010). These applications are running on both, desktop computers and mobile devices such as smartphones, tablets or pocket PCs, which are used to a growing extent by society (TNS INFRATEST 2012; URL 2).

As highlighted in literature (see e.g. MECKEL 2008; SCHNORR-BÄCKER 2004), the use of modern ICT shows strong impact on human information and communication structures: Related tools enable fast and easy access to large amount of actual information (benefitting e.g. from multimedia elements, links etc.). In response to technological possibilities, users' attitude towards these tools also changed: Today, users request customizable applications and information that is tailored to their needs and personal preferences (content, design, output mode etc.). Furthermore, they are eager to share and publish own opinions, experiences, and ratings on the Internet. The growing importance of this so called user generated content is closely related to users changing from passive information consumers to active information producers (LANGE 2007). This is facilitated by interactive functions, permitting for participation and cooperation. Among others, they provide opportunities for online discussions, online evaluation processes, establishing and maintaining contacts as well as online community building.

The possibilities offered by modern ICT are also interesting for large protected areas, encompassing nature parks, national parks, and biosphere reserves. This is particularly true for the manifold information and communication activities playing a key role in large protected area management objectives in terms of recreational use and tourism, environmental education, visitor information, and public relations. For protected areas the relevance of modern ICT use is underlined by research revealing the steady increase of Internet usage and growing demand for digital information directed towards their web sites on behalf of their visitors (see e.g. EBERLE 2009; HENNIG et al. 2012). But in practice, what does the use of modern ICT in large protected areas look like? How are different Web 2.0 components used? Which suggestions can be derived in order to improve benefits from using modern ICT? These questions have been investigated on the case of large protected areas in Germany, Austria, and Switzerland.

Methods

To gain insight into the use of modern ICT in large protected areas, a questionnaire was conducted among according sites in Germany, Austria and Switzerland. This took place during the first half year of 2012. In accordance, with basics and methods of empirical social science research, the questionnaire was prepared using SurveyMonkey (www.surveymonkey.com), a free online questionnaire and survey software. Primarily, the questionnaire focused on revealing and assessing the use of multimedia elements (photos; videos; audio files; and virtual tours), geomedia (static web maps; interactive, dynamic web maps; Web GIS; and route planners), social media tools (blogs and forums; newsletters; and social media platforms like Facebook), and different types of applications running on mobile devices (apps, eGuides, geocaching).

The data collected through the web-based questionnaire was preprocessed (e.g. data cleansing) and statistically analyzed (using SPSS 20). Afterwards and based on the questionnaire results, selected web sites and tools provided by large protected areas were studied in detail. Attention came up to content, structure, and design of these sites as well as implemented Web 2.0 components.

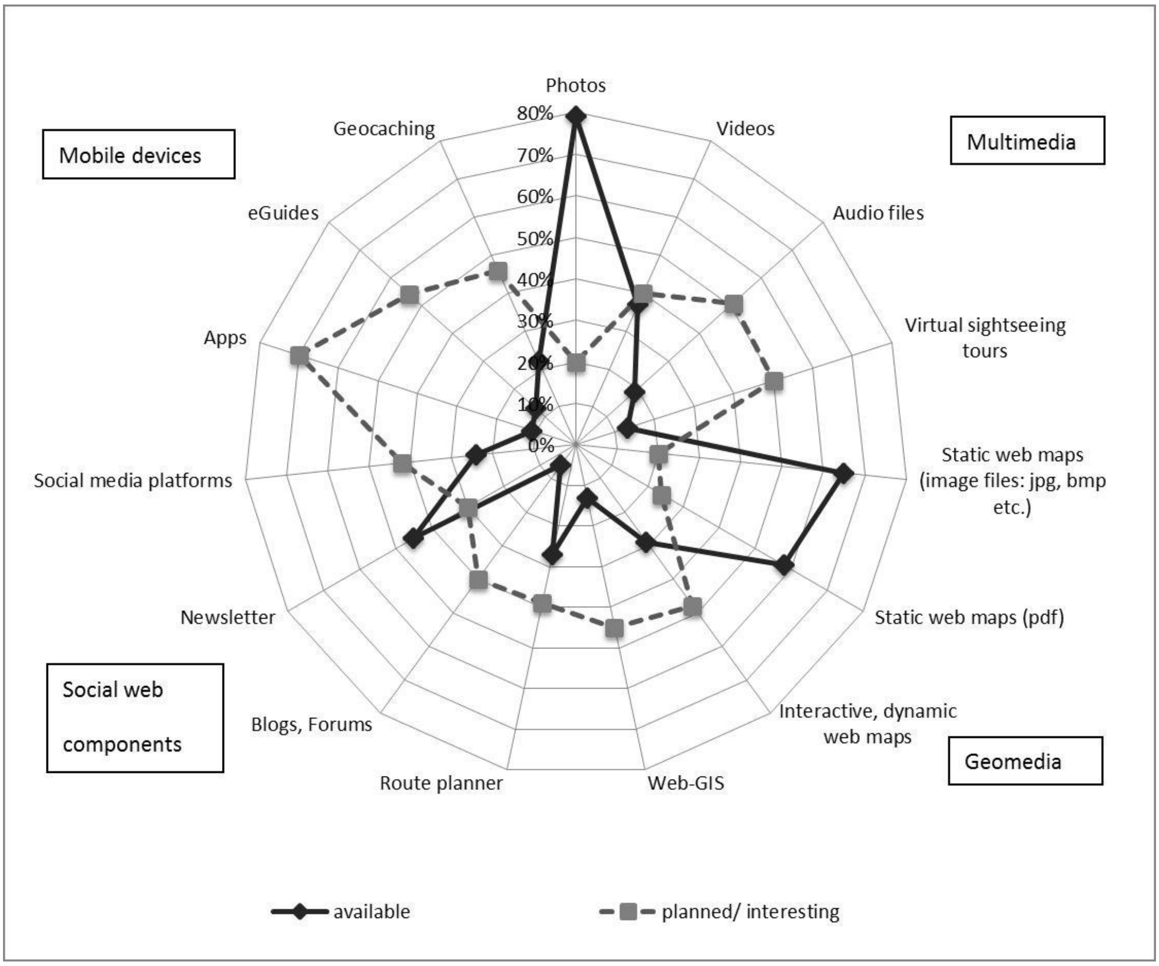

Figure 1

Results

The web-based questionnaire was sent to 138 large protected areas; 62 (45%) participated in the survey. In detail, 38 (61%) questionnaires were answered by German, 18 (29%) by Austrian, and 6 (10%) by Swiss protected areas. While national parks showed most interest in the survey (80%; 16 of 20), this was a little less in biosphere reserves (67%; 16 of 24) and considerably less in nature parks (32%; 30 of 94).

The overall study revealed that, in general, large protected areas make use of ICT to a quite different extent. The results in figures are comprehensively presented in Figure 1 and Table 1, and are shortly described in the following:

1. Particularly relevant for most sites are multimedia elements and geomedia: While photos and static web maps are widely used, videos, audio files, virtual tours, interactive, dynamic web maps, Web GIS, as well as route planners are considered to be interesting topics and/ or are planned to be implemented in the near future.
2. Social web component are deemed differently: Some large protected areas regard the use of these tools as quite useful, offering unique opportunities for information and communication work; others suppose them to be useless for their purposes.
3. Concerning mobile devices it has to be stressed, that even though only few applications are available, they are seen as highly interesting.

Table 1: Examples referring the use of modern ICT and web2.0 components in large protected areas (nature park NP, national park NLP, and biosphere reserve BR) in Germany Deutschland (DE), Austria (AT) and Switzerland (CH)

Modern ICT/ web 2.0 components		Examples	
Multimedia	Photo	Image gallery	NLP Schleswig-Holstein. Wattenmeer (DE)
		Slide show	NP Lauenburgische Seen(DE) BR Schwäbische Alb (DE)
		Linking (e.g. Flickr)	NLP Donauauen (AT)
	Video	Embedded objects	BR Südostrügen (DE) NP Ötscher (AT) NLP Schleswig-Holstein. Wattenmeer (DE)
		Linking (e.g. Youtube)	BR Entlebuch (CH) BR Südost-Rügen (DE) BR Oberlausitz (DE)
	Audio files	Audio podcasts	NLP Hohe Tauern (so called NLP-Radio) (AT) NLP Schleswig-Holstein. Wattenmeer (DE)
		Verbal description on the website	NLP Harz (DE)
	Virtual sightseeing tour	3D-flight	NLP Hohe Tauern (AT)
		(Interactive) panoramic image	NLP Hainich (DE)
		Google Earth animation	NLP Hohe Tauern (AT)
		Animated image show	NL Sparbach (AT)
Geomedia	Static web map (image files: jpg, bmp etc.; pdf)	Location, nature environment	NLP Berchtesgaden (DE) NP Barnim (DE)
	Interactive, dynamic web map	location/ direction (to find the site; within the site: regarding hiking, biking tours etc.); information related to the site	NLP Donauen-Auen (AT) NLP Hainich (DE) NLP Bayerischer Wald (DE) Schweizer NLP (CH)
	Web-GIS	Information related to the site	NLP Hohe Tauern (AT)
	Route planner	Arrival, on-site excursions	BR Mittelelebe (DE) Schweizer NLP (CH)
Social web components	Blog/ Forum	Posts covering different topics	NLP Donau-Auen (AT) NLP Thayatal (AT)
	Newsletter	News, Events etc. (e.g. via sms service)	NP Zillertaler Alpen (AT) Schweizer NLP (CH)
	Social media platform	Linking (e.g. Facebook)	BR Schwäbische Alb (DE) NLP Hohe Tauern (AT) NLP Schleswig-Holstein. Wattenmeer (DE) NP Altmühltal (DE) BR Oberlausitz (DE)
Mobile devices	App	Information related to the site	BR Vessertal-Thüringer Wald (DE) NLP Hohe Tauern (AT) Schweizer NLP (CH)
	eGuide	Information related to the site	Schweizer NLP (CH)
	Geocaching	Geocaching (basic information, GPS data)	NLP Hohe Tauern (AT) NP Diemelsee (DE)

Discussion on raising opportunities

Despite the existing extent of use of modern ICT, these tools can provide large protected areas a lot more opportunities. This is highlighted below.

Multimedia Elements

Multimedia is an important aspect of Web 2.0. Photos and videos open up possibilities to present large protected areas in an impressive way. Furthermore, the use of multimedia elements allows to provide the diverse user groups with tailored content and material. Since *different* media address *different* senses, the availability of *different* media facilitates the users to make a choice of information channels suitable to their personal preferences, abilities and needs (WEIDENMANN 2006). This is particularly relevant, bearing in mind, that some user groups are characterized by very specific requirements. Examples therefore are disabled people (e.g. the visually impaired) as well as the elderly (HENNIG et al. 2009; NEUSCHMID et al. 2012). Both demand for accessible ICT products (URL 3).

Thus regarding web accessibility, multimedia elements open up unique opportunities (NEUSCHMID et al. 2012). This is well shown by the website of Eifel National Park (see URL 4). Meeting accessibility guidelines (see e.g. URL 5), user interface and interactive functions (design output, interaction mode etc.) are implemented to improve accessibility and usability of this site: Users can control font size and contrast settings (between font color and background color). They can switch between different versions of the web site: a text-based version, a version offering to the user clear, comprehensible content in simple language, a version using video to deliver content via sign language.

Geomedia

On the Internet, geomedia plays a increasing role, today. This is reflected in rising numbers of static and interactive, dynamic web maps (e.g. embedded Google Maps objects), whose availability, meanwhile, is taken for granted in many situations (ORIGEL-GUTIÉRREZ 2004; THIELMANN et al. 2012). These cartographic products are mainly used to support people in navigation and orientation, as well as to find addresses. Furthermore, relying on interactive functions available in dynamic web maps (e.g. zoom, pan, access to context information using information windows adding multimedia elements), users are enabled to explore an area and become geographically informed without being there personally (PETERSON 2008). This also applies for web maps integrated in protected area web sites (see Table 1).

However, interactive, dynamic web maps provide further advantages: Due to its spatial contextualization, maps and cartographic presentations improve the understandability of the information visualized. The visual access to data and/ or information enables to convey information in a fast and powerful way. It is essential, well-known and generally accepted, that visually communicated contents are easier to access and understand than textual ones (PAIVIO 1986). WOOD (2010) states, that maps – and above all interactive, dynamic maps – are very powerful and useful tools for publishing and communicating spatial referenced content, and to encourage users to explore areas by themselves. JEKEL et al. (2010) underline, that maps fulfill relevant functions to impart information using interactive functions, and thus to enthuse users for the presented content.

These aspects are relevant for protected area management objectives as well. Properly developed web maps open up innovative presentation opportunities for information and communication activities in terms of recreation, tourism, and environmental education: On the one hand, information and education topics can be communicated benefitting from the spatial reference of infrastructure and natural attractions. On the other hand web maps can be explored by the users themselves and thus support the planning of visits as well as visitor management objectives (guiding visitors, attracting or avoiding the visit of some locations).

Social Media

In the past years social media applications – and in particular social media platforms (e.g. Facebook) – gained in importance for many domains. Since large parts of society use such tools frequently and regularly, business and public administration organizations began to integrate social media platforms to a growing extent in their communication strategies (URL 1).

Concerning their functionalities, these applications are based on so-called social networking services (SNS). They constitute the framework for user registration, identity management, contact management, information exchange (personal messages, chat, pin board etc.) as well as group building (EBERSBACH et al. 2008). Leveraging SNS, social media applications and platforms offer the opportunity to generate and use a wide range of interesting and useful data (KÖRNIG-PICH et al. 2010). In part, such data already exists (owing to contact management, posts etc.), and just needs to be recognized. Moreover, users can be contacted and asked directly to get, i.e. gather, relevant information. Hence, large protected areas have the possibility to answer open questions on their visitors: Which main visitor target groups can be outlined? What is (most) interesting to them? How to deliver information to different user groups in a tailored way? This can provide background for the development of (on site) management measures, suitable for different visitor groups (see e.g. HENNIG et al. 2009).

Applications running on mobile devices

One type of modern ICT applications which is deemed to be very attractive by large protected areas are the ones running on mobile devices. However, to date there are only few applications available to the users, i.e. visitors of protected areas (see Figure 1; Table 1). Mostly, they are used to convey information on site (focusing the protected area, natural and cultural attractions, the region etc.). Here it has to be underlined that – among others, by benefitting from GPS and LBS (locational-based services) – a wide range of innovative opportunities arises from using these tools:

- Topics and aspects which can be observed and encountered directly in nature, i.e. on site, can be explained comprehensively using actual information as well as multimedia elements and geomedia, and benefitting from links to additional interesting and related aspects and topics. On the one hand, information provision can be optimized and enlarged; on the other hand, information presented can vary in content, depth, and amount as well as the media used. Hence, information can be delivered in a customized and personalized way (e.g. referring to needs on accessible ICT products) focusing on different user groups, i.e. visitor groups.
- Interactive functions support for different modes of information presentation. This can motivate the users to experience and discover aspects directly on-site. Therefore, different ways exist: learning by play (e.g. by

Quizzes, leveraging geocaching), learning through own research (e.g. animating for personal experience and discovery), and learning through emotions (e.g. engaging all senses).

- Relying on the possibilities of Web 2.0 to facilitate and foster user participation, involvement, and collaboration everyone can be invited, i.e. encouraged, to publish and share opinions, experiences, and impressions somehow related to the site. Thus, people can enrich information and communication processes by their (valuable) input and become part of an online "protected area" community.

Conclusions and Outlook

The research (questionnaire and web site study) shows that modern ICT is manifoldly used in large protected areas. In doing so, these sites pay attention to actual and very relevant social trends. Since, by the mean of "technology", large parts of society (particularly youngsters) can get into nature and related topics, numerous, innovative opportunities arise to get people involved.

Generally, it seems that large protected areas are still not tapping the full potential of modern ICT use. In order to increasingly benefit from it, a lot of intense work is still necessary. This refers to the design of modern ICT applications being more user and task-oriented as well as improving the outlook and interaction capabilities of web sites, i.e. applications' usability and accessibility. Furthermore, to effectively and efficiently use and integrate modern ICT for protected area work, specific (didactical) concepts should be considered. Approaches can be adapted from different fields such as e-learning and learning with geoinformation.

Concerning this, the queried protected areas stressed scarce financial and personal resources which play a pivotal role for the implementation and maintenance of modern ICT applications. Therefore, several interviewees highlighted the need and relevance of exchange of expertise.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 295 - 298

Wildlife Management in Protected Areas - Goals and Concepts

Sven Herzog

Abstract

Wildlife management is a challenge for nearly all European large protected areas and their management concepts. In many cases, wildlife and wildlife management is connected with major conflicts between different stakeholders such as nature conservationists, farmers, fishermen, foresters, hunters, tourists and others.

The reasons for that phenomenon are manifold, but in most cases they are resulting either from the fact that wildlife itself underlies certain utilization interests within the (existing or planned) protected area and/or from the mobility of large wild animals, wandering out of protection zones into the adjacent cultivated landscapes.

Thus, the success or failure of protected areas in many cases critically depends on the question, as to how the wildlife management question will be solved and if the wildlife management concept is well established and integrated into the general concept from the beginning.

The present paper deals with the question, how wildlife management concepts including monitoring systems are to be developed for different goals of protected areas, how the different approaches will fit into the conservation concepts of a certain protected area and what instruments such as participatory processes are to be engaged to accomplish acceptance in the public as well as from the different stakeholders.

Keywords

Wildlife management, conservation concept, protected area, hunting, land use

Introduction

During the last decades, a lot of large protected areas have been established in Central Europe. This might be due to an increasing appreciation of nature conservation in a general public and thus in politics since the 1970s. Conservationists are celebrating this expansion of protected areas, but in many cases they do not agree, how these areas are to be managed in the best way and what the underlying purpose should be (NAUGHTON-TREVES et al. 2005). Political acceptance also does not exclude local conflicts between nature protection and other stakeholders, especially other land users such as agriculture or forestry.

Wildlife, concretely wild animals often are the catalyst of those conflicts, either due to damages in agriculture or forestry, for fear of large predators or because of the expectance of further restrictions to traditional land use such as agriculture, forestry, fisheries or hunting. These negative expectations are often caused by bad experiences with nature conservation administration or the respective nongovernmental organizations (NGOs) in the past. This phenomenon may be reinforced by the exponential increase of land under legal protection over the past decades (see e.g. NAUGHTON-TREVES et al. 2005).

Thus, the long-term success of a protected area critically depends on how the interactions between man and wildlife will be managed.

Beside the typical situation of wild animals being part of the protected area´s goals, several other scenarios have to be taken into account.

So, the management of species causing crop or vegetation damages outside (and sometimes in very special situations also inside) the protected area may also be addressed by the wildlife management concept as the management of e.g. introduced and maybe invasive species, or of large predators.

Additionally, a comprehensive concept for integrating (or excluding) certain, mostly traditional methods of utilizing natural resources such as freshwater fishing, hunting or beekeeping into the protection concept seems necessary.

Definition

A consistent definition of the term „large protected area“ is yet lacking and eventually it might be not meaningful: size is relative, and an area considered in e.g. Central Asia to be relatively small may be recognized in Europe as extraordinarily large.

Also IUCN (ANONYMUS 1994) categorization does not primarily consider the size of an area, but the goals. Practically, we will consider coherent protected areas of at least 5000 hectares. Smaller areas will be also taken into consideration if they are homogeneous management units such as a larger forest complex within an agriculturally dominated landscape.

In addition, we should keep in mind that wildlife management concepts should not only include the protected area itself but also the surrounding cultural landscape. This aspect should be one of the major future challenges in ecological management.

Wildlife management-wildlife regulation- hunting ?

The term „wildlife management“ often is mixed up with „hunting“ or „regulation“ (or, synonymous “control”), but we should clearly differentiate between these terms and their respective meanings.

Wildlife management includes all activities to influence wildlife population with respect of certain goals, and thus this term is the most comprehensive.

However, as CAUGHLEY & SINCLAIR (1994) assert, such a definition “may be too restrictive for some, who would argue that many of the problems of management deal with people and therefore that education, extension, park management, law enforcement, and land evaluation are legitimate aspects of wildlife management and ought to be included within its definition”.

In contrast, “hunting” is a traditional, extensive and –at least in most parts of Europe- sustainable form of land use (see HERZOG 2011).

So, any sustainable hunting activities need wildlife management measures.

Vice versa, hunting itself also may be included into the set of wildlife management tools. In that case, the biological and ecological effects of hunting, *i.e.* especially either the impact on abundance of a species or the benefits from e.g. habitat improvement will be used by and integrated into a management concept. “Regulation“ strives for influencing the number of individuals of a certain species in a certain area, either to make it increase or to make it decrease, mostly by increasing or decreasing mortality.

Regulation often, but not necessarily, occurs as a secondary effect of hunting activities. Contraceptive medicals, capturing and consigning animals, or killing animals by special extermination methods (as applied for *Anser anser* in The Netherlands, ANONYMUS 2008) are examples for regulation methods beyond hunting. On the other hand, e.g. vaccination of red fox (*Vulpes vulpes*) against rabies is not to be classified as a regulation method of the red fox, although it may also influence mortality.

Thus, “regulation” can be looked at as a subset of wildlife management. Also regulation may be carried out by using the mortality effects of hunting, but it is not equivalent to “hunting”.

Large protected areas: management objectives

Large protected areas may have a wide spectrum of objectives, more or less derived from or connected to the six categories established by IUCN (ANONYMUS 1994). Categories I and II are mainly focussed on the preservation of biodiversity by minimizing utilization of natural resources, whereas the other four categories are to be managed for different objectives connected with the sustainable utilization of natural resources. Thus, different categories of protected areas need different concepts of wildlife management within and also outside the protected areas.

During the history of any large protected area, the objectives may be subject of change.

In dependence on CAUGHLEY & SINCLAIR (1994), we can disclose several categories of goals, as there are for example:

- Conservation of landscape and scenery, maybe in connection with several animal species of human interest (example: Lueneburger Heide reserve as one of the oldest large protected areas in Germany)
- Conservation of certain plant and/or animal associations (example: “beech national parks” in Germany and South-Eastern Europe)
- Conservation of biodiversity (including genetic variation)
- Conservation of a set of ecological, genetic, behavioral, evolutionary and physical processes and the coevolved compatible populations which participate in these processes (FRANKEL & SOULÉ 1981).

The latter approach typically is part of the IUCN categories I and II and was continuously modified and refined during aftermath. Later *e.g.* it was called „natural regulation“ (see PICKETT et al. 1992) or, in the German-speaking part “Prozesschutz” (see. *e.g.* SCHERZINGER 1990, 1995, 1996, NEUSCHULZ 2000). This concept basically prohibits any utilization or active management. The idea is to exclude any anthropogenic influence. Obviously, this concept cannot be maintained consistently, due to *e.g.* nitrogen inputs from the atmosphere or climate change. Beside that, a consistent concept of “natural regulation” as it is a demand for the major part of any national park, should exclude any direct or indirect utilizations or even management influences. Thus, tourism, forestry, agriculture or agro-forestry, pest control, wildlife management, hunting, fisheries have strictly to be excluded. This demand often is foiled by national legislations, e.g. tolerating or even promoting tourism in national parks.

However, if the concept of natural regulation will have a stake in the future, it has to be applied either in a strict way or it should be abandoned, and the goals of the protected area have to be adapted or changed. Otherwise, the concept will be considered not to be a scientifically well-grounded approach.

Wildlife management concepts

Wildlife management concepts are to be adapted primarily to the objectives of the protected areas.

The most interesting case might be that of "natural regulation". This requires to abandon wildlife management completely within the protected area or at least within a defined "natural regulation" zone. However, because our protected areas in Central Europe are relatively small and animals are regularly wandering out of these areas, there will be a strong need to influence those animal populations that may lead to conflicts in the periphery. These are especially ungulates, large predators and invasive species.

Concerning large predators, as a first step a reintroduction program is worth to be discussed in many cases. Even such a reintroduction process is not covered by a "natural regulation" concept. Thus, reintroduction efforts are to be placed outside the "core areas" of natural regulation. Large predators are assumed not to be self-regulating in our densely settled countries. Thus, if we need some down-regulation of population sizes later on, this has also to take place outside these areas.

For large ungulates such as wild boar (*Sus scrofa*), red deer (*Cervus elaphus*), fallow deer (*Cervus dama*), mouflon (*Ovis ammon*) or even moose (*Alces alces*) or European Bison (*Bison bonasus*), we can determine that normally (exceptions see below) there will be no "damages" within protected areas. "Damages" by browsing or barking are a problem of cultivated landscape and are normally excluded by definition in protected areas. However, (apart from some interesting actual findings, MEIßNER et al. 2012) the home-ranges of these animals are covering hundreds or more of hectares. They will not respect the boundaries of protected areas and thus we face the risk of increasing damages in agriculture or forestry outside the area.

To maintain acceptance of the large protected areas, management measures should help to avoid those influences. Thus, either regulation or hunting should be integrated into management concepts. It would allow a down-regulation (or even up-regulations, if necessary) of population sizes of the species in question.

Regulation or hunting should take place outside the core ("natural regulation") areas. If we decide to abandon hunting activities, a concept of ungulate regulation, typically based on professional hunters should be established. In many cases, it should be possible (and much less expensive than professional hunters) to establish or maintain traditional hunting as a management tool. In that case, the objectives of the hunters have to be adjusted to those of the protected area, especially hunting restrictions in space and time are do be defined and communicated to the relevant stakeholders.

To reach a balance between the different demands and interests, a well-moderated (!) participatory "bottom-up" process might be helpful. Wherever the national legislation will allow that way, it should be chosen. Instead of the obligatory (top-down) way, with involvement of policy makers and lobbyists, an approach that includes persons and parties directly involved seems to be more promising (HERZOG et al. 2010). This approach may also be chosen in other situations, e.g. the establishment of large protected areas or the establishment of natural regulation concepts, if conflicts with agriculture or forestry are imminent.

Roe deer as a small, territorial ungulate will normally not influence the surrounding areas, so there will be no need for hunting or regulating roe deer.

If there are protection objectives such as the maintenance or the establishment of certain phytocenoses, even roe deer and other wild ruminants may become a problem if it is present in high densities. In these cases, a well defined management concept including hunting should be helpful: e.g. a focal hunting concept, supported by an overwintering concept and a concept for wildlife rest areas and visitor direction is required. These last-mentioned tools in general are also applicable if conflicts with ungulates will arise along the external boundaries of a large protected area.

A special but also typical situation of large protected areas is the occurrence of introduced or even invasive species. This heterogeneous group, including a lot of taxa from Amphibia to Mammals, has to be treated individually. So, the story of mouflon is a very interesting one. Introduced to central Europe from the Mediterranean during the last centuries, this animal is not part of the local fauna. However, the Central European population is in fact a large *ex-situ* gene conservation project, since the "original" island populations are close to extinction. Additionally, this species would perfectly fit into grazing approaches, being part of nature protection concepts maintaining open landscapes (see e.g. BUNZEL-DRÜKE et al. 2008).

Another example is racoon (*Procyon lotor*), influencing several highly endangered species by predation. However, this species requires a very intensive predator regulation or hunting, but we do not know if it would be possible to extirpate this species.

Both examples share the problem, that there is no "right" or "wrong" solution. Any case should be considered thoroughly and any decision would be a very individual one.

Monitoring

One important part of any wildlife management concept is monitoring. Especially in the last mentioned cases, monitoring often serves as a "stopgap", but monitoring is more. It is an indispensable tool to evaluate any management measure in a large protected area.

So, if we decided to manage a species (and "management" may also be "leave-it-alone-and-keep-an-eye-on-it"), we should asses the management by an appropriate monitoring concept. There is a wide spectrum of methods, beginning with "classical" abundance monitoring such as hunting bag analysis (in protected areas often not meaningful), snow tracking, pellet-count methods and many others. In addition, for maintenance of acceptance, a socio-economic or socio-cultural monitoring would be helpful.

As for the management concept, it holds also true for the monitoring concept that it has to be individually adapted to the objectives of the protected area in general.

Consequences for establishing protected areas

As it has been shown in few words, wildlife management of large protected areas critically depends on the general goals. Thus, wildlife management cannot be easily adapted *ex-post* as an additional module.

Moreover, a clear zonal structure of a large protected area is an important precondition for operating certain wildlife management concepts, and this in turn is a precondition for certain protection objectives, such as natural regulation.

When establishing a protected area, it seems from our today´s point of view indispensable, to develop an integrated approach covering the total set of objectives and the total set of management concepts and methods.

Integrating traditional land use such as hunting or fisheries into the wildlife management concept is possible in principle. However, we should not mix up different strategies. For example, hunters can help to reach certain objectives of a large protected area (not only regulation of abundance). In return, if we would like to integrate hunting into certain management concepts, we have to accept also the objectives, customs and traditions of hunters.

We should not leave the subject of large protected areas without talking about the question for the adequate category of such an area. Actually, we have a strong tendency in central Europe to higher categories (i.e. I and II following IUCN), leading to an increasing number of national parks and –latterly- wilderness areas. As discussed above, it seems often to be hard to fulfil the requirements of the respective category. This leads to the concept of "developing national parks", what means that the area does not achieve the requirements e.g. for a national park. But because a national park is desired from political reasons, the large protected area will be declared to be a "developing national park" that maybe will fulfil the respective criteria in say 30 years. In these cases it often would be better to start with a lower category that may be managed adequately, and keep the option of an "upgrading" in mind. This would help us to concentrate our energy on adequate management efforts instead of wasting resources in long-lasting conflicts between stakeholders.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 299 - 306

Utilization History of Alkaline Fens in the Natura 2000 Area Ödensee Salzkammergut New Strategies for Future Management

Karin Hochegger, Renate Mayer, Claudia Plank, Andreas Bohner, Jakob Schaumberger

Abstract

Alkaline fens (7230) are species-rich ecosystems. They are the habitats for many rare and endangered species. For example, the distribution of *Euphydryas aurinia* is mainly restricted to fens in the protected area Ödensee, Salzkammergut. Fens of this area were originally disturbed by peat cutting which was ceased in 1926. Today, the fens are in different stages of succession according to their past management. To define future management, it is important to understand and learn from the cultural history of these sites.

Fens of this area are characterized by a wide range of different management practices like low-intensity cattle grazing, mowing or clearing of scrubs as well as long periods of abandonment. The diversity of past management results in today`s biodiversity. Interpretation of aerial photographs over the past 60 years and a survey of the cultural history enable a better understanding of future needs.

Today`s management is mainly based on agricultural subsidies. With the ongoing structural change in agriculture new strategies and innovative solutions are needed for future management. Approaches for common strategies and instruments are developed by the INTERREG SEE project BE-NATUR.

The objective is a transnational management of habitats and species. The implementation contains the compilation of a GAP Analyses, the development of Action Plans for selected species and habitats on wetland areas as well as direct and indirect interventions at site level.

- Research on the use of marsh hay for horses or bedding
- Restoration of fens by water management
- Using horsepower to cut and harvest fens
- Long-term monitoring

Given the scientific expertise, management measures are now being implemented in selected areas for direct intervention. Monitoring the project is the basis for the targeted development of the areas, in accordance with the Natura 2000 management plan requirements.

Keywords

management strategies, succession of alkaline fens, conservation practices, traditional land use of wetlands

Introduction

Alkaline fens are peat forming wetlands that receive nutrients from sources other than precipitation and are characterised as wetlands which are mostly occupied by peat- or tufa-producing small sedge and brown moss communities. Usually, they develop on permanently waterlogged soils with a nutrient-poor, base-rich, calcareous water supply which results in rather neutral to alkaline milieu (OPW 2009). Above the timber line there are biotopes that remain stable on the long term. Below they have to be cultivated in some way to prevent reforestation (Ellmauer 2005).

Today 14 ha of raised bogs and seven ha alkaline fens remain at the Natura 2000 site Ödensee from an originally far bigger complex of bogs in the area (Pock et al. 2011). Therefore, conservations aims have to ensure future management of these alkaline fens. The presented research work aims at comprehending the utilization history of some alkaline fens of the Natura 2000 site Ödensee over a period of 150 years. The results should support decisions for future management of the site.

Research Questions

What ist to be learnt from the utilization history of alkine fens in the area? Can managment strategies be improved to appoint expertises and knowhow of traditional landuse systems? What kind of management methods are used for the continuing protection?

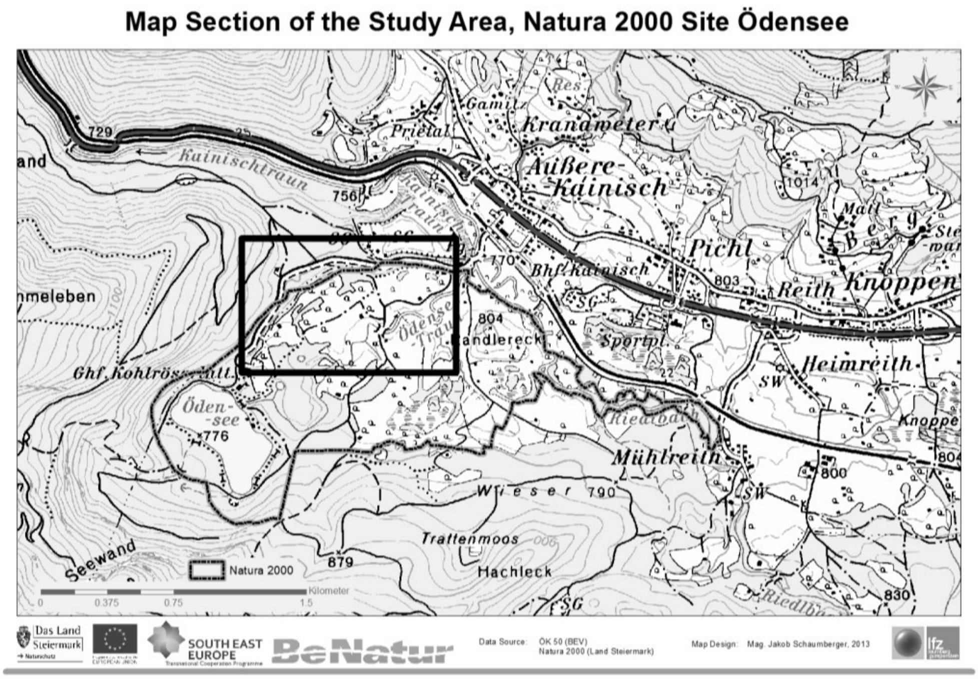

Figure 1: Study Area

Methods

Interpretation of historic maps as well as aerial photographs over the past 100 years and a survey of the history of landuse by a survey of farmers in the area. A SWOT analysis of land use management methods including employment of special tolls and machines for wetland areas. Comparison of the change of biodiversity in relation to manegment methods.

Analysis of the Utilization History of Alkaline Fens from 1875 to 1926

From a historic map (1875) and photographs taken in 1923 we can tell that the development of most of the alkine fens oft he area is of secondary origin. Large-scale peat cutting and draining resulted in massive destructions of bogs and the develompent of extensive alkaline fens. Peat cutting was necessary for the production of salt. Dried peat was transported to Bad Aussee by horse and ox. There peat was burnt to heat up the salt solution where valuable salt remained after the water had evaporated.

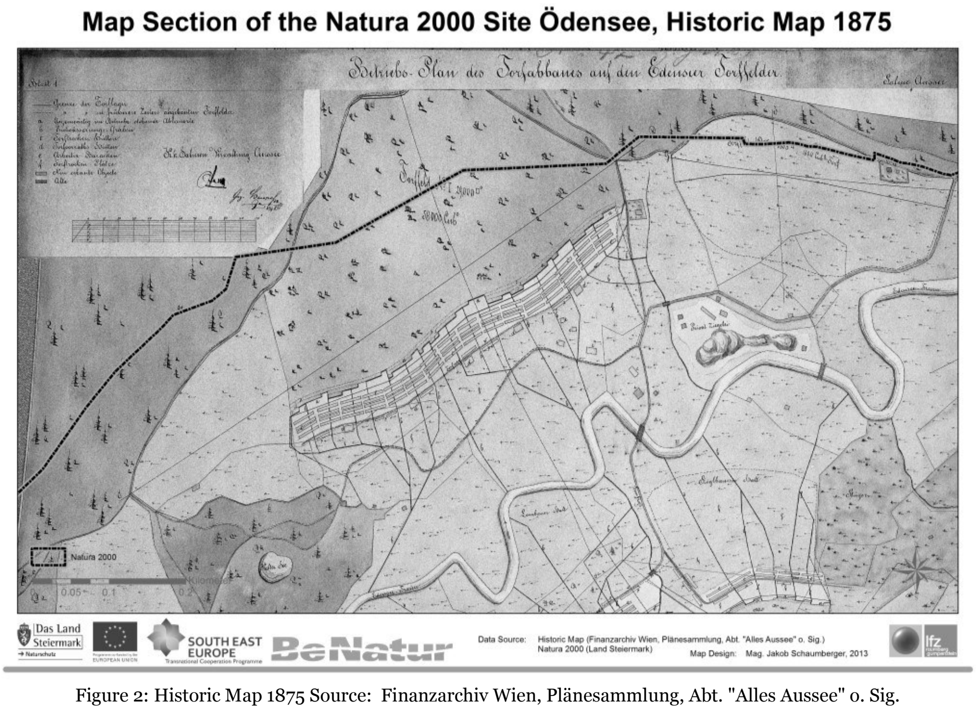

Figure 2: Historic Map 1875 Source: Finanzarchiv Wien, Plänesammlung, Abt. "Alles Aussee" o. Sig.

Alltogethet three peat areas with a total amount of 104.800m³ are presented on the map. The boundary of the potential peat and bog area is marked with a red line. In the section of our detailed investigation, with number I, the amount of peat is estimated with 58.000 m^3. Probably half of the amount was actually cut until 1926, leaving only about one third of the raised bog undisturbed. The broken red line shows former peat cutting areas. It seems that the older peat cutting areas, shown in green on the map are already covered with vegetation. Today different biotope types can be found in these areas as indicated in figure 7, where the FFH biotope types are seen on the historic map . Biotope types in the former peat growing areas are as follows: 7120, 7230, 6410,91D0 (POCK et al. 2011).

Simultaneously to the process of peat cutting drainage ditch were build. On the map they are marked with *b*, and lead directly to the next small river. Today some of these ditches still exist. Marked with *a* are the cutting areas which can be seen in the photograph of the next figure. Peat up to three meters in height was cut.

Land Use 1926-2012

In 1926, peat cutting ceased and the area was abandoned. Natural succession took place and vegetation could establish in disturbed bogs. Due to the high groundwater level of the site alkaline fens developed. The first aerial photographs made in 1953 show intensive agricultural utilization. Narrow plots were distributed among farmers of the next village for cutting of hay and bedding material. Narrow drainage ditches were built between the plots. The ownership of this area was never private, but state-owned.

After the second world war, the first motor mowers were introduced in the area, thus enabling regular mowing. The harvested hay was either used as bedding material for cows or as hay for horses. For the use of bedding material the hay was cut in a length of 6-10cm. It had very good quality as litter in terms of drawing capacity as well as producing very good manure. On the other hand, the harvested hay could be used to feed workhorses. In comparison to cows, horses need a higher content of row fibre with lower protein content. Therefore they can utilze hay of alkaline fens, which is traditionally harvested in autumn. **Traditional land use after the second world war could make valuable use of alkaline fens.** A farmers survey revealed that traditional land use consisted of regular mowing with motor mowers in autumn without any input of fertilzers and further on the area was not used for grazing. **Biodiversity of the sites could benefit of traditional agriculture.**

A paper from 1977 decribes the site as follows: After peatcutting the area is covered with vegetation of alkaline fens. Spruce, birch and poplar have established. Partly the sites have been drained for agricultural utilization (DAXLER 1977).

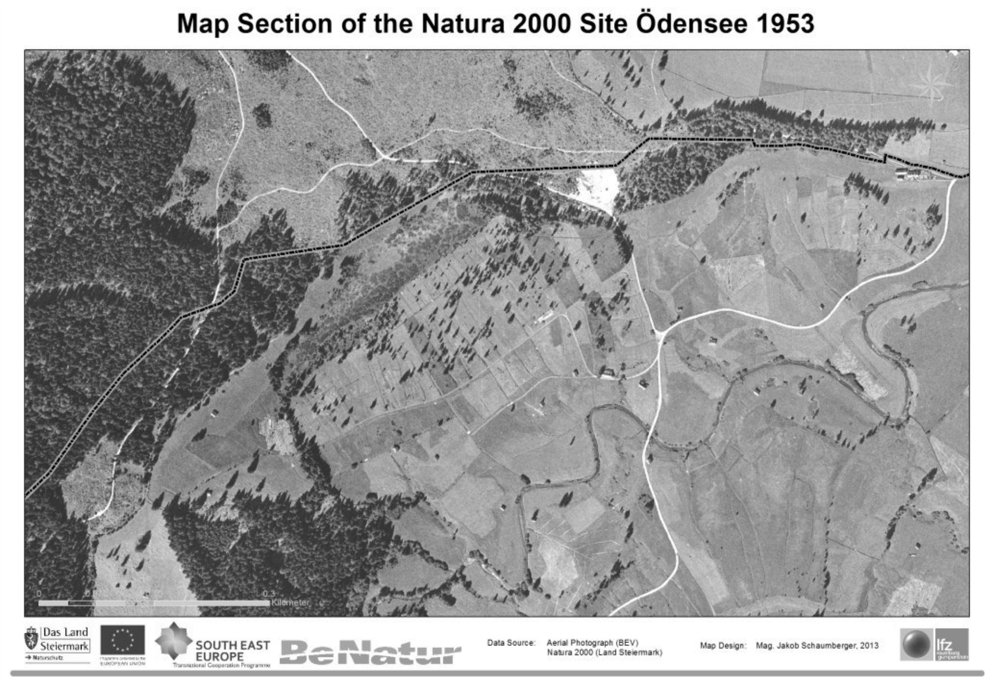

Figure 3: The aerial photograph shows the agricultural cultivation of the former peat cutting area.

1980- 1995 with ongoing structural changes in agriculture the sites were abandoned. Workhorses and manual labour were abolished, straw was bought and tranported from other regions. As a result trees and shrubs, especially spruce trees colonised the site. From 1980 up to 1995, aerial photographs show no sigificant changes, except spruce trees becoming more dominant.

In 2002 with raising consciousness about bogs, a renaturing project started. The site was partly cleared of spruce trees, the ditches were damed to raise ground water level. The aim of the project was the conservation of the site by preventing the growth of trees and scrubs by raising the ground water level. This was achieved through partly clearing Spruce trees, as well as damming the ditches to raise ground water level.

From 2002 to 2012, after the removal of spruce trees, more Alder Buckthorn started to colonise the site. From 2005 to 2012, different efforts were made to remove shrubs and little spruce trees by manual work.

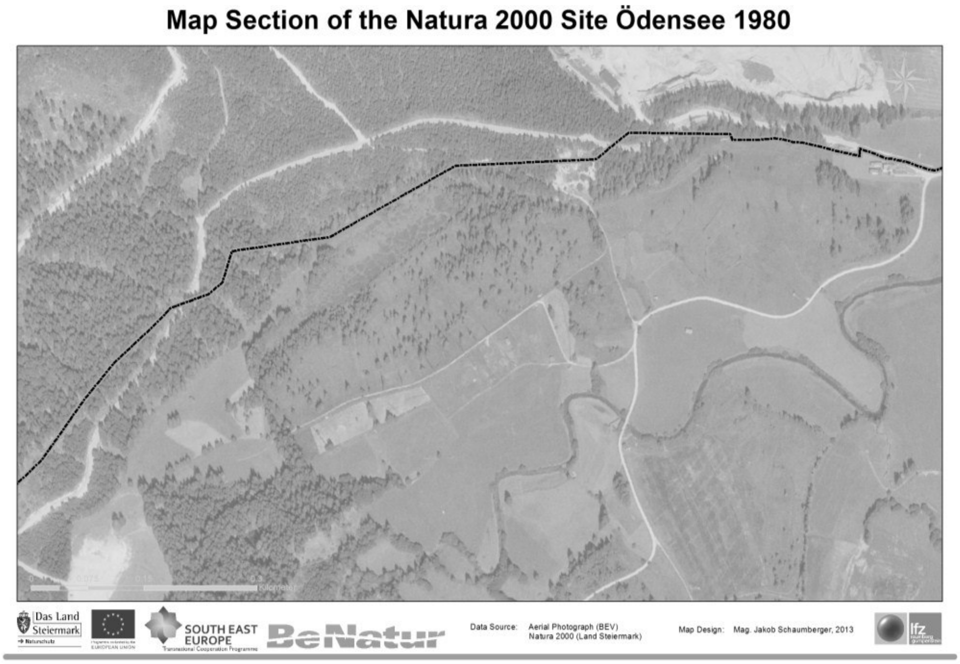

Figure 4: The aerial photographs shows that the site was abandoned and that spruce trees have become more dominant.

In 2010, the site was evaluated and a management plan defined the conservation aims. Protected and endagered species of the site species were defined (table1). The successional state in transition to woodland is the main challenge for future management. Without regular utilization the site will be quickly reforested. Management and restoration of fens for conservation often aims to maintain the species composition of a fen community at a specified stage along the natural transitional process, which can only be achieved by intervention, in the form of management.

Table 1: Protected and endagered species of the site

Protected and endagered species of the site	
bog rosmary	*(Andromeda polifolia)*
round-leaved sundew	*(Drosera rotundifolia),*
marsh orchid	*(Epipactis palustris),*
fragrant orchid	(*Gymnadenia conopsea*)
Heath spotted orchid	(*Dactylorhiza majalis*)
Common marsh orchid	(*Dactylorhiza maculata*),
globeflower	(*Trollius europaeus*),
bog-bean	(*Menyanthes trifoliata*),
musk orchid	(*Herminium monorchis*)

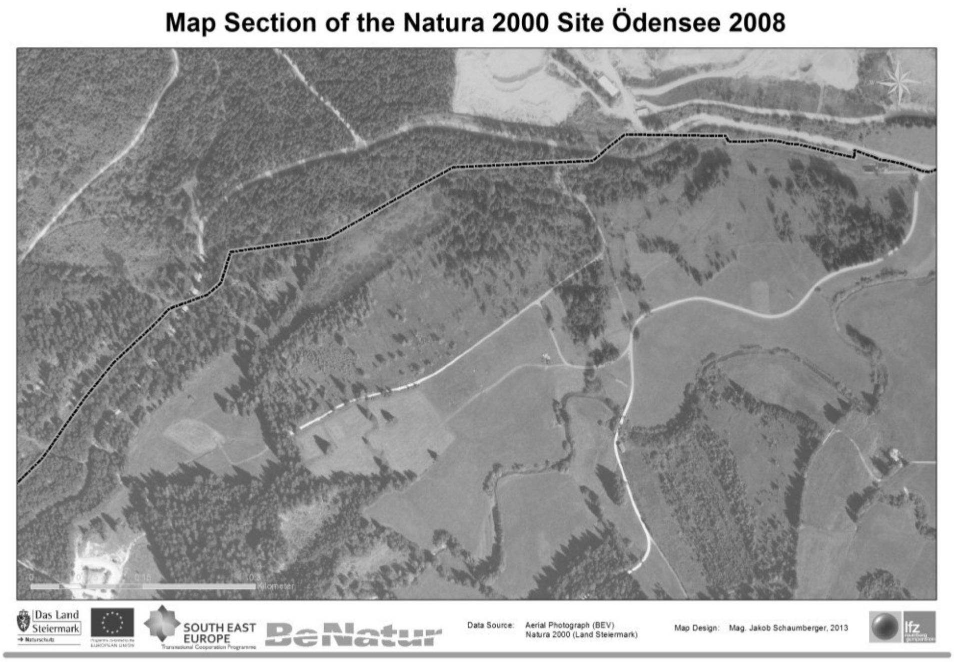

Figure 5: The site was partly renaturated by damming the ditches and removing big spruce trees.

Discussion

Based on the Utilization History of the Site, different Periods of Land Use can be defined:

1. Massive destruction of bogs with the complete loss of biodiversity
2. Recolonisation and natural succession of the former peat cutting areas with increasing biodiversity
3. Traditional land use after the second world war with low impact and high biodiversity
4. Abandonment and intensification with loss of biodiversity
5. Management and conservation to maintain biodiversity

Overlapping the historic map with the map of FFH biotope types (fig 7)various conclusions and research topics for future management can be drawn.

- The difference between secondary and primary alkaline fens in the area can be defined (see fig. 7, 7230)
- Secondary habitats of alkaline fens after peat cutting are quickly colonised by scrubs and trees, a process that is accelerated by nutrient enrichment and drainage around or within the site (91DO). The woodland that develops has wildlife interest but cannot support many of the species of open fen. The decision has to be made whether succession to a forest like state is preferable or wether the open character should be preserved. The latter will ask for different management measures.
- Alkaline fens of secondary origin have not been managed by extensive grazing. According to farmers marsh soil is too squashy.
- Primary alkaline fens in the area tend to be more stable. That could be due to different soil conditions with the absence of a layer of peat. Today, primary alkaline fens are still under cultivation and mowing can be acomplished with tractors (see fig 7, FFH 7230).
- The area where no FFH biotopes are marked is mostly covered by coniferous woodland, detailed investigation on the potential of these areas by removing spruce trees should be planed.
- In the former area of peat cutting a woodland biotope (91D0) established after the decline of traditional landuse like mowing for horse hay. Todays decision has to be whether a forest like state or an open vegetation is preferable.

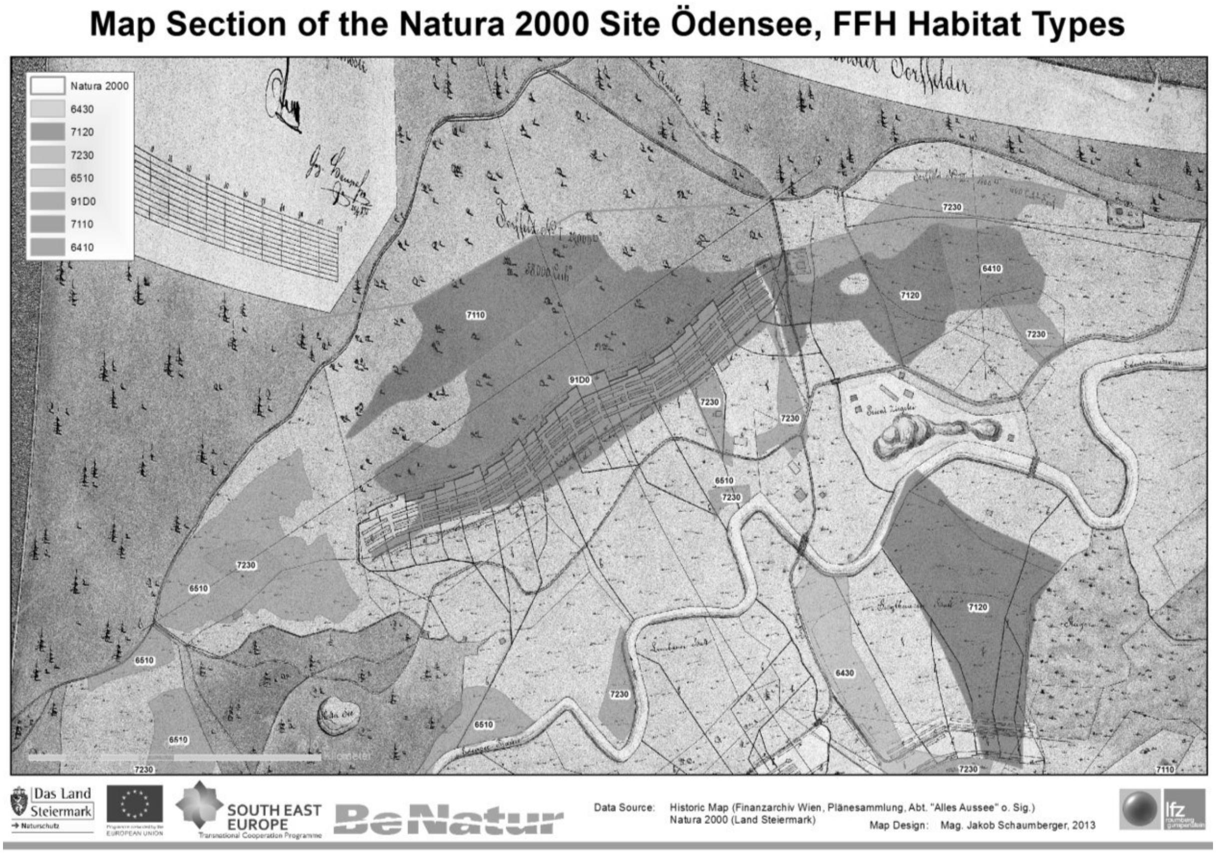

Figure 6: FFH Biotope types overlapping the historic map.

Actual Situation, Basic Approach for further Management

Today`s problems of management are based on massive destruction 200 years ago.

In summary, we can observe that from a former area of raised bogs estimated at 20 ha, two hectares remained undisturbed. About 18 ha of former peat cutting areas are occupied by different vegetation types today, some of wihich belong to the FFH biotope types of the protected area.

Today`s management is mainly based on agricultural subsidies. With the ongoing structural change in agriculture new strategies and innovative solutions are needed for future management. Approaches for common strategies and instruments are developed by the INTERREG SEE project BE-NATUR.

The objective is a transnational management of habitats and species. The implementation contains the compilation of a GAP Analyses, the development of Action Plans for selected species and habitats on wetland areas as well as direct and indirect interventions at site level. The Action Plan for alkaline fens brought the following results:

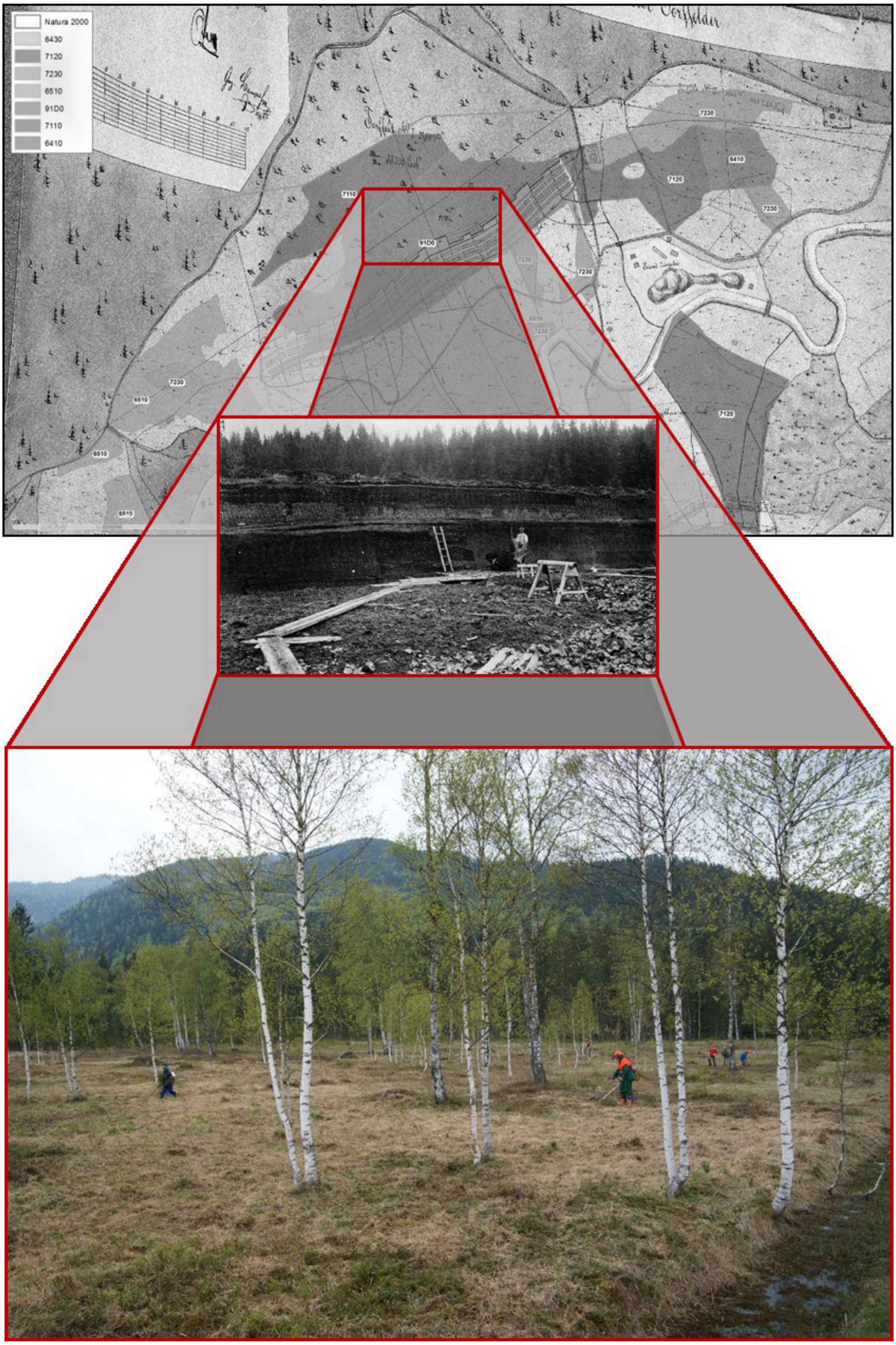

Figure 7: Peat cutting resulted in the development of exetensive alkaline fens. Historic map from 1875 with FFH biotope types above, photograph of the area from 1923 and 2010 (below).

Change of Management Patterns

Fens are highly sensitive ecosystems and are responding to a change in disturbance patterns with a change in species composition. Extensification as well as intensification of agricultural practices such as grazing, mowing and fertilizing but also changes towards tilling practices can strongly damage these habitats. This pressure becomes increasingly exigent due to changing agricultural systems, especially in south-eastern Europe. At the moment there is a small scaled mosaic-like structure of farmers who manage their patches of land in an extensive way, mainly for self-supply. Trends indicate that favourable site will be increasingly intensified whereas decentralised famers will stop their practices. This development will result in abandonment of large, formerly mown grasslands which will be prone to succession processes.

Table 2: Pressures and priorities for alkaline fens FFH 7230

Pressure	Priority	
	Austria	Hungary
Change of management patterns	Critical/High	Critical
Nutrient accumulation	Critical	Critical
Change of hydrology	High/medium	Critical
Mechanical damage	High	High
Invasive native and non-native species	High	High
Biocoenotic development, succession	Unknown	Unknown

Objectives for Conservation sorted by priority – Management Concepts

Depending on the environmental requirements of each habitat type, *management concepts* have to be evaluated. These management concepts will be based on a clearly defined objective. Every stand is different by natural means and may need slightly different approaches to reach the goal.

- The main objective is to keep the hydrologic environment at a favourable level. Water body should be stable and a stable, low trophic level has to be kept.
- *Alkaline fens* have to be managed in a proper and ecologically sound way (extensive land use in form of grazing, mowing, manual removal of trees and shrubs…)
- Keeping the habitats open an close to their natural species composition and dominance
- Fens have to be protected against directly adjacent agricultural land to puffer the influence of fertilizers, pesticides and herbicides.

Table 3: Actions necessary to reach the objectives

Objective	Possible actions	Time	Priority	
			AT	HU
Keeping the water body stable	-Closing of all existing drainage ditches, reinforcing any feeding water bodies	Mid term	Essential	Essential
Keeping trophic level of the stands stable and low	-Rehabilitation and preservation of the natural catchment areas -Creating buffer zones such as shaws or hedge rows	Long term	Medium	Medium
Keeping secondary habitats free of trees and shrubs	-Manual removal of emerging shrubs and trees -Alien species control (active and preventive)	Short term	High	High
Insulation against directly adjacent agricultural land	-Creating buffer zones such as hedge rows or fallow strips	Short term	Medium	Medium

Conclusion: Future management of Alkaline Fens at the Natura 2000 Site Ödensee based on the Knowledge of the Utilization History

As a result of the presented survey it can be assumed that alkaline fens of secondary origin are more difficult to manage. They tend to be colonised by shrubs and trees very quickly. Extensive grazing cannot be taken into consideration as the ultilization history and the farmers survey revealed. To implement future management a preferable period along the different successional states of the site must be defined. Todays challenge is therefore based on the search for management practices similar to the land use after the Second World War, a period of high biodiversity. What is needed are modern and innovative methods of cultivation which have the same impact as manual work. As a result of this research a new approach will be implemented with the use of work horses.

The following aims based on traditional land use have been defined for further development:

- Research on the use of marsh hay for horses or bedding
  Traditional the harvested hay which is low in protein content and rich in raw fibre was fed to horses. As the number of privately kept horses in the area increases, marsh hay could be sold in the area which would offer an incentive for regular mowing.

- Using horsepower to cut and harvest fens
  Heavy tractors cannot be used to cultivate fens. Research on the use of workhorses will bring results about their capacity to be used for fen management.
- Restoration of fens by water management
  Further research is necessary to understand how the fen works hydrologically (how water enters, moves through and leaves a fen and its chemistry and quality), how it has changed in the past, or might change in future. Man-made structures such as ditches also affect the water management of the fen. Recent damming of ditches should be evaluated.
- Long-term monitoring
  In order to evaluate any management measures long term monitoring of key species is important and necessary.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 307 - 308

Population Density, Habitat Preferences and Nest Predation of the River Warbler (*Locustella fluviatilis*) in the Donau-Auen National Park, Eastern Austria

Franz Hölzl & Christian H. Schulze

Abstract

The floodplain forest in the Donau-Auen National Park has been used for forestry and agriculture for centuries. These utilizations and several river regulation measures cause dramatic habitat changes. Nevertheless, the alluvial forests east of Vienna are still one of the most important breeding areas for the River Warbler in Austria and Central Europe. The aims of this study were to assess the present River Warbler density in the Donau-Auen National Park; to test if nest predation differs betweenrandomly selected sites in the floodplain and River Warbler territories; and to evaluate important habitat requirements and food preferences for the River Warbler population in the alluvial forest east of Vienna. Our results show that the River Warbler density decreased over the last few decades. Published habitat requirements of the River Warbler are in line with the results of our study and in the Donau-Auen National Park River Warblers only colonize the regularly flooded forest area, where they prefer forest sites with a high herb layer and a high abundance of Hymenoptera. The artificial nest experiment showed a lower predation risk at River Warbler territories compared to control sites.

Keywords

ground breeding passerine, food availability, habitat requirements, artificial nests, dummy eggs, alluvial forest

Introduction

The River Warbler is a small socially monogamous passerine and a long-distance migrant wintering in South-East Africa (Kennerley & Pearson 2010). In Austria the river warbler is highly dependent on alluvial forests. In human-dominated regions like Central Europe, floodplain forests belong to the most endangered ecosystems (Brinson & Malvarez 2002; Tockner & Stanford 2002). As known from other riverine floodplains, also the floodplains east of Vienna were used for agriculture and forestry for centuries and several river regulation measures lead to dramatic habitat changes and fragmentation of the remaining floodplain forests. These regulatory measures had and still have a strong impact on the characteristic periodic flooding events and resulted in far reaching changes of this ecosystem due to the reduced natural hydrological dynamics (Zulka 1994; Schratt-Ehrendorfer 2000; Reckendorfer et al. 2006).

Besides assessing the present River Warbler density in the Lower Austrian parts of the Donau-Auen National Park, this study aimed to evaluate the importance of published habitat requirements and food availability for River Warblers in the floodplain forest east of Vienna. Furthermore, we tested if nest predation differs between River Warbler territories and randomly selected sites in the floodplain.

Methods

The field work was conducted between April and August 2009. At the beginning of the breeding season River Warbler territories were mapped for a large part of the floodplain forests located north of the river Danube in the Donau-Auen National Park. Subsequently, different habitat variables like height of herb layer, number of trees, distance to next waterbody and food availability were measured or estimated for river warbler territories and randomly selected (control) sites. Food availability was quantified by standardized sweep netting in the herb layer. Potentially important prey organisms considered in this study were taxonomic groups such as Hymenoptera, Diptera, Arachnida and Pulmonata. For quantifying nest predation artificial nests with 4 dummy eggs, formed of the polymer clay "Fimo" (© Staedtler), were exposed in all breeding territories and at control sites for 13 days. This corresponds to the species´ natural incubation period (Glutz von Plotzheim & Bauer 1991). Missing and/or damaged nests or dummy eggs were classified as evidence for nest predation.

Results and Discussion

Our data are supporting the assumed decline of River Warbler density since the 1980s in the Donau-Auen National Park (Teufelbauer & Frank 2009). This is most likely linked to the loss of the formerly high hydrological dynamics and the associated transfer of former floodplain forests, dominated by flood-tolerant trees and nitrophilousunderstorey plants (e.g. stinging nettles), to forests of later successional stages. As a consequence, bird assemblages of foodplain forests are progressively replaced by bird assemblages typical for hardwood forests (EICHELMAN 1994, TEUFELBAUER & FRANK 2009).

In the Donau-Auen National Park the River Warbler is only breeding in the river facing parts of alluvial forests which are not dammed by the flood protection dam. The differences in habitat variables between River Warbler territories and control sites correspond to the known habitat requirements documented in the literature.

Ants and other Hymenoptera, both representing potential prey, were significantly more abundant in River Warbler territories than at control sites. However, other taxonomic groups like Diptera, Hemiptera and Lepidoptera which are known as important food source of the River Warbler (e.g. INOSEMZEW 1963; MACKOWICZ 1989) did not show significant differences between the two groups of sites in our study.

Our results suggest that nest predation is an important factor driving the choice of nesting sites in the River Warbler. The lower risk of predation in territories compared to control sites could be caused by differences in herb layer density, which proved to be higher in territories. This can affect the probability of nest detection by predators (FILLIATER et al. 1994). The identification of nest predators was difficult because in most cases either the eggs from predated nests or the entire nests were missing. One reason for missing artificial nests could be the large number of wild boars (*Sus scrofa*) in our study area (own observation), which might find the nests by random when they are rummaging for food.

Conclusions

The decline of the River Warbler in the Donau-Auen National Park is most likely related to the shrinking of suitable habitats due to changes of the entire floodplain forest. Human activities may not only have influenced vegetation structure and food availability but also the risk of nest predation. We suppose that the main driver for all these changes in the entire floodplain forest ecosystem is the dramatically reduced hydrological dynamic.

Acknowledgements

This study was conducted in close collaboration with the Nationalpark Donauauen GmbH. Permits were granted by the Lower Austrian Department of Nature Conservation and the ÖBF (Austrian Federal Forests). We want to thank Georg Frank and Christian Baumgartner who helped organizing fieldwork and provided scientific supervision. We are also very grateful to Daniela Hölzl and Konrad Fiedler for helpful comments on the statistics and to Karl Reiter and Martin Prinz for great support in managing our GIS data.

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Conference Volume | 5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill | pages 309 - 312

Status of peat lands in Upper Austria
A survey study on vegetation, including management plans for renaturation

Viktoria Igel

Abstract

The impact on our environment caused by large-scale destruction of mires is still unrecognized and highly underestimated by the general public, not raising too much awareness in political discussions or academic circles. Mires seem to continue to be mystical biotopes not concerning many people. However the need for sustainable conservation and effective renaturation programs is becoming a global issue.

Why is that?
The value of mires and intact, living peat lands is not only limited to unique landscapes and habitats of highly specialized flora and fauna, but they provide very real functional values in their natural state. Because of their water retentivity, mires influence the hydrologic balance of their surrounding positively. Apart from that, peat lands play a valuable role in the atmospheric carbon flux. Active peat lands are a slow sink for atmospheric carbon, while drainage and oxidation lead to a considerable release of carbon dioxide and methane into the atmosphere. We need to raise awareness to the significance our world peat land resources have on the environment.

Keywords

peat land, bog, fen, vegetation analyses, restoration, renaturation, conservation, Upper Austria

Introduction

In Central Europe, wetland areas decreased considerably during the last century, mainly due to urban scrawls and agricultural cultivation. Nowadays intact peat lands are highly rare biotopes. In Austria and Switzerland the original extend of peat lands has decreased by 90% since the beginning of industrialization 200 years ago. Today the bogs in Upper Austria cover less than 0,1% of the total land area. 55% of the remaining mires are classified to be affected by anthropogenic changes, and while 11% are intact 80% are endangered. Even in protective areas man-made impact like groundwater recession, eutrophication and increasing emission levels are noticeable. To prevent the silent extinction of these sensible ecosystems, and to actively enhance the situation, projects are initiated to systematically survey the remaining peat lands for further development and conservation plans. To preserve the remains effectively a precise knowledge of the actual state and condition of the biotopes is necessary. Only on the basis of a detailed inventory is it possible to develop specific strategies to protect and restore mires with suitable methods. For that purpose the Upper Austrian Ombudsoffice for Environmental Protection (Umweltanwaltschaft Oberösterreich) established the project “MEK” (Moorentwicklungskonzept Oberösterreich) in Upper Austria to conserve, restore and regenerate peat lands (PÖSTINGER 2011). The goal is an environmental sustainable preservation of peat lands in Upper Austria. Besides conservation of intact bogs the restoration of unbalanced peat lands is a priority. Because of a high but complex level of hydrological self-regulation a lot of experience and sophisticated strategies are needed to induce self regeneration and stabilization through the right procedure. With the help of a specifically designed peat land database it is possible to target renaturation plans very effectively corresponding to the actual priority, feasibility and financial capabilities. Taking historical inventories into consideration, like the ‘Franziszeischer Kataster‘ an Austrian cadastre since 1825, as well as including more recent publications, is a central aim of the project. Due to publications by KRISAI & SCHMIDT (1983) and STEINER (1992), there exists a profound description of a majority of the Austrian peat lands over the last three decades. Thanks to this data the development of bogs and fens in Upper Austria is reproducible.

Methods

In this study peat lands and bogs of the district “Kirchdorf an der Krems” in Upper Austria were examined from a botanical and landscape ecological point of view. By using the general methods of vegetation analysis following BRAUN-BLANQUET, the vegetation (including moss) was registered and plant communities were assigned with the program TWINSPAN and subsequently manually adjusted. All kinds of artificial structures and anthropogenic disturbances, as well as the vegetation analysis were drawn out in Arc GIS.

Results

Almost every investigated peat bog and fen showed influences by drainage, peat farming or damage due to grazing cattle, all of which are responsible for a progressive degradation of peat lands. In order to stop and avoid further deterioration, a re-cultivation program has to be implemented to improve the situation. Therefore suitable management strategies for each field site were elaborated. This survey was initiated through the "Umweltanwaltschaft Oberösterreich" as part of the project MEK to enhance the general situation of mires in Upper Austria, and supported by the National Park Kalkalpen as a co-operation partner.

Discussion

There are specific phenomena leading to the deterioration of peat ecosystems:

- The sensitive hydrology of peat bogs and fens gets easily imbalanced through **drainage channels** and similar measures, whereby vegetation changes are irreversible.
- Peat lands are often affected by **grazing cattle,** even though it is well known that the nutritional value of these areas is minor. The cattle cause considerable damage on the vegetation and ground level. The problem intensifies in consequence of the modern profit optimization progress: today the average cow weighs around 200 kg more than 50 years ago (DIETL 2007). Of course high performance cattle with heavy duty exceed less intensive used cattle comparatively.
- Industrial **peat cutting** to use as fuel for peat power stations is still happening while Russia, Ireland, Finland and Sweden rely partly on this unsustainable generation of energy (combustion capacity of ~300-600 Megawatts). Products in garden centers are an ongoing issue as well; For example Austria imports 190.000 tons of peat each year, mainly from Eastern Europe, to use for hobby gardening and the like. A distinct reduction of this inconsiderate use of peat is essential. Even though most initiatives promoting anti-peat-guidelines are on local level with little public impact, they are still beneficial movements worth mentioning (f.e.: Anti-Peat-Movement in Great Britain: www.naturalengland.org.uk / 28.04.2013; Austrian waste management department (MA 48) "Guter Grund - Torffreie Erde aus der Wiener Biotonne"; WWF Project: „Torf gehört ins Moor und nicht in den Garten!"). Unfortunately due to a lack of awareness on behalf of the consumer, shopping habits remain unchanged.

But why protect peat lands in the first place?

Bogs are habitats with highly specialized flora and fauna, playing a key role in global biodiversity. Around 25% of endangered vascular plants are found on wet-lands, as well as a diversity of reptiles and amphibians. Apart from High Mountain regions, bogs and fens are last wilderness areas in our otherwise intensively cultivated landscape, densely populated and agriculturally used.

Peat lands are important archives: Through analysis of pollen stored within peat it is possible to gain an understanding of climate developments since the last ice age.

Intact bogs are indirectly regulating the landscape water regime. Their enormous water absorptive capacity, combined with a considerable water retentivity, balances the hydrology of their surrounding positively. Peat lands therefore serve as highly effective water retention bodies, releasing water slowly to the environment and atmosphere. But once the hydrologic balance is disturbed and the water level drops, oxidative degradation starts and the peat body shrinks. Changes in the hydraulic conditions are induced: the peat grows impermeable to water and loses its ability to retain it, which results in fluctuation of the water table.

Living peat lands play an important role as a natural water filter and water collection system in our landscape (SUCCOW & JESCHKE 1986). Modern 'root-zone-disposal-facilities' copy this sophisticated self-purification process for sewage treatment.

A currently very relevant topic in mire conservation is the enormous carbon reservoir bound globally in peat deposits, exceeding the carbon amount stored in tropical rainforests 3,5-times *(*LINDSAY 1992*)*. On a global level, one third of all soil bound carbon (= 1 395 x 10^9 t) is linked to peat (JOOSTEN & CLARKE 2002). This valuable role in the atmospheric carbon flux has not raised appropriate attention so far. Intact peat lands function as carbon accumulators and as active (but slow) sink for atmospheric carbon, while drained bogs transmute to massive carbon emission sources, due to mineralization and peat degradation (SUCCOW & JESCHKE 1986, SUCCOW & JOOSTEN 2001, MATZ 2008). In addition nitrous oxide, methane and nitrate are released because of the accelerated metabolic circle (TIMMERMANN et al. 2009). Currently 150 – 250 x 10^6 t CO_2/ha/year are globally bound in intact peat lands, while drained bogs each year emit around 3 x 10^9 t CO_2 (JOOSTEN & CLARKE 2002). At present the CO_2 emission of tropical mires amounts up to two billion tons, equivalent to 8 – 10 % of the global emission of fossil fuels, with obvious impact on the global climate. We are turning natural carbon reservoirs into carbon rises through our own ignorance.

Renaturation- how it works

Renaturation or revitalization of peat lands intends to re-establish specific characteristics, like the re-animation of peat growth and stabilizing of the water body. Even though the aim is to restore peat lands to its original state, some changes are irreversible. Once a bog, which grew over millenniums, is considerably out of balance a degree of harmonization might be the best one can achieve. An efficient vegetation analysis, including hydrology and genesis is the necessary preliminary to any restoration and management plane.

Crucial for a successful renaturation is the profound understanding and consideration of three components: Water, vegetation and peat. The hydrology determines which plants will grow and if peat is accumulated or decomposed. The plants on their part affect the structure of the growing peat and its hydraulic qualities. The peat structure influences horizontal and vertical water movement and hence also the vegetation. Thus even the change of one component will inevitably influence the whole system; that is why this sensitive self-regulation mechanism is easily disturbed by anthropogenic intervention (TIMMERMANN et al. 2009).

Most effective is obviously the preventative environmental protection of healthy, intact peat lands. It is the responsibility of governments as well as great land owners to take measures accordingly, like the Austrian forestry office did recently with the ÖBf projects: "Aktiv für Moore" (2000-2005) and „Moor-Revitalisierung Inneres Salzkammergut“ (2010-2014).

Conclusion & Perspective

In Europe there are two opposing trends apparent: On one hand there are large-scale peat land restoration projects, with one of the biggest ongoing revitalization projects (over 40 000 ha) being conducted in White Russia. On the other hand there is still a lack of appropriate protective measures for the majority of wet habitats including bogs and fens. Today, it is foreseeable that mire conservation is becoming as much of an economic necessity as it is an ecological one, since the consequences of environmental damage (negative carbon footprint, water supplies a.s.f.) are rising and will do so excessively in the future.

It will be necessary to find a constructive approach to secure peat lands sustainably. Whereas information is a major key; only if people are made aware of the great value of these highly specialized (and extremely beautiful) biotopes is there the chance of a true interest for lasting preservation.

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Do protected areas achieve the objectives defined for the protection of processes, functions and diversity and where are the limits?

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Abstract

Along with the considerable increase of conservation areas over the last decades, the initial mission of protected areas has expanded (NAUGHTON-TREVES et al. 2005). The pristine purposesto maintain biodiversity, to protect rare or endangered species and ecosystems as well as the allowance of ecological processes remain unquestioned. It's the fulfillment of demands on human welfare which gained growing importance in the management of conservation areas. The range of these assignments is wide and depends, among others, on economic- and sociopolitical issues, or the history of local conservation efforts. Central challenges in newly established conservation areas in developing countries, for example, are to incorporate socioeconomic matters like land use in order to sustain local livelihoods. A more general and quite conventional challenge is to merge recreational as well as educational demands without loosening conservation efforts. In order to meet all those challenges the system of different types of protected areas was established by the International Union for Conservation of Nature (IUCN).

The question whether protected areas achieve their conservation objectives depends very much on the purpose (category) of the reservoir and its management regulations. The more important question to be asked is, whether and how the whole range of conventional and newly emerged tasks can be fulfilled without crossing the borders of protecting biological diversity. In this context the development of research based, best practice management solutions should be highlighted as an useful tool to establish conservation areas as exemplary models, to apply research based management strategies according to the type of protection area and to generate science based knowledge for educational purposes.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 315 - 316

What are currently the most relevant research priorities, research questions, methods and recent results regional and supra-regional, short and long term?

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Abstract

Traditionally, conservation efforts as well as research have mostly addressed single, rare or endangered species. The focus of these one-sided approaches has been broadened. It has been recognized that an ecosystem level perspective has to be applied and that we must go beyond the conservation of attractive flagship species to establish a network of protected areas representing the full variety of species or ecosystems. Priority in conservation literature is today dedicated to the assessment of conservation value and protection in the form of comprehensive, adequate and representative network of conservation areas and the identification of threatening processes and protection against these.

Additionally, increasing attention must be given to future scenarios, i.e. those driven by climate change, demographic development etc. This is the only approach that can successfully integrate issues of the vulnerability of ecosystems and that can support policies to protect habitats, refuges and migration corridors of species under current and future conditions. Further developed methods have to address these questions.

Particularly, in case of freshwater conservation strategies it is crucial to take into account ecological, hydrological and biogeochemical processes that are relevant for preserving the abiotic conditions and the flora and fauna of the respective ecosystem (Verhoeven et al. 2008). Freshwater conservation is a complex issue due to the status of rivers and floodplains as receivers of land use effects. Protecting a particular component of the biota and habitat requires controlling upstream river sections and catchments, the surrounding land, and, concerning migrating aquatic fauna, downstream reaches (Dungeon et al. 2006). Accordingly, beyond the traditional criteria that represent 'rarity' or 'naturalness', adequate criteria must be identified and applied to capture freshwater dynamics, processes and threats (process-oriented criteria).

A crucial aspect not only for freshwater conservation strategies is to consider the different spatial scales of the ecological, hydrological and biogeochemical processes that are relevant to preserving the abiotic conditions and the flora and fauna of the ecosystems (Verhoeven et al. 2008).Ecological theory suggests that conservation at large scale is preferable.

Setting goals is an additional important issue, intended to address the question of 'how much protection is needed/ is enough?' The principle of conservation efficiency needs to be investigated to provide guidelines for optimizing the economy of space, i.e. that conservation targets in a management plan are met with minimum area (Roux et al. 2008).

Future approaches have to take into account the specific needs of different ecosystem types, based on ongoing research on requirements and thresholds for the maintenance of these types.

The urgent demand of monitoring the effects – in terms of success or failure - of new approaches in protection research is emphasized also in the following chapter ("Long term ecosystem research")

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Conference Volume | **5th Symposium for Research in Protected Areas** 10 to 12 June 2013, Mittersill | pages 317 - 318

Long term ecosystem research

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Abstract

The idea of LTSER platforms (long term socio-ecological research) combines as subject of investigation entire landscapes with their manifold interactions between society and natural environment including social, economic and historical utilization aspects with classical longterm ecosystem research. This enables phenomena with social characteristics, such as hunting and wild animal management, the establishment and interaction of conservation areas with their surrounding environment or the effects of changes in production and consumption upon resource requirements, land use and ecosystems to be researched (Mirtl et al. 2010).The central question addressed by long-term ecosystem research as summarized by Mirtl et al. (2010) is: How do ecosystems respond to changes such as climate or human utilization in the long-term at different spatial and temporal scales? In line with this concept and ideas, nationalparks and protected areas would be excellent areas to establish long term ecosystem research in the majority of cases and could demonstrate the effects of long term changes based on their high natural values, high sensitivity, the controlled human utilization and well developed management plans.

The LTER activities worldwide are organized in different networks of scientists and would support also local research activities and provide an exchange of research results. Still in Austria the minority of protected areas are part of this research strategy beneficial for individual research needs of particular areas and of high value for an overall understanding of ecosystem changes. Based on the existing research platforms such as the LTSER platforms High Alps and Eisenwurzen we do see a need to expand this research strategy to other areas including especially riverine landscapes as these types of ecosystems show a high extent of alteration, multiple human pressures and thus, these systems are highly endangered.

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Conference Volume | 5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill | pages 319 - 324

Designing research in protected areas – theory and reality

Michael Jungmeier

Abstract

The designation of many protected areas in the world and, hence in the Alps, is supported, if not driven by science. The ongoing management has to face other priorities; frequently scientific matters are redefined as support functions for measures, education and public relations. Research agendas are in place to define a rationale, principles, goals, activities and technical framework for science in a park.
Using the example of seven research agendas, elaborated in Austrian parks within the last 15 years, the paper compares, discusses and evaluates the appropriateness and effectiveness of research agendas as such. Three biosphere reserves (Walsertal, Wienerwald, Nockberge as part of the newly established BSR Salzburger Lungau und Kärntner Nockberge), three national parks (Donau-Auen, Hohe Tauern and Gesäuse) as well as one nature park (Grebenzen) are compared. The experiences indicate that research agendas are not only an academic exercise, but can initiate and trigger systematic research in a park. However, in some cases there seems to be a considerable lack of commitment as well as of resources. Furthermore, the research agenda of the future defines the principles and processes rather than the activities and standards.

Keywords

Research design, national park, biosphere reserve, nature park, knowledge management

Introduction

The bodies that administer protected areas are knowledge-based organisations. They put knowledge of nature into practice by means of regulations, measures and educational work. There can be no doubt that no form of institution has greater knowledge of regional natural resources and regional sustainable development than the worldwide network of protected areas. In an attempt to draw up knowledge balance sheets for protected areas, Huber et al. (2013) showed that extensive knowledge capital can be built up, stored and also accessed in protected areas (see Figure 1):

- Human capital (e.g. employees, advisory bodies, stakeholders)
- Structural capital (e.g. information and educational establishments, libraries, databases, statutory regulations)
- Relational capital (e.g. partnerships, service providers, cooperations, umbrella organisations)

When accumulating knowledge, alongside the development of experience and exchanges between the parks, research plays a major role. To some extent this involves very great expense. Many parks attempt to structure research activities proactively. One instrument for this is the compilation of a research concept or research guidelines. All the concepts presented below are based on the intention of acquainting the park management with the research activities in the park and structuring these activities profitably. In most cases the intention is to initiate or stimulate science and research, or to focus these on a particular area.

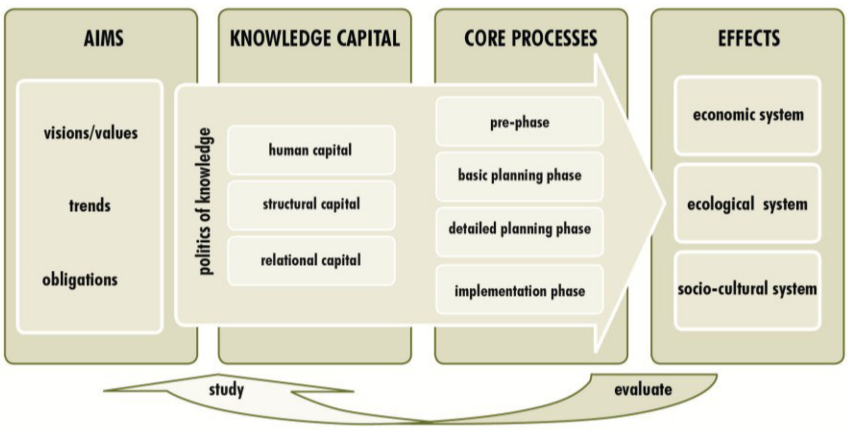

Figure 1: Knowledge assessment model for protected areas (HUBER et al. 2013, based on KOCH 2009)

Methods

All the concepts presented were compiled using the same method. On the basis of an analysis of the starting situation, the concept explores the following questions:

- What for – what function should research have in the park and what rationale underlies the research?
- What – what is the focus in terms of content and which central questions should the research answer?
- How – what organisational framework conditions should apply to the research in the park and what requirements will be imposed on the researchers?
- How much – what resources can be provided or raised for the research?

The central questions are answered in specially designed intensive workshops, using partly creative and partly analytical processes (cf. GETZNER et al. 2010) (Figure 2). Different groups can be invited to collaborate depending on the requirements specified by the park management. The research concepts of seven parks are described below.

Figure 2: What would these scientists find interesting about the National Park? – Workshop design for the research agenda. Photo: Jungmeier

Comparison of concepts

<u>Research Concept Donau-Auen National Park, 1998</u>

This concept underlines the significance of research for the National Park, especially as support for "perceiving problems, the decision-making process, evaluating measures and monitoring the effects of interventions" (HAUSHERR & JUNGMEIER 1998). The concept "stresses the coordination and regulation function of the National Park administration". The Donau-Auen National Park is also the only park in Austria to define the ethical limits of the research: "This research concept therefore demands (self-)restraint and abstinence of the scientists." The research concept is anchored within the management plan as an obligatory element, and has been partially implemented.

<u>Research Guideline Grebenzen Nature Park, 1999</u>

This guideline was compiled within a regional discussion process (DRAPELA & JUNGMEIER 1999). The aim of the research is to "develop awareness, increase value creation and document the region". The content focuses on the "activities by agriculture to protect nature and the environment", for which sketches of 20 research projects were developed. These were subsequently implemented (only) in rudimentary form.

<u>Research Guideline Wienerwald Biosphere Reserve, 2006</u>

This guideline was compiled within an internal discussion by the management team. The research is intended to support the management and investigate the "steep hemeroby gradients between original habitats and cities" as a theme of global significance. "Innovation, high end technologies, global relevance and interdisciplinarity" are stated as the guiding principles for this research focus (ZOLLNER et al. 2006a). The guideline has not yet been implemented; the research and management have developed in a different direction.

<u>Research Guideline Walsertal Biosphere Reserve, 2006</u>

A regional discussion process specified that research in the Biosphere Park primarily serves to "create benefits (increase value creation), promote the regional identity and document the region" (ZOLLNER et al. 2006b). (Note the congruence in terms of content with the research goals for the Grebenzen Nature Park, which were also compiled within a regional discussion process.) The content focuses on "researching the future" in the areas of Alpine farming, natural hazards and daily life, and also on "problem-specific ad hoc research". Major impulses are expected from small projects which (are intended to) fit together to form an overall picture. The guideline has been conceived as a "living document" and has been partly implemented.

Research Concept Hohe Tauern National Park, 2007

The intention behind the research in the park is to "monitor, understand ... and document developments in the area, ... , actively look into the role and responsibility of the National Park in the region and society (and) provide fundamental principles for the effective maintenance and sustainable development of the National Park and its region". The concept is based on a catalogue of research questions (Bauch et al. 2007b) and was developed within an internal discussion. It contains a series of organisational provisions, such as the creation of a scientific advisory board, standard procedures for both contract and grant-funded research, and also guidelines on documenting the research. The concept was approved by the trilateral council of the park and is therefore binding. Implementation has been initiated.

Research Agenda Nockberge National Park, 2007

The research agenda was put together in an international workshop. It was designed as a provisional action plan "to raise the profile of and stimulate research in the future Biosphere Park" (Jungmeier et al. 2008). Essentially three concrete research projects were conceived. Two of these have now been implemented (part_b, a project on governance in participation processes and the development of a BRIM system (Biosphere Reserve Integrated Monitoring)). They have had a substantial influence on the development of the Biosphere Park. The Lungau – Nockberge Biosphere Park, which was designated in 2012, wants to further develop and extend its research activities.

Research Concept Gesäuse National Park, 2013

This concept emphasises the importance of continuity in research work. "Research ... supports the best possible achievement of the objectives of the National Park and continues the tradition of the comprehensive inventarisation of the area. It ... creates new impulses for the region and its inhabitants" (Mahringer & Krainer 2012). The concept is based on the detailed analysis of 347 (!) research studies that have been undertaken and an intensive discussion process between representatives of the park, science and the region. The implementation has already been initiated.

Figure 3 shows a comparative summary of the research concepts. The actual research activities are not fully documented for all the parks, but the author ventures to assess the level of implementation.

		Donau-Auen	Grebenzen	Wienerwald	Walsertal	Hohe Tauern	Nockberge	Gesäuse
1	Category							
	National Park	y				y		y
	Nature Park		y					
	Biosphere Reserve			y	y		y	
2	Year	1998	1999	2006	2006	2007	2007	2013
3	Intention							
	Regulate / coordinate research	y				y		y
	Stimulate research		y	y	y	y	y	y
4	Contents							
	Definition of goals (what for?)	y	y	y	y	y	y	y
	Definition of contents (what?)	y	y	y	y	y	y	y
	Definition of frame (how?)	y	y	y	y	y		y
	Definition of resources (how much?)		y			y		
5	Participation							
	Staff	y	y	y	y	y	y	y
	Region		y		y		y	y
	Scientists	y					y	y
6	State of implementation*							
	No / not yet started			y				
	Little / just started		y			y		y
	Partly	y			y			
	Mainly						y	
	Completly							

* author´s estimate

Figure 3: Comparison of seven research concepts (compiled by the author)

The Nationalparks Austria Science Prize, which has been awarded on the occasion of this conference, provides us with some additional information relating to research in Austrian protected areas. Of the 34 papers submitted to the jury, 28 (more than 80 percent!) relate to the natural sciences. The human and cultural sciences are represented by three papers, and the economic sciences account for two contributions. In terms of their content 21 contributions can be allocated to the FoA Basic Investigation, and eight to the FoA Management Plan. All the other fields of activity of park management are represented either marginally or not at all (cf. Figure 4).

Pre-phase	
FoA-1: Development of Idea and Vision	0
FoA-2: Feasibility Check	0
FoA-3: Communication and Participation I	0
FoA-4: Incorporation into PA-Systems	0
Basic planning	0
FoA-5: Planning Handbook	0
FoA-6: Communication and Participation II	0
FoA-7: Basic Investigation	21
FoA-8: Implementation Planning	0
FoA-9: Designation and Establishment	0
Detailed planning	0
FoA-10: Mission Statement and Basic Concepts	0
FoA-11: Ecosystem-based Management Plan	8
FoA-12: (Regional) Economic Programmes	0
FoA-13: Specific Planning (Subsidiary Plans)	0
Implementation and management phase	0
FoA-14: Personnel & Organisational Development	0
FoA-15: Evaluating Management Effectiveness	0
FoA-16: Financing (Business Plan)	0
FoA-17: Impact Assessment and Limitation	0
FoA-18: Data and Information Management	1
FoA-19: Research Setting and Monitoring	1
FoA-20: Communication and Participation III	1
FoA-21: Development of PA's Region	0
FoA-22: Co-operation Design	0
FoA-23: Information, Interpretation & Education	2
FoA-24: Visitors, Services & Infrastructure	1
FoA-25: Marketing and Public Relations	1
Other	3

Mulitple attribution for some papers!

Figure 4: Contributions to the Nationalparks Austria Science Prize, shown by FoAs (Fields of Activity) in the management of protected areas (evaluation by the author, FoAs according to GETZNER et al., 2010)

Discussion

All the concepts with one exception laid the foundations for research activities. A comparison of the concepts reveals that they have the following points in common:

- The parks define research throughout as support for the management; research thus has a similar function to that of R&D in companies.
- With the possible exception of the Gesäuse National Park, the parks undertake scarcely any research themselves; it is given over or left to service providers and universities.
- The research concepts are only partially implemented. It is apparent that the resources allocated are not consistent with the objectives set.
- The research concepts were unable to resolve the following dilemmas:
- Parks, even Biosphere Reserves, are not research organisations; instead they are research brokers or consumers. It is not easy to "stay on the ball" in terms of specialist knowledge.
- It is not easy to appeal to top research providers, amongst other things because regionalised science, monographic presentations and research carried out with the purpose of influencing actions deliver (too) few "impact credits" for the academic career ladder.
- Regionalised research into protected areas remains on a small scale.

The future of research concepts lies in compound research concepts which intelligently and synergistically combine several or many individual components. The individual parks will also have to make greater efforts to connect themselves to international research networks, programmes and activities. The commitment to the importance of research in protected areas, for protected areas and with protected areas must be increased by means of the wide scale involvement of different participants. Strong parks need strong research.

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Conference Volume | 5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill | pages 325 - 330

Trends of ozone and meteorological parameters at high alpine sites

August Kaiser & Helfried Scheifinger

Abstract

Climate change and changes in the large scale chemical composition of the atmosphere influence thebiodiversity in and the appearance of protected areas even at remote sites. Data sets from Global Atmosphere Watch (GAW) stations are most appropriate to study background air pollution and meteorological trends. For the alpine sites Sonnblick, Jungfraujoch and Hohenpeißenberg we found increasing ozone concentrations until≈ 2003 especially in winter, whereas in summer there is a small decrease (period 1993-2011). The ozone increase in winter is favoured by changes in the air flow regimes and – to some degree – in an increasing sunshine duration, whereas in summer thereare notrendsin those meteorological parameters that are relevant for ozone.

Keywords

Climate change, atmospheric trace gases

Introduction

The alpine sites Sonnblick (3.105 m), Zugspitze (2.962/2.670 m), Hohenpeißenberg (985 m) and Jungfraujoch (3.580 m) contribute tothe Global Atmosphere Watch Programme (GAW) ofthe World Meteorological Organization (WMO). The aim of GAW is to document the large scale chemical composition of the atmosphere and its changes. The analysis of the trace gas concentration trends between 1993 and 2011 showsan increasing trend of ozone until ≈ 1999 to 2003, followed by a small decrease afterwards (GILGE et al. 2011). The increase is strongest in winter and spring, whereas during summer, a small decrease is found. On the other hand, the ozone precursors decrease during the whole investigation period, so that the ozone trend cannot be caused by the precursors alone (GILGE et al. 2010).

In this paper we compare the ozone trends at Sonnblick, Jungfraujoch and Zugspitze with trends in the relevant meteorological parameters: Vertical temperature gradient, sunshine duration and air flow regimes for the period from 19930101 to 20111231 exemplified for winter (December to February) and summer (June to August). The analysis of the Zugspitze data is not yet completed.

Methods

Vertical temperature gradients have been calculated for the valley atmosphere using the temperature data from Rauris (19,5 km north of Sonnblick, 934 m) and Sonnblick (3.105 m); for elevations above Sonnblick we used the temperature data from selected height levels (3.000 m, 5.000 m, 10.000 m and 15.000 m) of the radiosonde soundings at Munich and Vienna. Trends of monthly mean temperatures have been cross-checked with the HISTALP data set (http://www.zamg.ac.at/histalp/) showing good agreement and a temperature increase for all seasons except winter, wherea temperature decrease is found especially at higher elevations.

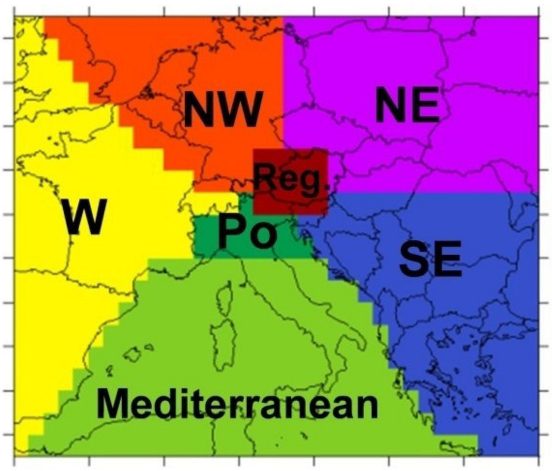

Figure 1: Regions of origin of air relevant for the ozone concentrationsat the alpine GAW stations. Air masses from the continent are rich, Atlantic air masses poor in ozone (KAISER et al. 2007).

The trend of the sunshine duration has been calculated using the measurements at Sonnblick. The trend of monthly mean sunshine duration at Sonnblick is in good agreement with the sunshine trend for the "Greater Alpine Region (GAR)" from the HISTALP data set and is thus representative for the whole region investigated.

To study the trends of the airflow regimes,4 day back-trajectories are used, calculated with the model FLEXTRA (STOHL 1998), based on the ERA-Interim wind fields of the European Centre for Medium Range Weather Forecast (DEE et al. 2011). The ERA-Interim fields are fields are not subject to model updatesand thus most appropriate for trend studies. The horizontal resolution of ERA-Interim is 1°. Arrival time of the trajectories at Sonnblick is each 3 hours, arrival height 100 m above model topography. Thus the air at Sonnblick is traced back each three hours for 4 days to study its origin. Based on KAISER et al. (2007)7 regions that are relevant for the ozone concentrations at Sonnblick (and at the other alpine GAW stations) have been defined (Fig. 1). The vertical extent of the regions is from ground up to 2.000 m. An additional category is the "free troposphere" at heights above 2.000 m, covering the whole region. For each trajectory the time it spends within such a region is calculated. Trends of the air flow regimes arederived with the help of monthly mean trajectory residence times for the different regions defined in Fig. 1.

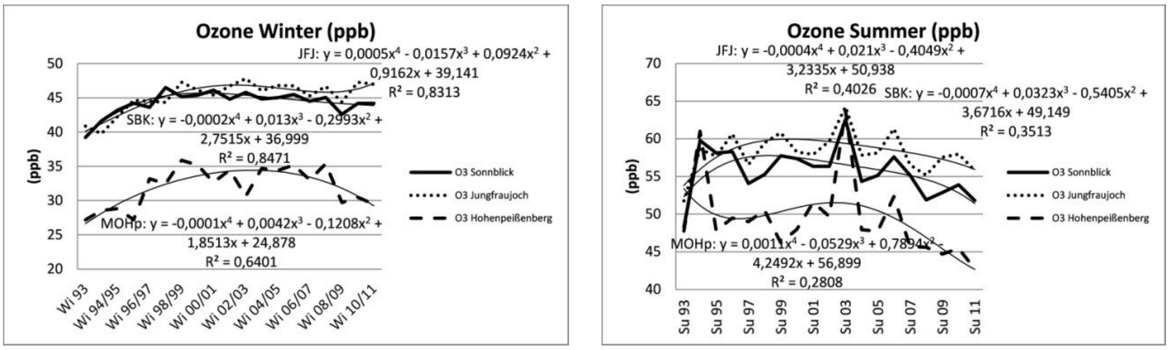

Figure 2: Mean seasonal ozone concentrations at Sonnblick (SBK), Jungfraujoch (JFJ) and Hohenpeißenberg(MOHp) in winter (left) and summer (right) with fitted 4th degreepolynomials.

Results

Fig. 2 shows seasonal mean ozone concentrations at Sonnblick, Jungfraujoch and Hohenpeißenberg and the respective ozone trends, fitted with a 4th degree polynomial. Consistent with GILGE et al. (2010) the increase of ozone is strongest in winter, whereas in summer the increase is limited to the very beginning of the period and predominantly caused by the low values in summer 1993. Overall there is an increase of ozone in winter, especially at the high elevated sites, but a decrease in summer.

Fig. 3 shows vertical temperature gradients for winter and summer for the valley atmosphere, derived from the temperature data from Rauris and Sonnblick and for the layer above the high alpine sites between 3.000 m and 5.000 m, derived from the radiosonde data from Munich and Vienna. A negative temperature gradient represents temperature decrease with height, a positive gradient temperature increase. Due to its diurnal variation with stable temperature gradients during nighttime (temperature decrease less than -1°C/100 m or even temperature increase with height) and near adiabatic gradients (-1°C/100 m) during the afternoon, monthly mean gradients are stable. Nevertheless, the more negative the mean temperature gradient, the stronger the vertical mixing of the atmosphere.

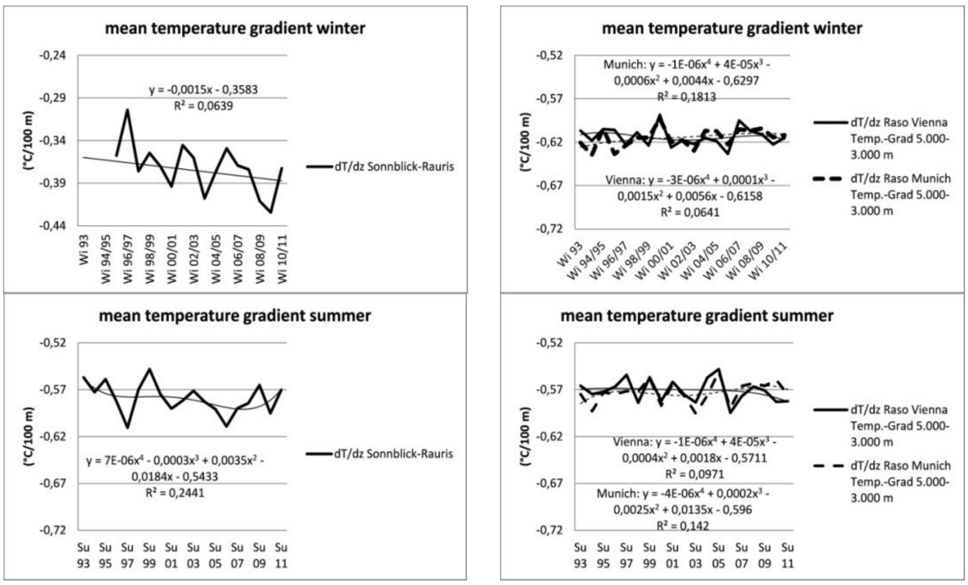

Figure 3: Mean vertical temperature gradient of the valley atmosphere (left) and for the layer between 3.000 m and 5.000 m (right) in winter(top) and in summer (bottom)with a fitted 4th degree polynomial.

Only for the valley atmosphere a relevant trend is found in winter, but much less pronounced in summer, indicating increased vertical mixing of the near ground atmosphere. For the level above the high elevated alpine sites between 3.000 m and 5.000 m, neither the radiosonde data from Munich nor those from Vienna show relevant trends.

Sunshine duration at Sonnblick shows two maxima in winter (from 96/97 to 97/98 and from 06/07 to 07/08) and in summer (94 and 03) as well (Fig. 4). For the whole period there is some increase in winter, but no trend at all in summer. In summer 1993 the sunshine duration is near to its average, the outstanding low ozone values in summer 1993 (Fig. 2) cannot be explained by the sunshine duration.

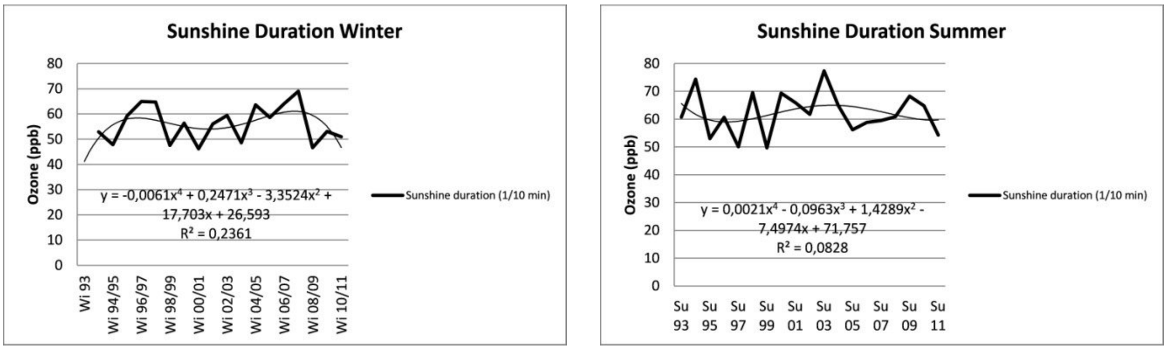

Figure 4: Mean sunshine duration at Sonnblick in winter (left) and summer (right) with a fitted 4th degree polynomial.

The dependence of the ozone concentration at Sonnblick (representative for all sites) from the trajectory residence time in the respective regions (Fig. 1) is shown in Fig. 5. Main sources of elevated ozone concentrations at the alpine GAW stations are air masses from the free troposphere from heights above 2.000 m in winter and air masses from the continent and the Mediterranean in summer whereas Atlantic air masses are relatively poor in ozone over the whole year (see also KAISER et al. 2007): The longer the air stays within these regions, the higher/lower is the ozone concentration. Note that the relations are not always linear.

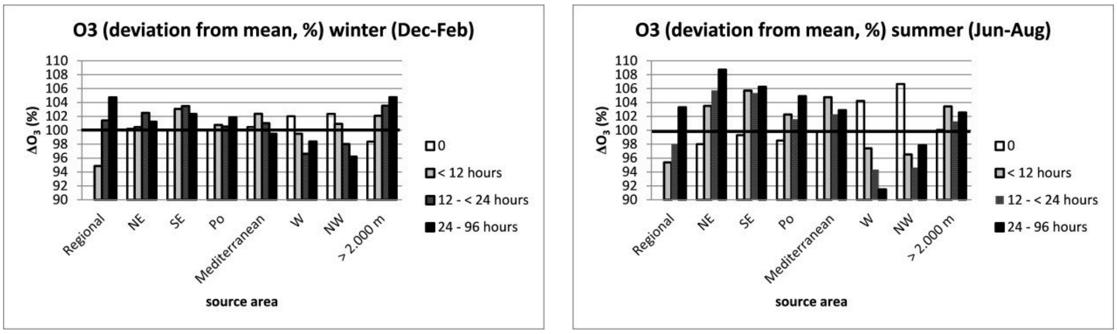

Figure 5: Ozone concentration at Sonnblick (deviation from mean) in dependence of the trajectory residence time (hours) in the respective regions of origin.

The trends of the air flow regimes are shown in Fig. 6. In winter the trend for free tropospheric air masses shows a pronounced maximum near 2003 and air flow from the Atlantic decreases over the whole period. Both processes favour increasing ozone especially until 2003. In summer the trends of the relevant air flow regimes are small.

In 1993 the relevant air flow regimes are close to the average: In winter 1993 air flow from the free troposphere (connected with high ozone concentration)is near to the average, that from the Atlantic (low ozone concentration) is relatively frequent; in summer both air flow regimes connected with enhanced, but also with reduced ozone are close to the average. Thus the outstanding low ozone concentration in 1993 cannot be explained by the airflow regimes.

Discussion

GILGE et al. 2010 assumed that the ozone increase at the alpine GAW stations may be caused by increasing vertical mixing of the atmosphere. Indeed, the valley atmosphere shows a tendency to less stable temperature gradients, i.e. some tendency to increased vertical mixing, especially in winter (Fig. 3). But the correlation between the monthly mean temperature gradient Sonnblick-Rauris and ozone in winteris positive (0.63 at Sonnblick, 0.56 at Jungfraujoch and 0.23 at Hohenpeißenberg) – the more stable the valley atmosphere, the higher the ozone concentration especially at the high elevated sites. This is an effect of large scale anticyclonic weather conditions with relatively high ozone values in the free troposphere above the inversion. On the other hand there is no relevant trend of the temperature gradient at higher elevations, and the correlation with ozone is small (values near to -0.3 for all stations) both in winter and in summer. Thus, the trend found in the temperature gradient of the valley atmosphere would rather contribute to decreasing ozone in winter. The assumption of GILGE et al. (2010) may be important for low situated sites, but must be dismissed for high alpine sites and even for Hohenpeißenberg.

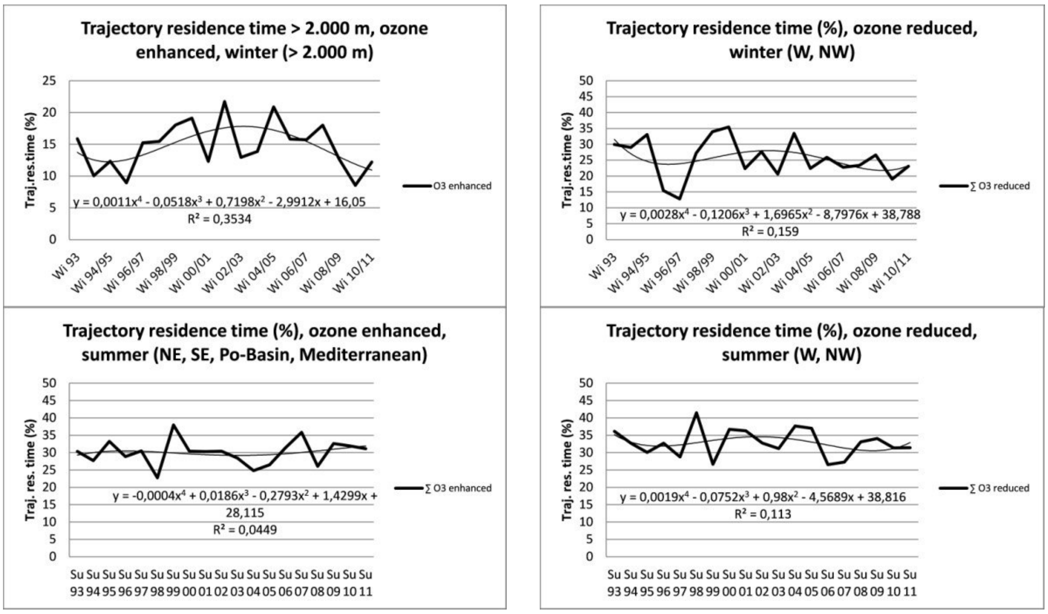

Figure 6: Trajectory residence time for air flow regimes connected with enhanced (left) and reduced ozone concentration (right) at the alpine GAW stations for winter (top) and summer (bottom).

The increase of the sunshine duration in winter (Fig. 4) may contribute to enhanced ozone formation to some degreeeven though photochemical ozone production is small in this season (the correlation is positive at all stations up to 0.5 at Sonnblick). The sunshine peaks in summer 1994 and 2003 are consistent with strong ozone peaks at Hohenpeißenbergwhere the correlation of ozone with the sunshine duration in summer is highest (0.6), whereas the high elevated sites only show ozone peaks in summer 2003. The effects of photochemical ozone production in summer are strongest at Hohenpeißenberg, but even visible at the high elevated sites. The course of the sunshine trend in summer with a maximum in summer 2003 (Fig. 4) is similar to that of ozone especially at Hohenpeißenberg (Fig. 2) indicating some effect of enhanced photochemical ozone production due to the trend of the sunshine duration. But over the whole period of investigation there is no trend of sunshine duration and some decrease of ozone.

The trends of the air flow regimes that are relevant for the ozone concentration at the alpine sites clearly favour an increase of ozone in winter (Fig. 6):The course of the trend for free tropospheric air masses agrees with the course of the ozone trend to a high degree; in addition, air flow from the Atlantic shows a small decrease. Both processes favour increasing ozone. In summer the trends of the relevant air flow regimes are small.

Conclusion

In this study, the dependence of ozone from the relevant meteorological parameters (vertical mixing of the atmosphere, sunshine duration and air flow regimes) is analysed with the aim to find an explanation for the ozone increase before 2003 which is accompanied with decreasing precursor concentrations. The correlations between these parameters and ozone are relatively small, but one should consider that all these processes go parallel, sometimes enhancing, sometimes compensating each other and the relations are not always linear.

Elevated ozone concentrations at the high alpine sites are connected with large scale anticyclonic conditions with inversions beneath the stations and free tropospheric air above the inversion in winter, enhanced sunshine duration and photochemical ozone production in summer and transport from the continent all over the year. The increase ofthe sunshine duration and of the transport of air from the continent in all seasons except summerfound in the period from 1993 to 2011favoursan increase of the ozone concentration at the high elevated alpine background sites in winter, spring and autumn. During winter, the trend of transport of ozone-rich air from the free troposphere to the alpine GAW sites is in agreement with the ozone trend, whereas in summer, neither the relevant meteorological parameters, nor the ozone concentrations show significant trends.On the other hand decreasing precursor concentrations (GILGE et al. 2010), but also increasing vertical mixing of the valley atmosphere as found in this study, may contribute to some decrease of ozone as found after ≈ 2003 in winter and after 2000 in summer. The estimation of the net effect ofprocesses reducing or increasing the ozone concentration is challenging and will need further investigation.

The outstanding low ozone values in the year 1993 cannot be explained by the meteorological trends and may be a result of the Pinatubo eruption.

Acknowledgements

The data from Hohenpeißenberg have been provided by the DWD, those from Jungfraujoch by empa, the trace gas data from Sonnblick by Umweltbundesamt Wien. Together with the ZAMG these institutes contribute to the so called GAW-DACH co-operation between Germany, Austria and Switzerland.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 331 - 340

Regeneration of high montane plant communities in the "Nationalpark Kalkalpen" (Northern Alps) after fire events

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Abstract

Forest fires are comparably rare and accidental in higher altitudes of the Alps. The restoration of the plant cover is obviously slow and the direction of the succession is still unclear.

We investigated the influence on the vegetation by fire events with emphasis on vegetation regeneration, plant species diversity and nature conservation targets. We surveyed two neighboring fire areas of different age (8 and 61 years after fire event) on a south exposed slope of the Hagler Mountain in the National Park (NP) "Kalkalpen" (Eastern Alps, Austria). For the vegetation survey we performed relevés of 25 m² along 3 altitudinal transect lines (1500m, 1550m, 1600m a.s.l.) across each fire site and in adjoining reference areas which were not affected by the fire. They are dominated by *Pinus mugo*. The syntaxonomical and ecological characterization of the plant communities was performed using habitat preferences and indicator values of the species.

We found out that fire events in high montane ecosystems of the Alps have a substantial long-term effect on the vegetation. Krummholz (*Pinus mugo*) will not regenerate within 60 years, it is replaced by natural, alpine grassland with significant disturbance indicators for several decades. Low indicator values for temperature on the older fire site shows, that species from higher altitudes may seize such areas as new habitats. The physiognomic turn from shrub to grassland vegetation and the decrease of beta diversity lead to the necessity of revision of nature conservation targets after fire events. Facing increasing fire events in the Alps as an effect of global warming, this becomes more important.

Keywords

Fire, vegetation regeneration, high montane ecosystems, Nationalpark Kalkalpen

Introduction

In some regions of the world, e. g. SE Australia, S Africa, fire is inherent to ecosystem dynamics. Plants of these ecosystems are adapted to periodic fires, some of them even rely on these recurring events (WALTER & BRECKLE 1999). Here fire is necessary to maintain the ecological balance.

In high montane ecosystems of the Alps, bushfires are considerably rare and accidental. They occur mainly on south exposed slopes with high sun radiation, where the vegetation is highly flammable.

There are no adequate data about fire frequencies in the Alps. SASS et al. (2012), however, predict a fire frequency of 250–525 years for northern Tyrol. Human impact is the main reason for fire events in the montane and subalpine belt and illustrates an increasing anthropogenic pressure on the Alps in the last 100 years.

This unsteadiness of fire events is also reflected by the vegetation of high montane ecosystems of the Alps. These biota show no special adaptations on periodic fire events. Fire has to be considered as an extreme event, which causes long-lasting changes in vegetation cover and ecosystem characteristics.

Direct consequences are the destruction of the plant cover and – depending on the intensity of the fire – of the organic soil layer, followed by geomorphological processes like altered conditions for erosion, mudslides, rock fall and avalanches (SASS et al. 2006).

On the other hand, fire leads to short-term mobilization of nutrients, which supports plant growth. Hence, the conditions of competition are altered completely by these factors.

We tried to find out how vegetation in high montane ecosystems reacts on fire events. Is there any evidence for regeneration of the pre-fire vegetation? Are there any unexpected trends in the development of the succeeding plant cover?

These questions are of growing relevance facing the recent climatic trends. Rising summer temperature could enhance the heat load of the earth surface, which, in turn, could lead to higher likelihood of forest fires. Furthermore, climatic changes could also drive changes in vegetation structure (see NICOLUSSI & PATZELT 2006). Consequentely, fire sites in future may gain even greater significance as special habitats in the vegetation mosaic.

Methods

We surveyed two neighboring fire areas of different age (the younger fire site, 8 years after fire event; and the older fire site, 61 years after fire event) on a south exposed slope of the Hagler Mountain, in the NP "Kalkalpen" (Eastern Alps, Austria). We conducted vegetation surveys in 3 transects at an altitude of 1400, 1450 and 1500 m a.s.l., respectively. We performed a set of vegetation relevés each with an area of 25 m² across both fire sites and in adjoining areas which were not affected by the fire (reference areas, dominated by *Pinus mugo*). 103 relevés were used for analysis. Numerical classification and syntaxonomical evaluation of the vegetation were performed using the program Juice (TICHÝ 2002) and TWINSPAN (HILL 1979). For ecological characterization we used Ellenberg's indicator values (ELLENBERG et al. 1991).

Results

We found a total number of 211 species on our research area. 48 species (22.8 %) were found on all three sites, 24 species (11.4 %) were shared between the older (A) and the younger (N) fire site, 17 species (8.1 %) between the younger fire site and the reference sites (R), and 11 species (5.2 %) between the older fire site and the reference sites. 27 species (12.8 %) were exclusively found on the older fire site, 53 (25.1 %) on the younger fire site and 24 (11.4 %) on the reference sites (table 1). This means a species turnover rate from the reference sites to the younger fire site of 65 %, and from the younger to the older fire site of 60 %. This is visible in the average Bray-Curtis dissimilarity too (BRAY & CURTIS 1957). The dissimilarity between the reference site and the younger fire site amounts 89 %, between the younger and the older fire site 90 % and between the reference site and the older fire site 83 %.

Table 1: Shared, exclusive and total species number (presence/absence transformation) of the vegetation data set, n=103. R=reference areas, N=younger fire site, A=older fire site.

	R	N	A	%
shared species	48	48	48	22,75
	17	17		8,06
	11		11	5,21
		24	24	11,37
exclusive species	24			11,37
		53		25,12
			27	12,8
total nr of species		211		100

A TWINSPAN numerical classification results in a clear clustering of the vegetation along the fire-time gradient. All relevés of the particular fire sites form distinct relevé groups. Manual improvement led to a similar result. The vegetation table is presented in table 2 (see appendix, p. 337-339).

The younger fire site was characterized by low values of plant cover with inhomogeneous patches of well growing herbs. We found species from montane forest clearings as well as from subalpine talus vegetation. A lot of species were of colline to lower montane distribution (e.g. *Mycelis muralis*, *Calamagrostis epigeios*, *Thymus pulegioides*) and characteristic for anthropogenic habitats (*Urtica dioica*, *Epilobium montanum, Taraxacum officinale agg*.). A quite good regeneration of *Larix decidua* was observed, but most individuals were not older than 1-3 years. Due to the inhomogeneity of the stands it is not possible to assign the vegetation to any association described in GRABHERR & MUCINA (1993).

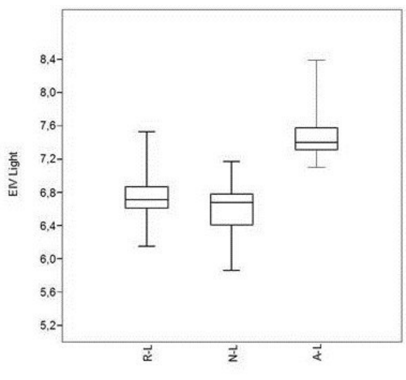

Figure 1: Boxplot of Ellenberg's indicator values for light calculated as unweighted mean values of the single relevés. R = reference site, n=13; N = younger fire site, n=50; A = older fire site, n=40.

The older fire site displayed the structure of relatively homogeneous grassland, characterized by species of semi-dry calcareous grassland and some talus and debris habitats. *Helicotrichon parlatorei* is widely dominant. Interestingly, some other species from normally higher altitudes occurred, such as *Veronica fruticans, Minuartia* *austriaca, Trisetum alpestre, Achillea clavennae* or *Polygala alpestris.* The community could be considered as a disturbed variant of the Seslerio-Caricetum sempervirentis, subtype of *Helicotrichon parlatorei* (DULLINGER et al. 2001). DULLINGER et al. (2001) mentioned further a species assemblage named "Lawinarrasen" with *Helicotrichon parlatorei*. The tussocks of this species are well adapted to recolonize unstable slopes of calcareous mountains.

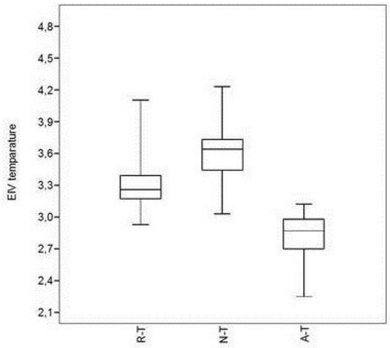

Figure 2: Boxplot of Ellenberg's indicator values for temperature calculated as unweighted mean values of the single relevés. R = reference site, n=13; N = younger fire site, n=50; A = older fire site, n=40.

The vegetation of the reference areas is classified as subalpine Krummholz over limestone bedrocks (Rhododendo hirsuti-Pinetum prostratae ZÖTTL 1951, Rhodothamno-Laricetum WILLNER & ZUKRIGL 1999, see WILLNER & GRABHERR 2007).

Significant changes between the three sites are visible using the mean Ellenberg Indicator values (EIV), calculated as a mean of the unweighted values of all relevés.

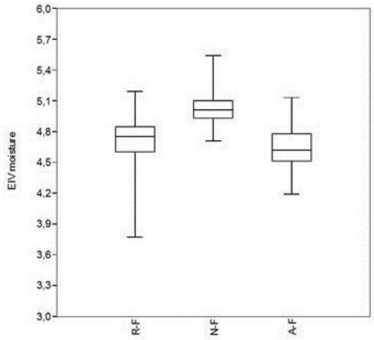

Figure 3: Boxplot of Ellenberg's indicator values for moisture calculated as unweighted mean values of the single relevés. R = reference site, n=13; N = younger fire site; n=50, A = older fire site, n=40.

The mean EIV light remain similar on the younger fire site but increased at the older fire site (figure 1). On the opposite the mean EIV temperature increased on the younger fire site to a lower temperature value on the older fire site (figure 2). The older fire site shows a significantly lower mean T-value even than that of the reference site.

The mean EIV moisture is increased at the younger fire site and similar to the reference site at the older fire site (figure 3).

The mean R-value indicates the lowest fluctuations. Compared to the reference sites it shows no differences on the younger and increases slightly on the older fire site, (figure 4).

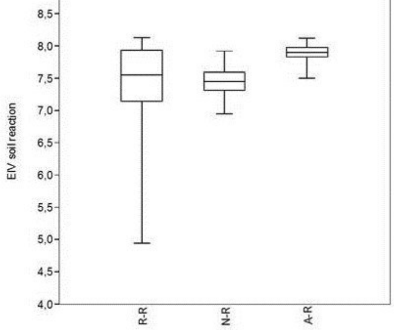

Figure 4: Boxplot of Ellenberg's indicator values for soil reaction calculated as unweighted mean values of the single relevés. R = reference site, n=13; N = younger fire site; n=50, A = older fire site, n=40.

The mean N-value was strongly affected by the fire. The younger fire site showed a significantly higher N-value than the older fire site and the reference sites (figure 5).The older fire site showed a week but significantly lower N-value than the reference sites.

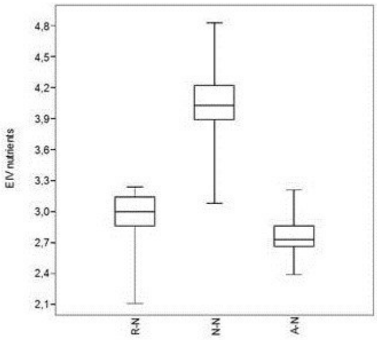

Figure 5: Boxplot of Ellenberg's indicator values for nutrients calculated as unweighted mean values of the single relevés. R = reference site, n=13; N = younger fire site; n=50, A = older fire site, n=40.

Some differences can be explained by the vegetation structure. Figure 6 shows the mean vegetation cover per site. It can be seen that, even 60 years after fire event, the percentage of total cover of the reference sites is not reached.

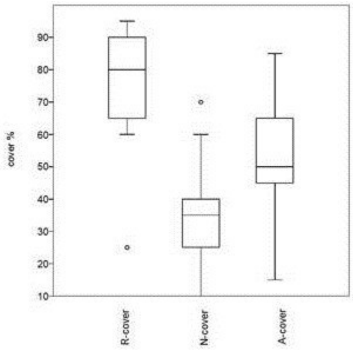

Figure 6: Boxplot of total vegetation cover calculated from the average cover values of the single relevés. Two outlayers are excluded. R = reference site, n=13; N = younger fire site, n=50; A = older fire site, n=40.

Calculating the cover values separately for the different plant growth forms (woody species, perennial and annual herbs and bryophytes), shows a way to explain this in a different way (figure 7). Especially woody species do not regenerate even after 60 years. A higher bryophyte cover is characteristic for the reference site. Annuals do not occur in the reference site, but they do not play such an important role at all as it is known for early succession stages in lower altitudes. In the contrary, their proportion increases in the older fire site. Here the general cover increased again compared with the younger fire site, but caused mainly by perennials.

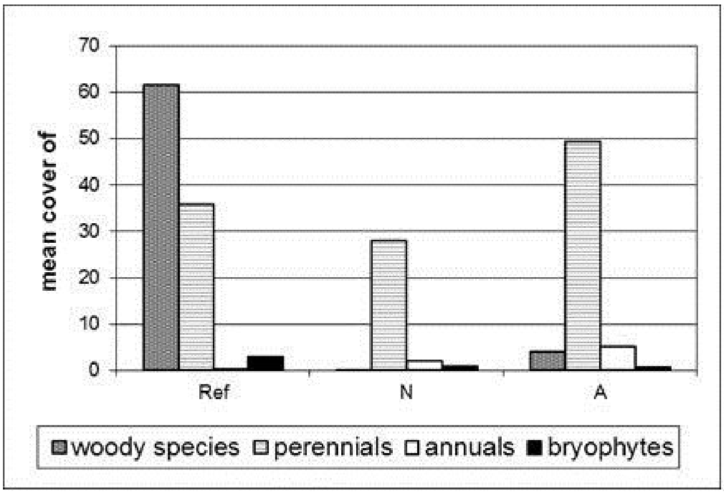

Figure 7: Bar chart of mean cover values divided into different plant growth forms. R = reference site; N = younger fire site; A = older fire site.

Discussion

The high EIV nutrient on the younger fire site is plausible in the light of the nutrient mobilization after fire events. Leaching and erosion leads subsequently to a loss of humus and nutrients, which explains the low nutrient values of the older fire site. The relatively large fluctuation on the younger fire site is a result of the inhomogeneity of the site conditions and hence the vegetation of this part.

Some widely distributed weeds are involved in post-fire regeneration even in the high montane belt, which increased the mean EIV temperature short time after the fire event, as we can see at the young fire site. The significantly low temperature value on the older fire site can be explained by the immigration of alpine species in that area. This is an important indication that post-fire areas could act as a secondary habitat for endangered alpine species.

The high mean moisture value on the younger fire site can be explained by the reduced competition for water due to the lack of the tree and shrub layer. After 60 years the area has leveled off in their natural moisture potential similar to the reference sites.

The L-value has hardly changed 8 years after the fire event. This is surprising because the loss of shrub layer leads to completely new light conditions. Only on the old fire site, a significant increase of the mean light value can be observed. This is to be explained by the migration of species from the subalpine to alpine belt into the area. They generally show higher light indicator values.

Also the R-value has changed only little after the fire. Striking, however, is the high statistical spread of the soil reaction value at the reference sites. This variation is explained by the presence of acid soil indicator species, which occur on the mor humus layer developed from pine needle litter under the old *Pinus mugo* shrubs. The fire event destroyed the humus layer more or less completely leaving the bare upcoming bedrock (limestone), which primarily determines the soil pH for the next decades. The low nutrient and high soil reaction value of the older fire site is due to the loss of the remains of the original humus layer by post fire erosion and leaching.

Our results show, no evidence for regeneration of the original vegetation type of this high montane ecosystem 60 years after a fire event.

Based on the changed site conditions, the evolving vegetation is a stable subalpine dry grassland.

The younger fire site displayed a ruderal character which is typical for disturbed areas. The mobilization of nutrients by the fire attracts short-living “weeds”. Beside that species from the reference sites as well as from the older fire site play a prominent role in the species composition. Presumably, this is a short term state that will change slowly over the next years. The younger fire site shared more species with the reference sites, than the older one. This indicates, that the 60 years lasting succession still did not lead to a regeneration of the pre-fire vegetation.

The high alpha diversity on the older fire site indicates its importance for nature conservation targets. We found some species from alpine habitats on this site. If global warming leads to changes in the competitive situation of alpine vegetation (Grabherr at al. 2010, Gottfried et al. 2012), fire sites could serve as refuge for endangered species. So these habitats could play an important role in the vegetation mosaic of National Parks.

Conclusion

Fire events in high montane ecosystems of the Alps have a substantial long-term effect on the vegetation. Krummholz will not regenerate even after 60 years. It is replaced by natural, alpine grassland vegetation with significant disturbance indicators. Species from higher altitudes may seize such areas as a new habitat. The physiognomic turn from shrub to grassland vegetation leads to the necessity of revision of nature conservation targets after fire events, especially for management planning in National Parks. Facing an increase of fire events following global warming in the Alps, this is vitally important.

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Table 2: Vegetation table from the south slope of the Hagler Mountain, National Park "Kalkalpen" (Eastern Alps, Austria). Clusters obtained as a result of TWINSPAN classfication. Cluster A = older fire site (n=40); cluster N = younger fire site (n=50); cluster R = reference site (n=13).
All relevés from June to August 2011, relevé area 25 m². The second column provides the following layer information: t1, t2 = first and second tree layer; sl = shrub layer; hl = herb layer; j = juvenile woody species; ml = moss layer.

Kategorie		AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA	NNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNNN	RRRRRRRRRRRRR
Slope (degree)		[illegible]	[illegible]	[illegible]
Cover total (%)		[illegible]	[illegible]	[illegible]
Altitude		[illegible]	[illegible]	[illegible]
Relevé Number		[illegible]	[illegible]	[illegible]
Helictotrichon parlatorei	hl	3333232322332223221242r13rr.1.1112rrr.2	..........................r...........	.........r..
Veronica fruticans	hl	11r111r.11211111211r1211111111rr11111.1r	....................rr.r.r..r............	....
Carex ornithopoda	hl	11.11rr...111...111.r1r1..1rrrrr111.1r.1	....	..r..........
Euphrasia salisburgensis	hl	r..rrr111rrrr1.1..1r1rr1r111111111111r1	....	....
Adenostyles glabra	hl	11.rr1rr1rrr11111r1rrr.r11r11r.1rr11r1r	...............rr............r..........	...........r.
Trisetum alpestre	hl	1111111111111111111111.22r111111121r11.r	..............r.........................	....
Achillea clavennae	hl	rr1r1.1r11.11rr.1rr.rr.1.r.rrr11rrrr.r..	........r.......r........r.r............	..........r..
Gentianella aspera	hl	1r.rr.1r11..r1rrr.1rr.12...rrr1r11rrr.rrr	.......................r................	....
Botrychium lunaria	hl	rrr.rr.....r.rrr.r.r..rr...r....rr......	....	....
Linum catharticum	hl	...r.........r.r..11..11...rr1..rr....r.	....	....
Minuartia austriaca	hl	.rrr.rr.r1rrrr2211r2rr1111r.rrrrr..rrrrr	..1..............1......................	r11......2r..
Thymus praecox	hl	..1rr11r11r.1..21.12...1.....r1.r.....r.r	....	....
Hippocrepis comosa	hl	rr111rr1rrr1r.r1r.rr.rr1..r.rrrr..r11...	.....r.r.......r1.rr.r..r..rr..rrrr.r..r.r..rrr	....
Carlina acaulis	hl	rrrrrrrrrrrrrr...r.....r.rrrrrr....1rr.rr	.r..........r....r...........r..........	..........r..
Cardaminopsis arenosa	hl	.rr..r..r1rrr.rrrrrrrr.rrr1r..rrr.rrr.rr.	r.rrr.....r..r..........r....r.11rr.11.1.r..rr...r..r	..........r..
Polygala alpestris	hl	.......rrrrrrr............1...r.........	....	....
Larix decidua	hl	......r..............rr.r..........1...r.r	....	....
Larix decidua	sl	..............................r2.222.2r	....	....
Carex sempervirens	hl	122222r11..1.2..122...rrr..........r.r..	....	....
Scabiosa lucida	hl	...............1.r...rr.....1r..r1r..1..	....	...........r.
Carduus defloratus defloratus	hl	rrrrrrrrrrr1rrrrr.11r.1r.r1111rrrrr111r11	.r.r..rrr....r.....rr..rr....r.r.r.rr..rrr.r....	1r1rrrrr.....
Campanula cochleariifolia	hl	.r.r11.rr1rr1r11r11.r.r1r1111r1r1r11r11.1	1......rrr.1r..1.rrrr.1..1.rr....r.r.rr...rr.r.1...	2......1r.11.
Rumex scutatus	hl	....11..........11......1...............	....	....
Sesleria albicans	hl	r11.1r121r.1r1...1......................	....	..........r..
Kernera saxatilis	hl	....r.r...............r...........r.....	....	....
Acinos alpinus	hl	11r.11rr1rrr11r.11.....1...r...rr.r1..1.	rrr......rr......r.r....................	1r1....1.....
Teucrium montanum	hl	.................r..r..........r..r.....	....	....
Epilobium montanum	hl	..............r.........................	rr.212111111r11r11111111r111111111.121222222211321 12122	....
Urtica dioica	hl	................rr......1...............	r..221211212r1212rr1r21121r112111122122111111 12212	....
Taraxacum officinale agg.	hl	..........r.............................	rrr.1rrrrrr..rrrr.rrr.rrrrrrrrrrrrrrr11rrrrrrrr1rrr	r.r..........
Mycelis muralis	hl	....	..rrr1rrrrrr.rr.rrrrrr.rrrrrrrrrr.rr11r1r.1r211r11r1	..........rrr
Salix caprea	hl	...................................r.r.r..	r...r.........rrrrr.rrrrrrr.rrrrr.r1rrrrrr.rr1rrr	....
Arenaria serpyllifolia s.str.	hl	...............r........................	1.....1.11.11...1.2..r.rr.rr1..1rr.rr..r1..r...rr.	....
Moehringia muscosa	hl	..........r.r.r.1rr.r....r....r.........	111r1rrr11r1111.111r111.1rrrr1r1r11rr.rr..r1rr11r1r	rrrr.r....r.1
Tussilago farfara	hl	....	......r........r.......r.........1rrr1rrr1r.rr.rrr	....
Larix decidua	j	...............r.....r............r.....	rrrrrr1rr1.r.rrrrrrrrr.rrr.rr..r.rr1rrrrrrrrrr.rrr.	.r...........
Marchantia polymorpha	ml	....	...r..r........rr1.....r...r..1....r...rr.....1...rrr.r	....
Cirsium palustre	hl	....	.....rr..rr.........r....r..r..r...r...r..rr1r..rr..	....
Gymnocarpium robertianum	hl	rr.r...........21.rr2rr...2r.r11..r...r..1.	r.r2r....r.r11111r1rrrrrr1r1r11.1..11r1r1rr.rrr.rrr1r	121..1...r...
Epilobium angustifolium	hl	....	.....111.........................r1..1r1rr1.r1...r	....
Dryopteris filix-mas	hl	...............r.......................r	.....r.rr..1r.rr....r..r..rr..r......rr..r.r.rr.r.r	..........r..
Calamagrostis epigejos	hl	....	.......1r.......rr.rr.r1...rr.........1...r...r....	....
Athyrium filix-femina	hl	....	...rr1.rr.......rr.r.....r..............	....
Ceratodon purpureus	ml	....	.........................1......1..r1..r..r....	....
Poa annua	hl	....	2...............r.rr...............1..........	....
Poa nemoralis	hl	....	..........r..1..r.r.............21...r....1........	..........r..
Thymus pulegioides	hl	.........r..............................	12r1112.r.1..1.1r...............r.......1.........r..	2.2rr........
Euphorbia amygdaloides	hl	....	rr.rr.r.1..1............................r...........	1r.1.1.......
Fissidens dubius	ml	....	....	1.r.r.r.rrr..
Sorbus aucuparia	j	....	......r.................................	..r1r1r..r..r
Polygala chamaebuxus	hl	....	....	r.1..1.r.....
Vaccinium myrtillus	hl	...............r........................	.r1r..r.....1r..........................	1.11111r.2..r
Pinus mugo s.str.	sl	1	..r.....................................	533555555
Dicranum scoparium	ml	....	r.......................................	..1.1.r.r11r.
Hylocomium splendens	ml	....	....	....r....r...

Continuation of Table 2 with accompanying species

Kategorie		A … A N … N R … R
Slope (degree)		[illegible]
Cover total (%)		[illegible]
Altitude		[illegible]
Relevé Number		[illegible]
Galium anisophyllon	hl	r r r 1 r r 1 r r 1 1 r r 1 r 1 1 r r 1 r r 1 r r r r r 1 r r 1 r 1 r r 1 1 1 1 2 1 1 2 r 1 r 1 . 1 . 1 1 1 2 r 1 r . 1 . r . 1 1 . r r . r r . 1 1 1 r r r . r . 1 1 . 1 1 r r . 1 1 1 1 r r r r 1 . 1 r .
Erica carnea	hl	3 1 2 r r r 2 2 2 2 . . 1 2 . r . r 2 1 2 . 1 . . . 2 2 3 2 2 2 2 2 2 3 3 3 3 3 3 r 1 1 . . r r . r . . r r r . r r r r r r r . . r r r r r r r r r . r r r r r r r r r r r r . r r . 2 r 2 2 2 1 1 2 4 1 2 1 2
Calamagrostis varia	hl	2 . . 1 1 2 1 2 1 1 1 . 1 1 r r 2 . r 2 2 1 2 1 . 1 1 2 2 1 . 1 2 r 1 2 2 1 1 2 . . 1 . . 2 1 2 r 1 1 . . r r . r . . . 1 . . r r 1 r r . . r 1 r 1 r 2 1 1 2 . . 2 . 2 1 r . 1 1 r 2 . r 2 2 2 1 2 1 2 . r .
Campanula rotundifolia	hl	r r r . . . . r r 1 r . r r . . . . r . . . r . . . . 1 1 1 1 . 1 r . . 1 . 1 1 . . . r . r 1 r . . r 1 r 1 r . 1 1 1 1 1 r r r r 1 . 1 r r . r 1 . . r 1 . 1 1 r 1 1 r r . . . r
Asplenium viride	hl	. r . r r r . . . . r . r r r r r 1 . r 1 r . . . r r . r . r r . . . r r . . r r r r r . . . . r r r r r r . r . . . . . r r . r . r . r . r r . r . r r . . . . r r r r . . r . 1 r r . . r . . . . r . .
Helleborus niger	hl	. r . r . r . . . . r r 1 . . 1 . . . . . . r r 2 r r . r r r r . . . 1 r r r r . r r r . r r r r r r r . r . . . . r . . . . r . r r . . 2 1 2 1 . 1 r r . . r . .
Asplenium ruta-muraria	hl	. r . r r . . . r . r r 1 . r . . 1 . r r . . r . r r . . . r r r r r r r . . . r r r r 1 . . . . r . 1 r . 1 r . r . . . r r r . . . r . . . . r . r . . . r . r . . . . r . . . . .
Asplenium trichomanes	hl	. . . . r . . . r . r . . . . . . r r . r r . . . r . . . r r r r r . . . . r r . r r . . r 1 1 r . . . . . . r r . r . . . . r . . r . . . . . r . . . . r . . . . .
Vaccinium vitis-idaea	hl	. . . . 1 r r 1 r r r 1 r . . r r 1 1 . r . . r . . 1 . . 1 r . . . . r r 2 1 2 3 . . 1 r . 5
Lotus corniculatus var. alpicola	hl	. r r . . r r r . . r . . . . . . r . r r . . . . . . r 1 1 1 . . r . r . . . 1 r . r . . r r . . . . r . . r . . . . r . . . . . . r . . . . r r . . . . . . r . . . r . . . .
Campanula scheuchzeri	hl	. . . r r . r . . . . r r r r . . . r r r . . . . r . r r r r 1 . . . . . . r . . r . . r . . . 1 . . . . r 2 r . . . . r . . . . r r r .
Sedum atratum	hl	. . . . r r . r . r 1 r r 1 . . . r r 1 . 1 . . r r . r . r . . . . r . . . . r . r r . . r r . . 1 . . . 1 . . . . r . . . . . 1 . . . .
Ranunculus montanus	hl	. . . . . r . r . . . . r . . r r . . . . r . . . . r r . r r r . r r r . . . . r . . . r . . . . . . 1 r 1 . r 1 r r . r . . .
Fragaria vesca	hl	. . . . . r . . . . r . . . r . . . . r 1 1 1 . 1 r . . r . r 2 r . . . . . . 1 r r r r . . . 1 . . 2 . . . . 1 r . 1 . . r r . . . . . .
Betonica alopecuros	hl	. . . . r r r . . . . r . . . . 1 r . . 1 r . . . . . . r . r r . r . . . r . 1 . . . . r . . r . . . . r r 1 . r r . r . r . . .
Polygala amara	hl	. r r r . r . . . . r r . . r r 1 r . . . . 1 . . r r . . . . r . . . r . . . . r . . . . r r . r . . r . . . .
Galeobdolon flavidum	hl	. . . . 1 r r . . 1 . . . . . r . . . . 1 . 1 r r . r r r 1 r . . . 1 . . . . 1 . . . . r . . . . 1 1 .
Daphne mezereum	hl	. . . . r . . . . r . . . . r . . . . . r . . r . . . . . r . r r r . . . . r . . . . r . . 1 r . . r r r .
Tortella tortuosa	ml	. . . . r . . . . 1 . r . . 1 1 . . . r . . 1 r . . r . r r . r r . . . . r . . . . r r . . . r
Cystopteris fragilis	hl	. . . . r . . . r . . r . . r . . . . r . . . . r . . . . r r . r . . . . . . r . . . . r r r r r . . . . r . . . .
Polystichum lonchitis	hl	. . . . r . . r . . . . r . r . r . . . r . . . . . r . . . . . . r . . . . . r . r r . . . . r . . . . . . r . . . . . . r . . . . . .
Valeriana montana	hl	. . . . r . . 1 . . r . r . . 1 1 . . . . r 1 . . . . r . . r . . . . . r . 1 1
Linaria alpina	hl	. r . . . . r . . . . 1 r r . . . . 1 r . . . . 1 . . . . r . . r . . . . 1 . . . .
Picea abies	j	r . r . . . . . . r . r . . . . r . . . . r . . . . r . . r . . . . r . . . . r . . . . 1 . . r . . . 1 . . .
Phyteuma orbiculare	hl	r . r 1 1 1 . . . . 1 . . . . r . . . . 1 . . . . r . . . . r . . 2 . . . . 1 . . . . . .
Hieracium murorum	hl	r . . . . r . . . . r . r . . . . . . r r . . r . . . . r . . . . 1 . . 1 . r . . . . . . r . . .
Rubus saxatilis	hl	. . . . r r r . . . . r . . . . r . . . . r . . . . r r . . . . r . r . . r . . 1
Ranunculus nemorosus	hl	. . . . r . r r . . . r . r . . . . r r . . . . r . 1 r . . r . . . . . .
Heracleum austriacum	hl	r . . r . . . . r r . . . . 1 . . . . r . . . . r . . . . r r . . . . r . . . . . .
Cerastium holosteoides	hl	. . . . r . . . . r r . . . . r r r . 1 . . . . r . . . . 1 . . . .
Larix decidua	t1	. . . . r . 2 . . . 2 2 . . . . 4 2 2 . 3 . . . . . .
Senecio rupestris	hl	. . . . r . . . . r . . . . r . . . . r . . . r . . . . . . r r . r . . . .
Carex brachystachys	hl	. . . 1 r . . . . 1 . r . . . . r . . . . r . . . .
Ajuga reptans	hl	. . . . r . r r r r . . . . 1 . . . r . . . . .
Picea abies	hl	. . . . . . r r r . . . . 1 . . . . 1 . r . 1 . . . .
Mercurialis perennis	hl	. . . . r . . . . r . . . . r . . . . . 1 . . . . 1 r .
Globularia cordifolia	hl	. . 1 . r . . . . r r r 1 . . . . 1 . . . . .
Picea abies	sl	. . . . 1 1 2 . 1 . . . . r . . 2 1 . . . . . .
Aconitum napellus s. str.	hl	. . . . r . . . . r 1 . r r . . . . r . . . .
Polystichum aculeatum	hl	. . . . r . . . . r r r . . . . r . . . r . . . .
Polytrichum formosum	ml	. . . . r . . . . r . . r . . . . . r . . . . r . . . .
Cerastium arvense strictum	hl	. . . r . 1 . . . . 1 1 . . . . r . . . .
Hypericum maculatum s. str.	hl	. . . . r . . . 1 . . . . r . . . . r . . r . . . . . .
Silene pusilla ssp. pusilla	hl	. . . . r r . r . . . . r . . . . 1 . . . .
Cirsium vulgare	hl	. . . . r r . . . . r . . . r . . . . r . . . .
Salix appendiculata	hl	. . . . r . . . . r . . . r . . . . r . r . . . .
Luzula pilosa	hl	. . . . r . . . . r . . . . r . . . . r . . . . r . . . .
Pulsatilla alpina ssp. Alpina	hl	. . . . r r . r . r . . . . r . . . . .
Dentaria enneaphyllos	hl	. . . . r . . . . r r 1 . . . .
Carex digitata	hl	. . . . r . . . 1 . . r . . . . r . . . . r . . . . . .
Gymnocarpium dryopteris	hl	. . . . 2 r r . r . . . .
Calamagrostis villosa	hl	. . . . r . . . . r . . . .
Salix caprea	j	. . . . r r . . r . . r . . . .
Luzula sylvatica ssp. sylvatica	hl	. . . . r . . . r . . . . 1 . . . . . .
Campanula glomerata	hl	. . . . r 2 . . 1 . . . . 1 . . . .
Eupatorium cannabinum	hl	. . . . r . . . . . . r . r . . . r . . . .
Potentilla brauneana	hl	. . . . r r . r . . . . r . . . .
Bryum capillare	ml	. . . . r . . . . r . . . . r r . . . . .
Polytrichum juniperinum	ml	. . . . r . . . . 1 . . . . 1 . . . . r . . . .
Pinus mugo s.str.	j	. . . . . r . . . . r . . . . r . . . .
Ditrichum flexicaule	ml	. . . . 1 . . . . r r . . . . r . . . .
Viola biflora	hl	. . . . r . . . . r . . . .

Kategorie		A … A	N … N	R … R
Slope (degree)		[illegible]		
Cover total (%)		[illegible]		
Altitude		[illegible]		
Relevé Number		[illegible]		

Rhododendron hirsutum	hl	2
Asplenium fissum	hl	r r
Hieracium villosum	hl	r r
Digitalis grandiflora	hl	r r 1
Picea abies	t1	2 2 2
Knautia arvensis agg.	hl	r r r
Valeriana tripteris	hl	r 1 r
Euphrasia officinalis	hl	r r r
Ranunculus hybridus	hl	r r
Centaurea montana	hl	r r r
Alchemilla anisiaca	hl	r 2
Bryum argenteum	ml	r r r
Larix decidua	t2	2 2 1
Ctenidium molluscum	ml	r r r
Dryopteris dilatata	hl	r r r
Campanula cespitosa	hl	r r 1
Carduus defloratus viridis	hl	r r r
Polygonatum verticillatum	hl	r r 1
Anthyllis vulneraria alpicola	hl	r r
Ptilidium ciliare	ml	
Oxalis acetosella	hl	
Plagiothecium laetum secundum	ml	
Saxifraga rotundifolia	hl	
Lycopodium annotinum	hl	
Calypogeia azurea	ml	
Dryopteris carthusiana s. str.	hl	
Veronica chamaedrys	hl	r r
Myosotis arvensis	hl	r 1
Noccaea rotundifolia rotundifo	hl	r 1
Rosa pendulina	hl	r r
Bryum caespiticium	ml	r r
Trisetum flavescens	hl	r r
Meum athamanticum	hl	r r
Silene vulgaris ssp. vulgaris	hl	r r
Huperzia selago	hl	r
Pinus mugo s.str.	hl	r r
Orobanche alba	hl	r r
Carex mucronata	hl	r
Primula auricula	hl	r r
Pinus sylvestris	j	r r
Encalypta streptocarpa	ml	r r
Cerastium carinthiacum carinth	hl	r r
Arabis alpina	hl	r r
Acer sp.	j	r r
Senecio ovatus	hl	r r
Homogyne alpina	hl	r
Picea abies	t2	2 2
Blechnum spicant	hl	r
Geranium sylvaticum	hl	r r
Hypnum cupressiforme	ml	r r

Other species:

Acer pseudoplatanus [6] 95: r; *Alchemilla coriacea* [6] 41: r; *Alchemilla monticola* [6] 42: r; *Alchemilla vulgaris agg.* [6] 82: r; *Antennaria dioica* [6] 35: +; *Arabis ciliata* [6] 93: 1; *Athamanta cretensis* [6] 7: r; *Atropa bella-donna* [6] 49: r; *Barbilophozia attenuata* [9] 103: +; *Barbula convoluta* [9] 78: +; *Blechnum spicant* [6] 54: r; *Carex mucronata* [6] 14: +; *Cerastium glutinosum* [6] 71: +; *Clematis alpina* [6] 48: r; *Cystopteris alpina* [6] 64: r; *Dicranum montanum* [9] 92: +; *Epilobium palustre* [6] 58: 1; *Euphorbia cyparissias* [6] 50: r; *Festuca rupicola* [6] 61: 2; *Fraxinus excelsior* [7] 65: r; *Homogyne alpina* [6] 97: r; *Huperzia selago* [6] 94: r; *Hypnum andoi* [9] 98: +; *Juncus monanthos* [6] 19: +; *Juniperus communis ssp. communis* [6] 40: r; *Juniperus communis ssp. communis* [4] 90: 1; *Knautia arvensis* [6] 41: r; *Knautia maxima* [6] 56: 1; *Lathyrus pratensis* [6] 47: r; *Leontodon helveticus* [6] 74: r; *Leontodon hispidus ssp. hispidus* [6] 97: +; *Leucanthemum atratum* [6] 94: 1; *Lonicera alpigena* [6] 100: +; *Luzula luzulina* [6] 42: +; *Medicago lupulina* [6] 89: r; *Melica nutans* [6] 47: +; *Orobanche sp.* [6] 32: r; *Phyteuma spicatum* [6] 48: +; *Pinus sylvestris* [1] 37: 3; *Plagiochila porelloides* [9] 92: +; *Plagiothecium undulatum* [9] 103: +; *Poa angustifolia* [6] 57: +; *Pulsatilla alpina ssp. alpina s.lat* [6] 98: r; *Rhododendron hirsutum* [6] 97: 2; *Rhytidiadelphus loreus* [9] 103: +; *Rhytidiadelphus triquetrus* [9] 103: +; *Salix purpurea* [6] 87: r; *Salix sp.* [7] 83: r; *Sambucus ebulus* [6] 76: 2; *Scabiosa sp.* [6] 97: +; *Schistidium apocarpum* [9] 42: +; *Sedum album* [6] 71: r; *Senecio abrotanifolius* [6] 93: +; *Silene alpestris* [6] 59: +; *Silene nutans ssp. nutans* [6] 82: 1; *Solanum nigrum* [6] 74: r; *Sorbus aria* [6] 100: 2; *Sorbus aucuparia* [8] 91: +; *Sorbus chamaemespilus* [7] 103: 1; *Teucrium chamaedrys* [6] 31: 1; *Thesium alpinum* [6] 24: r; *Ulmus glabra* [7] 88: r; *Verbascum sp.* [6] 81: r; *Veronica serpyllifolia ssp. humifusa* [6] 93: r

Conference Volume | 5th Symposium for Research in Protected Areas, 10 to 12 June 2013, Mittersill | pages 341 - 342

Challenges in Conserving Private Protected Areas: where are the opportunities?

Sristi Kamal

Keywords

nature conservation,protected area, private land, qualitative research

Abstract

Globally, formal protected areas (IUCN categories of protected areas) have undergone significant change in past few decades with respect to their ownership structure. Establishment of the earliest protected areas involved converting private land into public; however, with the growing demographic pressure and the simultaneous demand to increase the size and number of protected areas to halt biodiversity loss, private land as protected areas has begun to play a significant role in biodiversity conservation. This study focuses on private land under nature conservation in different forms of protected areas in Poland, namely a national park, a landscape park and a Natura 2000 site which is the most recent form of nature protection in the country (19.8% of Poland is under Natura 2000) as a relatively new Member State. Site selection process required use of satellite imagery in cases of protected areas where data on private ownership inside the protected area was not available. In order to examine the standpoints of different stakeholder groups on the importance and challenges of private land conservation, research methodologies from social and socio-psychological fields were used, such as qualitative in-depth interviews and Q methodology. Problem definition and understanding of various perceptions is imperative for successful mitigation of potential conflicts and also effective implementation of conservation on private land in Poland.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 343 - 344

Aerosol Measurements at the Sonnblick Observatory On-line Identification of Long-Range Transport of Particulate Matter

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Abstract

Absorption and scattering of light by aerosol particles influence the radiation transfer in the atmosphere. Aerosols can thus affect the Earth's climate and influence visibility. At the Sonnblick Observatory, number concentrations of aerosol particles as well as mass concentrations are generally very low, reflecting the global background status of the site with prevalent clean air conditions. Nevertheless air quality at high alpine sites can be impacted by long range transport of Saharan dust or by biomass burning, an ubiquitous source of particulate matter in Europe.

The instrumental setup operated at the Sonnblick Observatory during two field campaigns in 2012 and 2013 allows the on-line characterization of periods with elevated concentrations of aerosols. Here we present results of these measurement campaigns and discuss the potential of the on-line identification of transport phenomena of particulate matter.

Keywords

atmospheric aerosols, Saharan dust, biomass burning, optical parameters

Introduction

Aerosolized particulate matter is highly relevant for air quality and related topics such as human health, but also climate issues. While health issues are more often discussed for highly polluted regions, characterization of aerosols in clean environments is urgently needed to investigate their effect on the climate, atmospheric visibility or the formation of precipitation. It has already been shown that mountain observatories can be used as platforms for the long term investigation of background concentrations and even free tropospheric air masses (Galasyn et al. 1987). More recently this approach has been extended to more comprehensive sampling programs for particulate matter (e.g. Weingartner et al. 1999, Collaud Coen et al. 2004) focusing on variations in aerosol concentrations due to transport phenomena as well as particle formation during nucleation events. Earlier aerosol sampling at the Sonnblick Observatory illustrated the seasonal cycles of major ions (Kasper and Puxbaum 1998) as well as implications for scavenging processes (Kasper-Giebl et al. 2000) and radiative forcing (Iorga et al. 2007). The characterization of carbonaceous aerosol particles underlined the marked impact of particulates originating from wood burning (Puxbaum et al. 2007) or living biomass (Sanchez-Ochoa et al. 2007). Event based studies showed the influence of long range transport of Saharan dust (Koller et al. 2009).

Methods

Aerosol characterization at the Sonnblick Observatory is performed routinely by two condensation particle counters (TSI, CPC 3022A) for monitoring of the total number concentration, an optical particle counter for the determination of particle size distribution in the size range between 0.3 and > 5 µm (Klotz, TCC-3) and a SHARP monitor (Sharp 5030, Thermo) for the determination of aerosol mass concentration. The set-up was extended temporarily by two three wavelength Nephelometers (TSI 3563, Ecotech Aurora 4000), a Scanning Mobility Particle Sizer (Vienna Type DMA) and an Aethalometer (Magee Scientific AE 33). Thus a comprehensive picture of the physical characteristics of the particulate matter prevailing at the site can be given. Long-range transport can be identified as well as daily variations of concentration values due to the uplifting of boundary layer air masses or an increase of particle number concentrations due to nucleation events. The set-up also allows to identify Saharan dust events on-line based on the approach given by Collaud Coen et al. (2004) and Fialho et al. (2005) and to characterize periods of elevated concentrations of black and brown carbon – tracers for biomass combustion. To highlight the potential of further evaluations most of the data is made accessible on-line via the Sonnblick Observatory homepage - www.sonnblick.net.

Results

During the field campaign conducted from October to December 2012 daily average number concentrations generally were in the range of 450 to 600 cm^{-3}. As expected these values are quite low, reflecting the clean air status of the site. Nevertheless they are slightly higher than determined in previous winter measurements in the years 2005 to 2008 (KOLLER et al. 2009). Looking at diurnal daily cycles more variations could be observed in the recent measurements as well. Number concentrations determined with the CPCs were compared with the overall signal of the SMPS to account for methodological differences.

Daily mean mass concentrations measured with the Sharp 5030 are in the range of 2 µg/m³, but sometimes were found to be < 1 µg/cm³. Thirty-minute average mass concentrations up to > 6 µg/m³ were observed during a number of consecutive days in December 2012. These increases of mass concentrations coincided also with elevated number concentrations determined with the CPC. Size resolved measurements showed an increase of number concentrations in the particle size classes >0,3 µm and >0,5µm.

During the spring campaign which started in February 2013 particle mass concentrations as well as number concentrations are increasing, due to the changing meteorological conditions. The occurrence of a Saharan Dust event (26.4.2013 until 6.5.2013) allows to investigate the influence of such a long range transport phenomenon on the changing aerosol size distributions, the absorption and scattering coefficients as well as the single scattering albedo. Sampling will be continued until summer 2013.

Acknowledgements

Thanks go to the Austrian Academy of Science, Clean Air Commission and the Local Authority of Salzburg, Referat 16-02 Immissionsschutz, for providing the CPCs and to EcoTech for loan of the Aurora 4000. Further thanks go to the colleagues working at the Sonnblick Observatory for maintenance of the instruments and support.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 345 - 352

The Impact of *Robinia pseudoacacia* on Ground Vegetation and Plant Nutrient Matter in Donau-Auen National Park

B. Kastler & C. Samimi

Abstract

We investigated the influence of Black Locust (*Robinia pseudoacacia L.*) on ground vegetation and plant nutrient matter in the riparian forest of Donau-Auen National Park.As a legume, *Robinia pseudoacacia* is able to change soil nutrient availability by fixing atmospheric nitrogen in the soil (see HECKER 2000). It may be assumed, that a change in resource availability can affect the species composition of a habitat.Especially in environments with low content of soil nitrogen, such as dry grassland or dry forests, the presence of *Robinia pseudoacacia* can have a great influence on the plant community (see NENTWIG 2010).The aim of this thesis was to examine the relationship between Black Locust, soil nitrogen content and species composition of the habitat in Donau-Auen National Parkand evaluate the hypotheses mentioned above.To assess the influence of the tree on the local ecosystem, 34 plots were selected within four areasnear Stopfenreuth, Orth and Hainburg. In addition to vegetation surveys (spring and summer), soil samples were taken and analyzed for physical and chemical soil parameters. Data analysis was conducted with univariate and multivariate statistics.

The influence of Black Locust on the availability of nitrogen in the soil was proven to be significant. The NO_3-content showed the highest response while the C/N-ratio appeared to remain unaffected by the presence of *Robinia pseudoacacia*. Nevertheless, the ground vegetationseemed to be influenced by the neophyte, wherebyboth the availability of nitrogen and the increased exposure to light due to reduced shading underBlack Locust appears to be relevant. Near the tree some nitrophilous species gained abundance while some photosensitivespecies thinned out.This speciesshift can perhaps be assumed to affect the naturally high biodiversity of the habitat in Donau-Auen National Park.

Keywords

Invasive Species, Biodiversity,Black Locust, Nitrogen Fixation, Vegetation-Soil Effects

Introduction

Robinia pseudoacacia, also known as Black Locust, is a neophytic tree that originates from North-America and was brought to Europe in the 17th century as an ornamental plant and forest tree. As a legume,Black Locustis able to change soil nutrient availability by fixing atmospheric nitrogen in the soil. Especially in habitats with low content of soil nitrogen, such as dry grassland or dry forests, it is known that this can affect the soil chemical properties, nitrogen-cycling and species composition of the local vegetation (see BERTHOLD 2005; BÖHMER et al. 2000; CASTRO-DIÈZ et al. 2009; KOWARIK 1992; RICE et al. 2004;WANG et al. 2012). Changes of species assembly in these cases are based on the increased nitrogen availability, promotion of nitrophilous species and consequently supplanting of oligotraphent species, which often entails an endangerment of the local biodiversity. Moreover, the tree is suspected of having allelopathic qualities, which are very difficult to detect (see DIERSCHKE 1994) and therefore were not estimated in this study. Compared to other trees in the study area (such as *Acer*, *Fraxinus*, *Quercus*) the leaves of *Robinia pseudoacacia* shoot relatively late and do not offer much shade. Theincrease of radiation intensity under Black Locustshould also be considered as an influencing factor for ground vegetation cover.

The present study aimed to investigate the effects outlined above in the naturally nitrogen-rich habitat of Donau-Auen National Park. In this context, the questionwas explored how the neophytic tree impacts soil nitrogen availability and ground vegetation.Additionally, the significance of density and age of the *Robinia pseudoacacia* population should be assessed in this regard. The study sites are located in a protected area in which the tree was introduced for reforestation and bee pasture before the national park was established. In the riparian forest of the study area Black Locust partly forms pure stands and is considered as a problematic species because it is feared to endanger the rich biodiversity of the habitat (see NATIONALPARK DONAU-AUEN GmbH 2009). Until now, the tree is not directly impacted by intensive control measures in Donau-Auen National Parkbut is being targeted for use as fuel wood (personal information from Dipl.-Ing. Bernhard Posch, ÖBf, 11/02/2013).

Methods

<u>Study Sites and Experimental Design</u>

The research areas are located in the riparian forest near Stopfenreuth, Orth and Hainburg on three non-flooded areas behind the Marchfelddike and one area in the flooded-forest in front of the dike (see Figure 1). This sampling design accommodates the assumption that frequent flooding leads to modified transportation of dissolved and solid matter (see BLUME et al. 2010). Therefore, the main focus of the study lies on the non-flooded areas, while the flooded areaprovides an additional view on different environmental conditions.Each of the four areas intrinsically shows similar physical soil parameters and relief position.

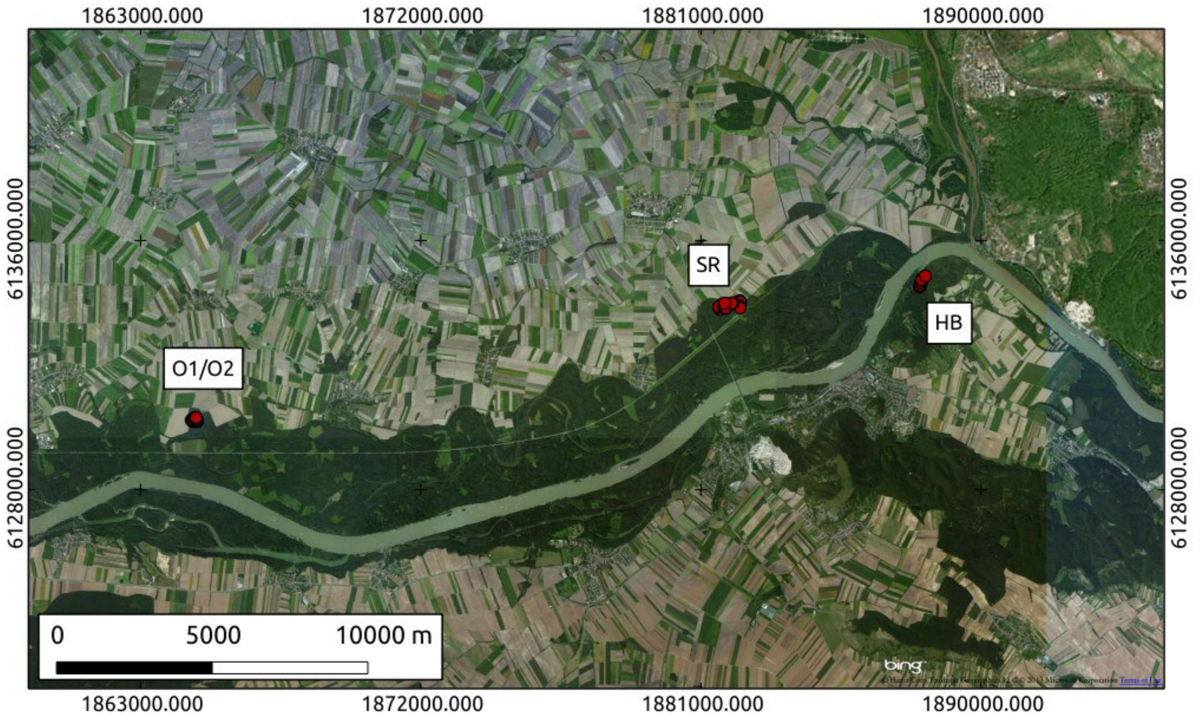

Figure 1: Study Areas (Database: Bing maps © Harris Corp. Earthstar Geographics LLC © 2013 Microsoft Corporation)

In Stopfenreuth (SR), 18 plots with varying density and age of *Robinia pseudoacacia* were selected in a mixed Oak-Ash-Elm forest. In Orth (O), two areas with extremely different vegetation cover could be investigated in close proximity to each other. The area O1 (5 plots) hosts a dense Black Locust forest, while O2 (5 plots) hosts a pure Oak-Hornbeam forest. The 6 plots in Hainburg (HB), the only research area not protected by the Marchfeld dike, were placed in a mixed Maple-Ash-Poplar forest with varying density and age of Black Locust.

By analyzing soil parameters as well as surveying the species composition of the ground vegetation, the study aimed to monitor the potential changes associated with thedensity and age of present *Robinia pseudoacacia*.

Vegetation Surveys and Soil Samples

To assess the influence of the tree, 34 plots at approximately 300 m^2 with varying density and age of *Robinia pseudoacacia* were selected in the forest stands. Vegetation surveys took place in April and June 2012. All woody species were recorded. Using a nested sample design, herbaceous species were sampled on randomly selected squares of 1x1 m. To evaluate the influence of Black Locust, the trees of each investigation site were classified into groups of density (loose-middle-dense) andage (young-middle-old).In addition,mixed soil samples were taken. For each site,tensampleswere extracted with a hollow drillfrom the upper 40 cm of the soiland mixed in a container.Approximately 500 grams were retained from that mixed soil matter, hermetically sealed and cooled. Within 24 hours,the samples were analyzed in the laboratory for NO_3 and NH_4.Thereafter, C/N ratio and standard parameters such as grain size, pH-value and moisture were evaluated.

Statistical analysis

The collected data was analyzed with univariate and multivariate statistical methods using the open source software R. Various correlation and regression analyses, cluster analyses and ordinations (NMDS, CCA) were generated to estimate the influence of Black Locust on soil nitrogen and carbon as well as on the ground vegetation species composition.In the NMDS diagram isolines generated with the R-function `ordisurf´ (see SIMPSON 2011) illustrate to what extent the environmental parameters influence the species composition of each investigation site.

Results

Soil analyses did not detect any NH_4in the studyarea. NO_3 therefore represents all mineral nitrogen that was considered in the analyses. The findings show a significant elevation of total soil nitrogen content due to the presence of *Robinia pseudoacacia*(see Figure 2a) while C/N ratio does not significantly vary with presence or absence of the tree (see Figure 2b). On closer inspection, the NO_3-content conspicuously increased under Black Locust and was also positively correlatedwith the density (cor = 0.512, p = 0.0053) and the age (cor = 0.317, p = 0.099) of the trees (see Figure 2c and 2d). A regression analysis showed similar results (see Figure 3).

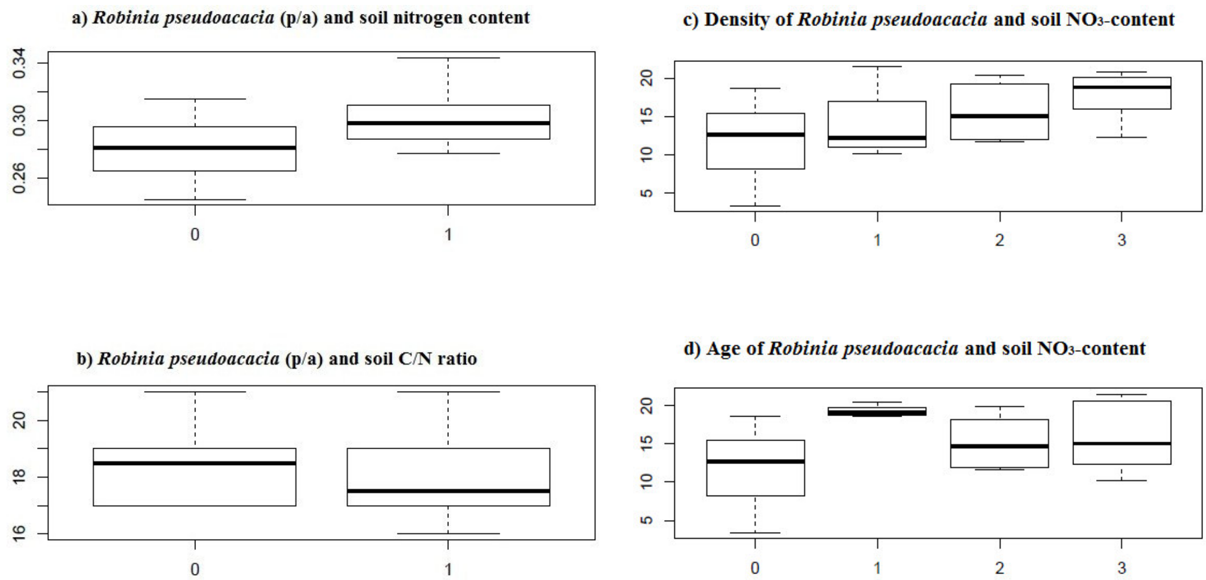

Figure 2: *Robinia pseudoacacia* and Soil Nitrogen

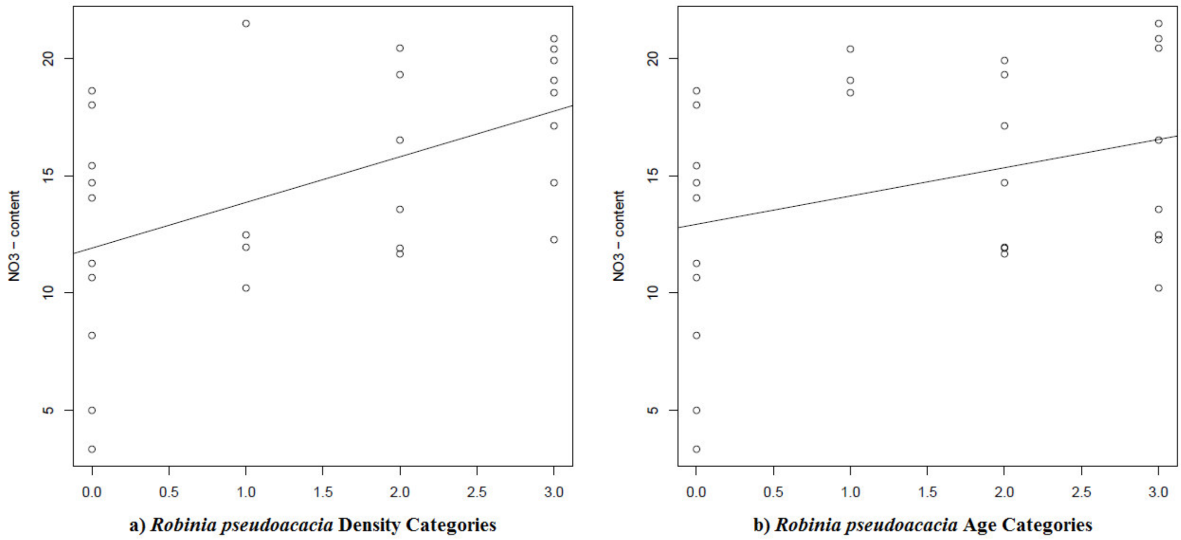

Figure 3: Density / Age of *Robinia pseudoacacia* and Soil NO3-Content

The NMDS (non-metric multidimensional scaling) of the investigation sites (SR: 1-18, O1: 19-23, O2: 24-28, HB: 29-34) and the environmental parameters post-hoc plotted on the diagram showed a significant influence of C/N ratio, Black Locust density and sand content on the species assembly. Black Locust age and NO_3-contentwere not identified as significantly influencing variables (see Table 1).Figures 4, 5 and 6 show the influence of the significant environmental parameters on the NMDS ordination diagram.

Table 1: Influence of Environmental Parameters on Vegetation Assembly

Environmental parameter	Non-parametric fit (R^2)
C/N	**0.50** (p=0.002) **
Density (*Robinia pseudoacacia*)	**0.32** (p=0.029) *
Sand	**0.36** (p=0.030) *
Age (*Robinia pseudoacacia*)	0.11 (p=0.236)
NO_3	0.09 (p=0.541)
Significance codes (999 permutations): ** (p ≤0.01), * (p ≤ 0.05)	

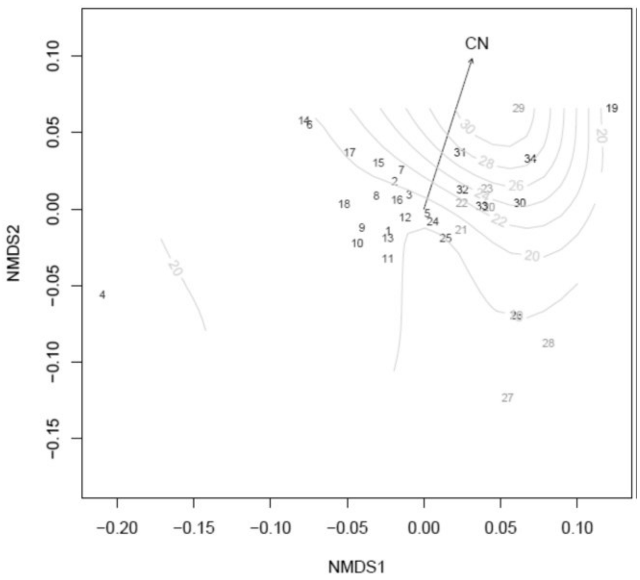

Figure 4 Influence of C/N on Ground Vegetation Assembly

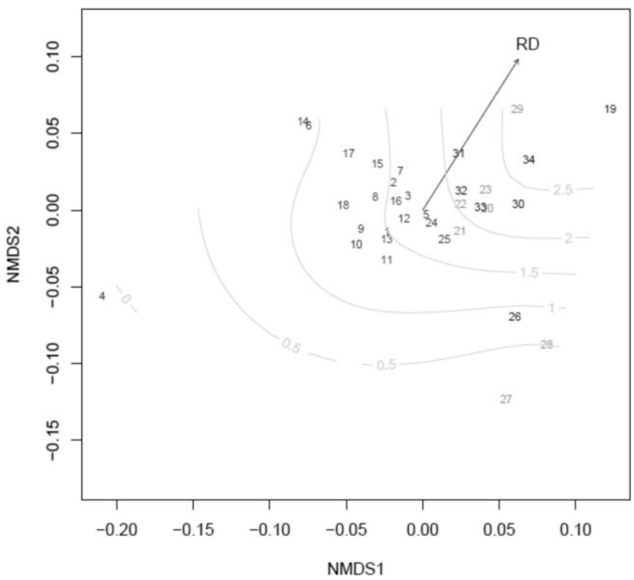

Figure 5: Influence of Density of *Robinia pseudoacacia* on Ground Vegetation Assembly

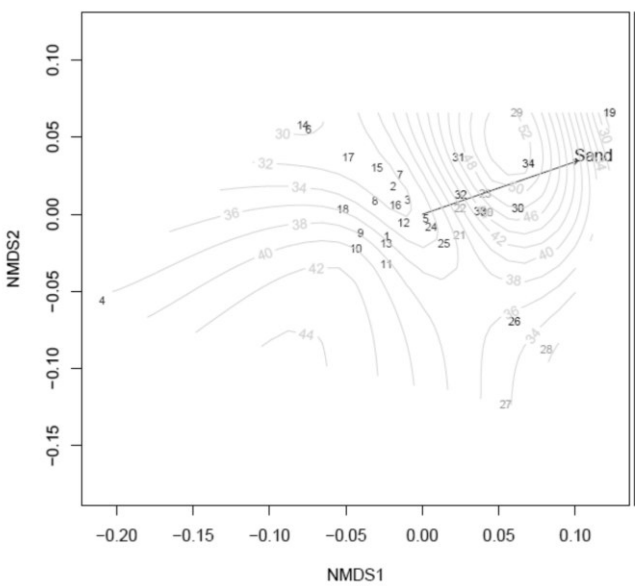

Figure 5: Influence of Sand on Ground Vegetation Assembly

A closer assessment of the influence of *Robinia pseudoacacia* (density and age) on vegetation composition was provided by a CCA (constrained correspondence analysis).The results show that the density of Black Locustseems to have a stronger impact on the sites in O and HB, while the sites in SR appear to be stronger influenced by the age of the trees. On sites located in the lower part of the diagram there are no exemplars of Black Locust.

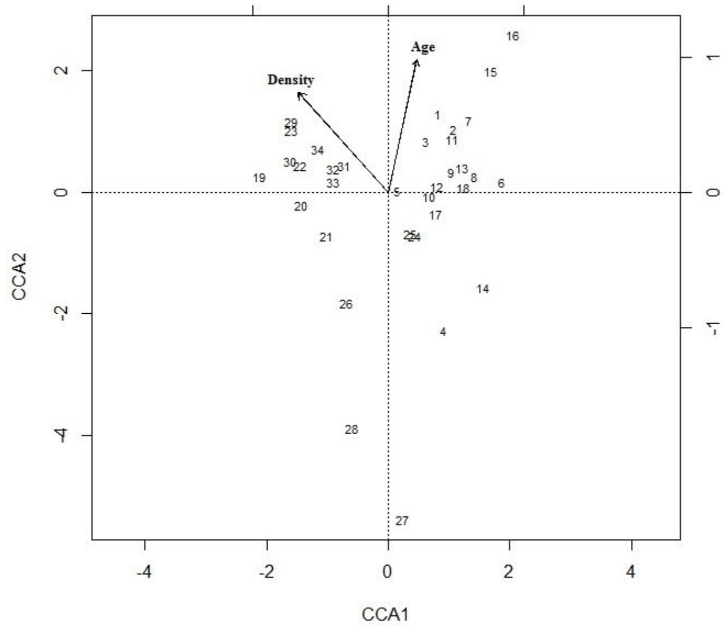

Figure 6: CCA of Investigations sites influenced by Density and Age of *Robinia pseudoacacia*

As the ordination diagrams (NMDS, CCA) showed, *Robinia pseudoacacia* appears to influence the species composition of the ground vegetation cover. Further detailsregardingthe occurring changes could be identified by a closer examination of the vegetation data (see Table 2). The abundance of some nitrophilous species, such as *Sambucus nigra* and *Urtic adioica* increased considerably with rising density of Black Locust. This expansion, however, only seemed to apply to extremely nitrophilous species (N9) which are tolerant to light. Other nitrophilous species such as *Aegopodium podagraria* (N8)show a slight increase. Furthermore, some species such as *Allium ursinum, Anemone ranunculoides, Galium odoratum,* or *Polygonatum latifolium* seemed to be restrained by *Robinia pseudoacacia*.These species are nitrophilous or moderately nitrophilous but alsofairly photosensitive, which might be the reason for their decline beneath Black Locust. Other species, e.g. *Viola odorata*, also seem to avoid sites with Black Locust even though there are noapparent site specific reasons.

Table 2: Site Demands (Nitrogen, Light) and Abundance of Species compared to Density of *Robinia pseudoacacia*

Scale value*	Species	Coverage of Robinia**	Coverage of Species***
N9, L7	*Sambucus nigra*	I	6.5
		II	136.7
		III	176.1
N9, x	*Urtica dioica*	I	4
		II	4
		III	73.5
N8, L5	*Aegopodium podagraria*	I	121.6
		II	227.2
		III	269.3
N8, L2	*Allium ursinum*	I	845.9
		II	828.3
		III	159.2
N8, L5	*Viola odorata*	I	20.4
		II	26.1
		III	2.5
N8, L3	*Anemone ranunculoides*	I	13
		II	17.7
		III	0.2
N5, L3	*Polygonatum latifolium*	I	8.8
		II	7.5
		III	1.2
N5, L2	*Galium odoratum*	I	3.7
		II	2
		III	0.5

* N – Nitrogen:1 = indicate nitrogen poorest sites, 2 = between 1 and 3, 3 = occurs more frequently on nitrogen poor sites, 4 = between 3 and 5, 5 = indicatemoderately nitrogen rich sites, 6 = between 5 and 7, 7 = indicate nitrogen rich sites, 8 = indicatehighly nitrogen rich sites, 9 = concentrate on extremely nitrogen rich sites, x = indifferent.
L – Light: 1 = deeplyshaded sites, 2 = between 1 and 3, 3 = shaded sites, 4 = between 3 and 5, 5 = half-shaded sites, 6 = between 5 and 7, 7 = half-light site, 8 = light site, 9 = bright light site, x = indifferent.
Scale Values based on ELLENBERG (1992)
** I: no *Robinia pseudoacacia*, II: 1-10 *Robinia pseudoacacia*, III: >10 *Robinia pseudoacacia*.
*** cumulatedpercentage coverageof the species over all 34 investigation sites

Discussion

Nitrogen and Carbon

As no NH_4 was found in the soil samples,a high activity of nitrifying micro-organismswas assumed, which converts NH_4 into NO_2 und NO_3 (see BLUME et al. 2010).The ratio between carbon and nitrogen (C/N) does not vary with presence or absence of *Robinia pseudoacacia*. A possible reason can be found in the fact that mineral nitrogen in the study area only represents a very small part of total nitrogen. Therefore, the increasedmineralization due to Black Locust may not be reflected in total C/N ratio.

Density and Age

Age assessment and classification of the age groups turned out to be very difficult. Due to former silvicultural interventions, some trees were cut, dilapidated and developed plenty of sprouts so that the age of the trees was beyond recognition. Furthermore, on most plotsthere were several trees with various ages, which is the reason for group-categories only representing an average value of each site.In all analyses the density of the *Robinia pseudoacacia* population could be evaluated as a significantimpact factor for soil NO_3-content and species composition of ground vegetation cover.In this context, the age of Black Locustalso seemed to influence soil NO_3-content but could not beidentifiedas significant regarding the vegetation cover. However, the limited relevance of the tree age could be due to thedata uncertainties outlined above. Furthermore, on O and HB the populations of *Robinia pseudoacacia* varied in density but were of similar age. Only SR featured Black Locust in all categories of density and age. The results of the CCA lead to the assumption, that thisalso may be a reason why the age of Black Locustwas not significantly influencing all investigation sites. The age differences between the individuals of *Robinia pseudoacacia*on most sites (O and HB) may not have beenlarge enough to produce a significant result in the NMDS.

NO3 and Radiation Intensity

The NMDS diagram also does not displayNO_3-content as a significant parameter affecting species assembly of the research sites, even though we detectedthat it waspositively correlated with Black Locust density. This instance might be an indicator for the ambiguous influence of soil nitrogen on species composition of the habitat which is assumed to be overshadowed by the influence of radiation intensity. In the naturally nitrogen-rich habitat of the riparian forest, sites without *Robinia pseudoacacia*also provide high levels of soil nitrogen. Therefore, the increase of nitrogen due to Black Locust almost only promotes species that are extremely nitrophilous.Moderately nitrophilous species in any case find favorable conditions in the habitat and appear to be barely affected by the presence or absence of Black Locust. Conversely, the increased radiation intensity under *Robinia pseudoacacia* seems to have an explicit impact on the species assembly of the mostly photosensitive forest vegetation. Several shade-loving species became rare on sites that were dominated by Black Locust.However, some species seemed to avoid suchsites, even though this observation could not be explained by any site specific parameters such as nitrogen availability or radiation. In these cases, allelopathic qualities of Black Locust or other environmental impacts may be involved.

Nature conservation

Robinia pseudoacacia is a pioneer plant, which needs a lot of light to grow (see HECKER 2000). Therefore, itseemsunlikely that in the dense forest of the study area the tree will spread independently to agreat extent as it does e.g. on dry grassland. Nevertheless, the occurrence of a new species always does set off a process of change (see KEGEL 1999). As KOWARIK (1992) described, the final state after successional processes could be different under Black Locust than under other trees. Concerning this, *Robinia pseudoacacia*can in fact be characterized as an endangerment for the conservation of the local ecosystem. Furthermore, the present study could find indicators for a progressive monotonisation of the ground vegetation as mentioned in BÖHMER et al. (1989).Under certain circumstances, this could threaten the rich biodiversity of Donau-Auen National Park.

Conclusion

In summary, it was proven that *Robinia pseudoacacia* affects plant available soil nitrogen content as well as ground vegetation assembly, while the latter not only seems to be influenced by soil nutrient matter but also by the altered radiation intensity due to reduced shading under Black Locust. A promotion of extremely nitrophilous species could be found in some cases, such as *Sambucus nigra and Urtica dioica*. Radiation sensitive species like *Allium ursinum* or *Galium odoratum* showed an unambiguous decline under *Robinia pseudoacacia*. Even though Black Locust is a pioneer plant, which on forest stands presumably does not spread independently to a great extent, one should not disregardthat the presence of *Robinia pseudoacacia* might constitute a long-term impairment of the local biodiversity.Since the present study does not aim to give management recommendation, further studies would be needed to pursue this issue.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 353 - 362

Habitat preference of the sublittoral fish assemblage in a free-flowing section of the Danube River, Austria.

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Abstract

The main channel of the free-flowing section of the Danube River downstream of Vienna (Austria, Europe) is impacted by impoundments upstream and has been altered by flood protection measures, by bank stabilization and maintenance of a navigation channel. In order to provide information for planning of restoration measures, and due to the high indicator value of the fish assemblage, we investigated habitat suitability and patterns of habitat preference of the sublittoral fish assemblage within a selected, representative river reach. The hydraulic information from a 3D numerical model with a high spatial resolution was combined with precise positions of caught individuals. The recording of the position of caught individuals was possible by the application of a newly developed technique which complements standard boat-electro fishing procedures. Combining hydraulic conditions from the hydrodynamic model with the abundance of fish enables the projection of information based on sampling points to area, and to simulate the potential impact of different restoration measures on habitat availability and habitat quality, and may therefore serve as a basis for conservation issues.

Keywords

Large River, river restoration, habitat modeling, species conservation

Introduction

Fish are important elements in the bio-assessment of river ecosystems worldwide (Roset et al. 2007), and are effective in describing the effects of human impacts in relation to natural or near-natural conditions. Several review papers underline the importance of physical habitat structure in determining both the abundance and species composition of stream fishes (Ahmadi-Nedushan et al. 2006, Bovee et al. 1998, Lamouroux et al. 1999, Parasiewicz & Dunbar 2001, Vadas & Orth 2001). An understanding of how hydraulic forces relate to fish habitat will assist in planning restoration projects (Newbury & Gaboury 1987, Rabeni & Jacobson 1993). Management schemes based on a process-oriented view, aiming at nature conservation and predicting expected species distributions, should therefore integrate these findings (Tockner et al. 1998, Schiemer et al. 1999, Schiemer 2000, Porter et al. 2000, Schmutz et al. 2000, Wolter & Bischof 2001).

A large part of the main stem of the free-flowing stretch of the River Danube east of Vienna adjoins the Alluvial Zone National Park, and at the same time it represents an important section for navigation. In order to improve the ecological situation of this site, a pilot reach with a length of 3 kilometers was selected to study the effect of a set of measures (modification of groynes, removal of rip-rap, displacement of shoreline stabilization, river bed stabilization measures) on the fish assemblage. A major reason for the slow recovery of fish faunas of regulated large European rivers is the loss of productive habitats in the main channels (Aarts et al. 2004). Changes in streamflow modify physical habitat (Bain & Finn 1988), therefore we analyzed the effect of discharge on community composition and fish abundance as well as on habitat availability, habitat use and habitat preferences. The results should facilitate the simulation of habitat suitability within the entire river reach and of specific shore types. It should also help localize key habitats and shortfalls, as well as provide a basis for improving habitat conditions for fish in the main stem of the free-flowing Danube east of Vienna.

Material and Methods

Study site

Sampling was carried out in a 3-km-long test reach in the Danube, from river kilometer 1884.50 to 1887.50, which is equivalent to approximately ten times the average width. The samples were taken for the project "Pilot Project Bad Deutsch Altenburg" in the period between beginning of March to late August 2007 in the pilot reach. An overview of the investigation area is shown in Fig. 1.

Table 1: Species number and fish assemblage composition expressed as number of individuals (Ind), abundance (CPUE = catch per unit effort expressed in individuals per minute fishing time) and cumulative percentages ($Perc_{cum}$) of the abundances of single species of the total catch and at different discharge regimes (Q1200, Q1500 and Q1750). Also indicated are the ecological guilds according to SCHIEMER & WAIDBACHER (2002). SD = standard deviation.

			Total catch				Q 1200				Q 1500				Q 1750			
Family	Species	ecolog. Guild	Ind	CPUE	SD	$Perc_{cum}$	Ind	CPUE	SD	$Perc_{cum}$	Ind	CPUE	SD	$Perc_{cum}$	Ind	CPUE	SD	$Perc_{cum}$
Cyprinidae	***Alburnus alburnus***	eurytop	1459	1,3444	**±** 2,839	70,12	580	**1,807**	**± 2,858**	69,31	631	**1,472**	**± 3,008**	76,97	248	**0,793**	**± 2,593**	61,43
Cyprinidae	*Barbus barbus*	rheophil A	139	0,1635	± 0,337	78,65	49	0,158	± 0,404	75,37	40	0,149	± 0,280	84,74	50	0,183	± 0,326	75,65
Cyprinidae	***Leuciscus idus***	rheophil B	58	0,0849	**±** 0,324	83,08	37	**0,192**	**± 0,524**	82,74	15	**0,048**	**± 0,182**	87,27	6	**0,023**	**± 0,094**	77,45
Cyprinidae	*Aspius aspius*	rheophil B	68	0,0827	± 0,178	87,39	22	0,083	± 0,160	85,91	24	0,072	± 0,146	91,02	22	0,094	± 0,221	84,72
Cyprinidae	*Abramis brama*	eurytop	67	0,0722	± 0,176	91,15	25	0,105	± 0,219	89,92	21	0,049	± 0,134	93,59	21	0,066	± 0,168	89,79
Cyprinidae	*Leuciscus cephalus*	eurytop	36	0,0450	± 0,133	93,50	11	0,041	± 0,119	91,48	6	0,025	± 0,077	94,90	19	0,069	± 0,179	95,15
Cyprinidae	*Chondrostoma nasus*	rheophil A	35	0,0332	± 0,121	95,23	17	0,055	± 0,185	93,59	13	0,031	± 0,088	96,50	5	0,016	± 0,057	96,38
Cyprinidae	*Vimba vimba*	rheophil A	9	0,0143	± 0,101	95,98	7	0,033	± 0,155	94,86	2	0,011	± 0,086	97,08				
Salmonidae	*Hucho hucho*	rithrale	9	0,0117	± 0,070	96,59	6	0,022	± 0,081	95,69	1	0,003	± 0,026	97,25	2	0,011	± 0,086	97,24
Cyprinidae	*Abramis bjoerkna*	rheophil B	7	0,0082	± 0,059	97,02	3	0,005	± 0,029	95,89	4	0,019	± 0,097	98,25				
Percidae	*Perca fluviatilis*	eurytop	4	0,0076	± 0,077	97,41	3	0,022	± 0,136	96,72	1	0,002	± 0,018	98,37				
Cyprinidae	*Rutilus rutilus*	eurytop	10	0,0071	± 0,044	97,78	5	0,016	± 0,071	97,35	2	0,003	± 0,026	98,55	3	0,002	± 0,018	97,42
Percidae	*Gymnocephalus schraetser*	rheophil A	2	0,0071	± 0,078	98,15	2	0,023	± 0,138	98,22								
Salmonidae	*Salmo trutta*	rithrale	4	0,0053	± 0,037	98,43	1	0,002	± 0,014	98,29					3	0,014	± 0,062	98,50
Gobiidae	*Neogobius melanostomus*	translocated	6	0,0050	± 0,031	98,69	3	0,007	± 0,038	98,55	3	0,008	± 0,039	98,97				
Gadidae	*Lota lota*	rithrale	2	0,0034	± 0,038	98,87					2	0,010	± 0,065	99,48				
Cyprinidae	*Rutilus pigus*	rheophil A	2	0,0033	± 0,031	99,04	1	0,006	± 0,045	98,79					1	0,004	± 0,032	98,82
Cyprinidae	*Abramis sapa*	rheophil B	6	0,0033	± 0,033	99,21	6	0,010	± 0,058	99,19								
Percidae	*Sander lucioperca*	eurytop	3	0,0024	± 0,014	99,34	2	0,003	± 0,017	99,31	1	0,001	± 0,006	99,52	1	0,003	± 0,015	99,08
Cyprinidae	*Cyprinus carpio*	eurytop	7	0,0021	± 0,019	99,45	2	0,006	± 0,033	99,54					4	0,001	± 0,006	99,14
Cyprinidae	*Carassius gibelio*	eurytop	2	0,0019	± 0,022	99,55					1	0,001	± 0,006	99,57	1	0,005	± 0,037	99,51
Esocidae	*Esox lucius*	eurytop	3	0,0018	± 0,015	99,64	1	0,002	± 0,015	99,61	1	0,001	± 0,007	99,61	1	0,003	± 0,020	99,71
Salmonidae	*Oncorhynchus mykiss*	alien	1	0,0014	± 0,019	99,71					1	0,004	± 0,032	99,83				
Cyprinidae	*Scardinius erythrophthalmus*	stanophil	1	0,0013	± 0,017	99,78									1	0,004	± 0,029	100,00
Gobiidae	*Neogobius kessleri*	translocated	1	0,0011	± 0,015	99,84					1	0,003	± 0,026	100,00				
Cyprinidae	*Leuciscus leuciscus*	rheophil A	2	0,0011	± 0,015	99,90	2	0,004	± 0,027	99,75								
Cyprinidae	*Abramis ballerus*	rheophil B	2	0,0011	± 0,015	99,95	2	0,004	± 0,027	99,89								
Gasterosteidae	*Gasterosteus aculeatus*	translocated	1	0,0006	± 0,008	99,98	1	0,002	± 0,014	99,96								
Siluridae	*Silurus glanis*	eurytop	1	0,0003	± 0,005	100,00	1	0,001	± 0,008	100,00								
	Individuals		1947				789				770				388			
	total species number			29,0				24,0				19,0				16,0		
	species number $sample^{-1}$			2,0	± 2,0			3,0	± 2,0			2,0	± 1,0			2,0	± 1,0	
	Shannon-Wiener Index			0,50	± 0,47			0,58	± 0,52			0,48	± 0,49			0,43	± 0,41	
	$CPUE_{cum}$ $sample^{-1}$			1,9	± 3,1			2,6	± 3,5			1,9	± 3,0			1,3	± 2,7	

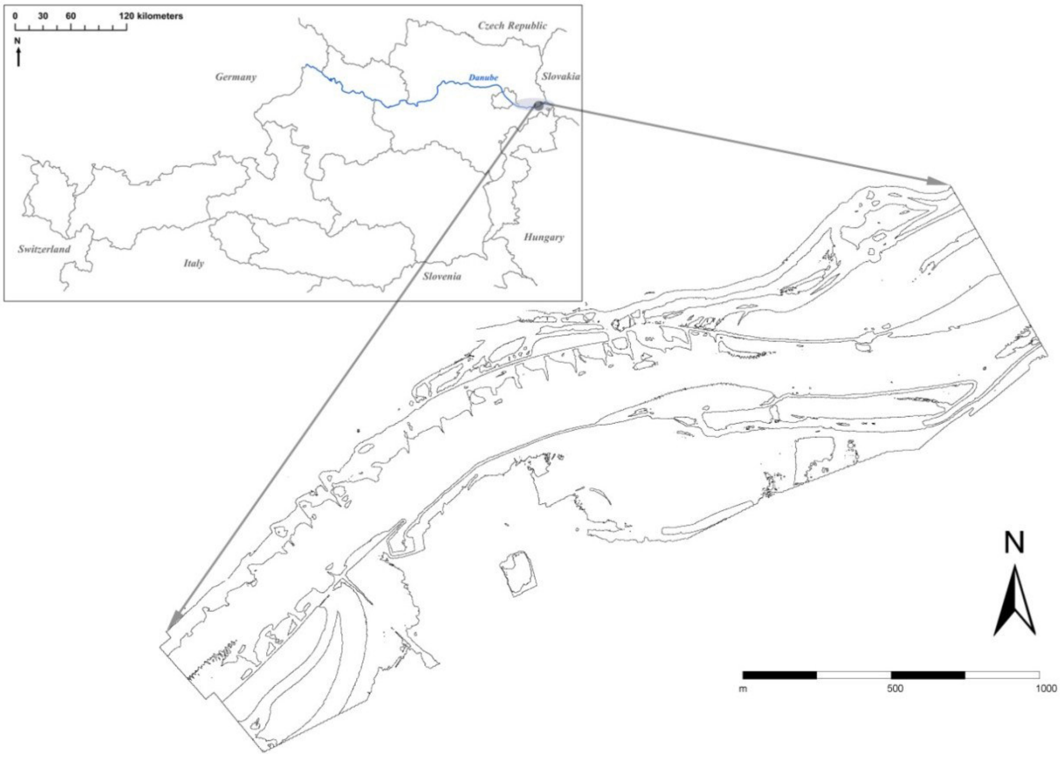

Figure 1:. Location and length of the study site in the free-flowing part of the Danube River east of Vienna, Austria.

Electrofishing

An electrofishing boat equipped with a 300 - 500 V Generator (DC) was used for taking the samples. In order to establish an electric field in the water column, the current was conducted into 6 anodes of 1.25 m length situated in front of the boat and a cathode placed along the side on the back part (Fig. 2). As a standard fishing method a modified continuous line fishing procedure was developed, and from each sample, the combined information on position, water depth and fish-individual number was stored in short time intervals (seconds). Samples were taken during the day along both shores of the river. Sampling proceeded with the flow direction downstream at the speed of the flow velocity or, if velocities were low, slightly faster (FLOTMERSCH & BLOCKSOM 2005). Every second during operation, the geographical position was determined with a dGPS (Leica® GS20, accuracy ± 30 cm) and water depth was measured with a single beam echosounder (Simrad® EQ33). These data were synchronized and stored using the hydrographic software profil2000®. Additionally, every single geographical position where fish were netted was specifically marked and stored separately by the hydrographic software (Fig. 2). This enabled more detailed analyses of occurrence as compared to available standard procedures and provided the required quality of data to analyze habitat use and habitat preference. Overall, 175 samples were taken between March and August 2007; the average length of the lines was 494 ± 306 m and an average catch lasted 6.6 ± 4.5 min. The number of samples was 55 at a river discharge of 1200 m^3s^{-1} (Q1200), and 60 at Q1500 and Q1750, respectively. All collected individuals were immediately placed in containers (1.0 x 0.6 x 0.6 m) which were filled with water from the river. After each catch, they were identified to species, counted and their size (total length; ±1mm) protocolled before they were released back into the river. All individuals from all species caught during one continuous line were considered to represent one sample, because a species/size identification/measurement within one netting operation was not possible due to the short duration. The netting operation lasts only a few seconds, which makes it impossible to protocol all required information of all single individuals during one fishing event. A further point is the simultaneous occurrence of many individuals due to schooling behavior at certain areas. Therefore, this data set cannot be used to analyze species-specific habitat selection.

Statistical analyses

Catch data were standardized to catch per unit effort (cpue, individuals per minute fishing time) to express fish abundance (HAYES et al. 1996). In order to meet the requirements of statistical comparisons, these data were log transformed according to MCCUNE & GRACE (2002) to test for differences between species or species composition of the assemblages between discharge regimes. Calculation of Shannon-Wiener Diversity (H´, MAGURRAN 1988) and tests for differences in species composition were conducted with analysis of similarities (ANOSIM, SIMPER) and nonparametric multidimensional scaling (MDS) using the software Primer 6.1.13®. The Kruskal-Wallis Test (SPSS 16.0®) was applied to compare biodiversity, abundance of single species, and fish sizes observed at different discharges.

Hydrodynamic model

As the parameters required for habitat modeling, i.e. flow velocities or water depths, can only be measured in discrete locations, a three-dimensional hydrodynamic model was employed to allow for an upscaling from the point to the reach scale. For this purpose, the river simulation model RSim-3D (TRITTHART & GUTKNECHT 2007a) was applied. It solves the three-dimensional Reynolds-averaged Navier-Stokes equations using the Finite Volume Method (FVM) on a mesh consisting of arbitrarily shaped polyhedra. This approach has the potential to deliver more accurate results than standard methods when applied to recirculating flows, because it can significantly reduce numerical diffusion (Tritthart and Gutknecht, 2005). Since vortices and recirculation zones are frequently encountered in fields of non-submerged groynes like those present in the Danube River reach, using the polyhedral mesh methodology is particularly advantageous in this case.

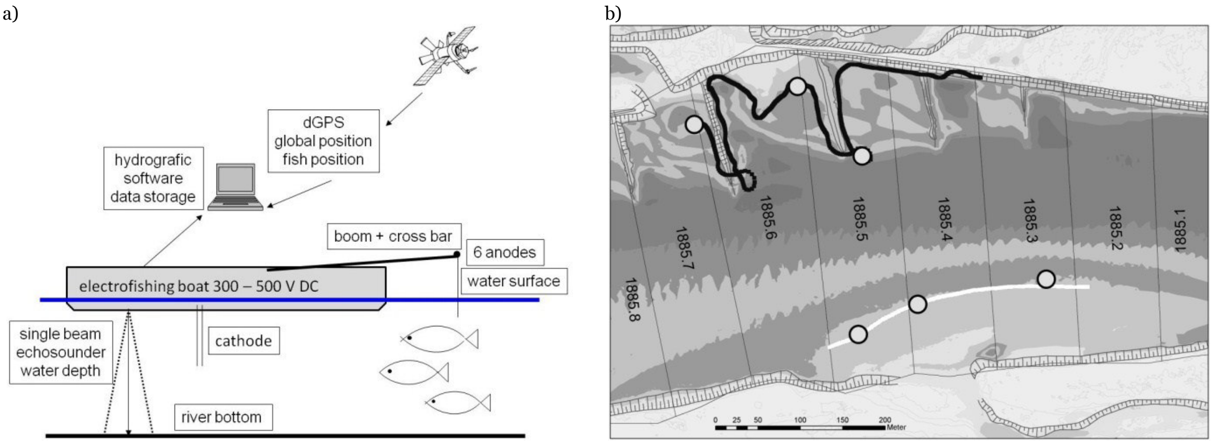

Figure 2:
a) Setup of the electrofishing boat. The position of the boat was recorded synchronously with water depth every second. The positions where fish were encountered were marked separately. These data were transferred to the hydrodynamic model in order to analyze habitat use and habitat preference with regard to water depth and flow velocity. V = Volt, DC = direct current.
b) Map of fishing tracks (green line) in the main channel of the Danube between river kilometer 1885.3 and 1885.6 along a groyne field and at a gravel bar. The red points mark sites where fish were captured.

Numerically, within the RSim-3D model a generalized second-order upwind scheme (BARTH & JESPERSE, 1989) is employed to discretize convective terms in the governing equations, whereas the diffusive terms are discretized using central differences. The SIMPLE method (PATANKAR & SPALDING 1972), reformulated for arbitrarily shaped control volumes, provides coupling of pressure and velocity fields. Turbulence is modeled by means of the standard k-epsilon two-equation turbulence closure (LAUNDER & SPALDING 1974). The position of the free surface is determined by iteratively translating pressure surpluses and deficits in the surface cells into differences of the water surface elevation until the calculated relative pressure is zero everywhere at the surface (TRITTHART & GUTKNECHT 2007a).

The 3D hydrodynamic model set up for the pilot reach at the Danube River covers 3 km as well as an additional stretch of 500 m upstream and 500 m downstream to reduce influences of boundary conditions on the domain of interest. A constant discharge boundary condition was employed at the inlet; known water depth was set at the outlet. After an initial calibration of the model for a discharge of 1930 m^3s^{-1} (mean flow), steady-state simulations were run for a total of ten characteristic discharges from 915 m^3s^{-1} (regulated low flow) to 5060 m^3s^{-1} (highest navigable flow). As the RSim-3D model is based on a bed roughness parameterization employing absolute roughness heights (TRITTHART & GUTKNECHT 2007b), errors for runoffs different from the calibration discharge are considered to be small.

The model was calibrated and validated using separate data sets of velocity and turbulence measurements obtained from ADCP and ADV instrumentation, bed grain size distributions from over 100 samples, gauge hydrographs and officially published water surface elevations for three characteristic discharges (regulated low flow, mean flow and highest navigable flow). Further details of the model validation results for the pilot reach at the Danube River east of Vienna are given in TRITTHART et al. (2009).

Predictive habitat modeling

With regard to the effectiveness of the fishing method, which is based on operating experience, and although 10 percent of the total catch consisted of individuals caught between 3 and 4 m water depth; only data with a water depth shallower than 3 m were considered in the analyses. As normalized probability density functions ranging from 0 to 1, the frequency-of-use graphs (RALEIGH et al. 1986) were applied to determine habitat suitability for the selected Danube reach (equation 1).

$$FUG_i = f_i / f_{[\max]} \qquad \text{(eq. 1)}$$

where: f_i is class frequency and $f_{[\max]}$ is maximum class frequency.

Suitability indices and curves in general indicate the suitability of habitats based on a single parameter. They are computed from empirical frequency distributions, which are standardized based on the most strongly occupied class (BOVEE & COCHNAUER 1977, BOZECK & RAHEL 1992). The class with the largest frequency (highest suitability) receives a SI value of 1. All further classes are weighted after it. The unused classes have the suitability index (SI) 0.

In streams and smaller rivers the documented frequency of individuals is based on visual observation (e.g. snorkeling, HILLMAN et al. 1987). At the Danube, however, due to high suspended load concentration and size of the river, the frequency of individuals was recorded based on mesounit electrofishing. Additionally to the derived suitability indices, habitat preference curves (IVLEV 1961) were derived based on the relation habitat suitability to habitat availability (equation 2).

$Preference = U / A$ (eq. 2)

where: U is class frequency of habitat used and A class frequency of habitat available.

At the Danube, both curves (suitability / preference) were applied for predictive habitat evaluation according to the method of multiplying suitability indices (Bovee, 1986) (equation 3). The application of multiplying suitability indices commonly uses water depth and flow velocity (partially cover) as input parameters (eq. 3).

$SI_{total} = SI_d \cdot SI_v$ (eq. 3) concluded $SI_{total} = \prod_{i=1}^{I} SI_i$ (eq. 3)

where: SI_d = Suitability Index depth, SI_v = Suitability Index velocity, SI_{total} = Suitability Index total, SI_i= Suitability index variable;

To gain quantitative (spatially distributed) modeling results, the method of Weighted Usable Area (WUA) (BOVEE 1986) was selected as a function of number of grid cells, habitat suitability / preference and area of single grid cell (equation 4).

$WUA = \sum_{i=1}^{n} HSI_i \cdot A_i$ (eq. 4)

where: n = total number of grid cells, HSI_i = habitat suitability index, A_i = area of single grid cells (m^2).

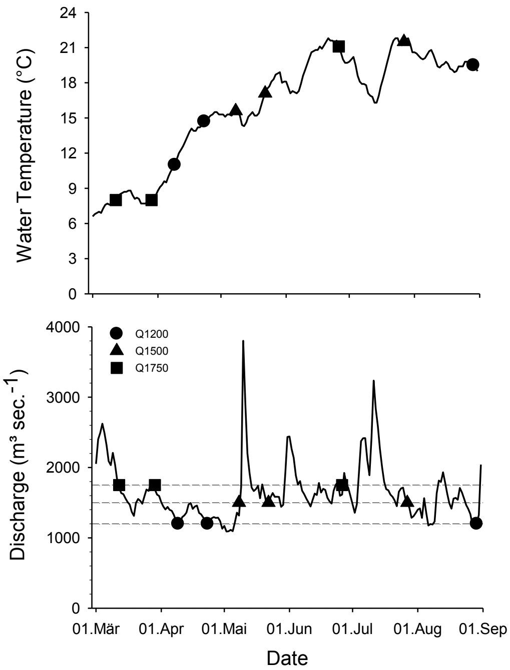

Figure 3: Seasonal course of water temperature (daily average) of the Danube River (water gauge Hainburg, upper graph) and average daily discharge during the investigation period. Symbols reflect sampling dates at different discharge rates. The dashed lines in the lower graph indicate the three applied model-discharge rates.

Results

Species assemblages at different discharges

The discharge of the Danube River during the sampling period ranged from 1090 to 3801 m^3s^{-1}; the average was 1650 m^3s^{-1} (Fig. 3). Water temperature showed an increasing seasonal trend: it rose from 6.6°C in early March to 21.8°C in early August, and then declined slowly to 19.5°C until late August. The modeled discharges of 1200, 1500 and 1750 m^3s^{-1} fitted well with the field situation during sampling (Fig. 3, lower graph).

The total catch from the overall 175 samples was 1947 individuals from 29 fish species. An average catch included 2 individuals of two different species. A large variation between single samples is indicated in the high standard deviation of single species and assemblage composition (Table 1). Total species number decreased from 24 at Q1200 to 19 at Q1500 to 16 at Q1750. A similar trend and significant differences were observed in overall abundance (sum of abundances of every sample) between the three discharges (Kruskal-Wallis Test, $p<0.05$); the lowest value was found at 1750 m^3s^{-1}. No significant relationship between water temperature and species number, or between water temperature and fish abundance, was found. Generally, 4 to 6 species accounted for more than 90 percent of the assemblage in terms of abundance at each discharge situation. Irrespective of the discharge of the river, four fluvial specialists (*Barbus barbus*, *Leuciscus idus*, *Aspius aspius* and *Chondrostoma nasus*) and three generalists (*Alburnus alburnus*, *Squalius cephalus* and *Abramis brama* dominated the total catch. The comparison of the assemblage by means of species accumulation curves (Fig. 4) and by the similarity between samples revealed significant differences between the three discharge regimes. Species accumulation curves at all discharges increased rather steeply; no satiation effect is visible. The steepest increase was observed for Q1200, followed sequentially by Q1500 and Q1750. The pairwise test revealed significant differences between the assemblages at Q1200 vs. Q1750 (R = 0.051, significance level = 0.3%) and between Q1500 and Q1750 (R = 0.03, significance level = 1.8%). No significant differences were found between the assemblage at Q 1200 and Q 1500 (R = 0.002, significance level = 37.6%). A pairwise comparison of abundances of single species between the different discharges revealed that only two species, namely bleak and ide, showed significantly different abundance between the different discharge regimes. The size range (total length) of all captured individuals ranged from 4.5 to 120.0 cm. The most abundant size class was 10-15 cm, which referred mainly to the sizes of the most dominant species, *A. alburnus* (Fig. 5). The size of the characteristic riverine species with high abundances ranged from 40 to approx. 65 cm. Fish sizes at different discharge regimes were not significantly different ($p>0.05$).

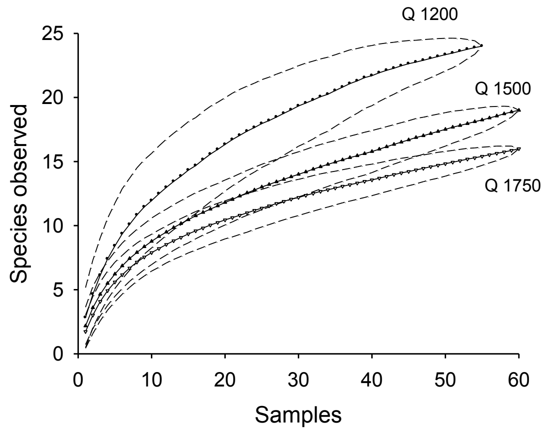

Figure 4: Species accumulation curves of samples taken at different discharge regimes in the pilot reach of the Danube River east of Vienna from March to August 2007.

Habitat use and habitat preference

Habitat availability, habitat use and habitat preferences of the assemblages for water depth and flow velocities at three discharge regimes are given in Fig. 6. At all three analyzed discharge regimes, measured water depth showed a uniform distribution pattern with a maximum frequency at 1.0 to 1.5 m. Water depth classes used by fish showed a similar pattern, but higher frequencies compared to the ones available were observed for the range between 0 up to 1.5 m. The resulting preferences were therefore highest for the depth classes below 1.5 m water depth. A preference-index of 1 was observed for water depths between 0.5 to 1.0 m at Q1200 and Q1500, and for the class 1.0-1.5 m at Q1750. This indicates a change of habitat use with increasing discharge. Preference values for deeper water (> 1.5 m) were distinctly lower at all discharge regimes.

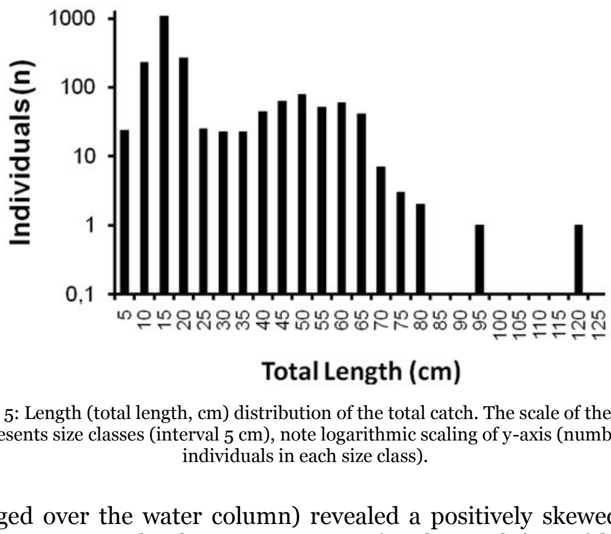

Figure 5: Length (total length, cm) distribution of the total catch. The scale of the x-axis represents size classes (interval 5 cm), note logarithmic scaling of y-axis (number of individuals in each size class).

Flow velocity values (averaged over the water column) revealed a positively skewed distribution pattern at all discharge regimes. In contrast to water depth, an over-proportional use of sites with a velocity between 0.6 and 1.8 ms^{-1} was observed. The highest preference were found for the velocity class between 0.9-1.2 ms^{-1} for all three analysed discharge regimes.

As a result, the combination of the variables water depth and flow velocity revealed a general preference of the assemblages for habitats shallower than 1.5 m, and for an average flow velocity above 0.9 ms^{-1}. With increasing discharge regime, the trend was toward preferring deeper habitats characterized by lower flow velocities.

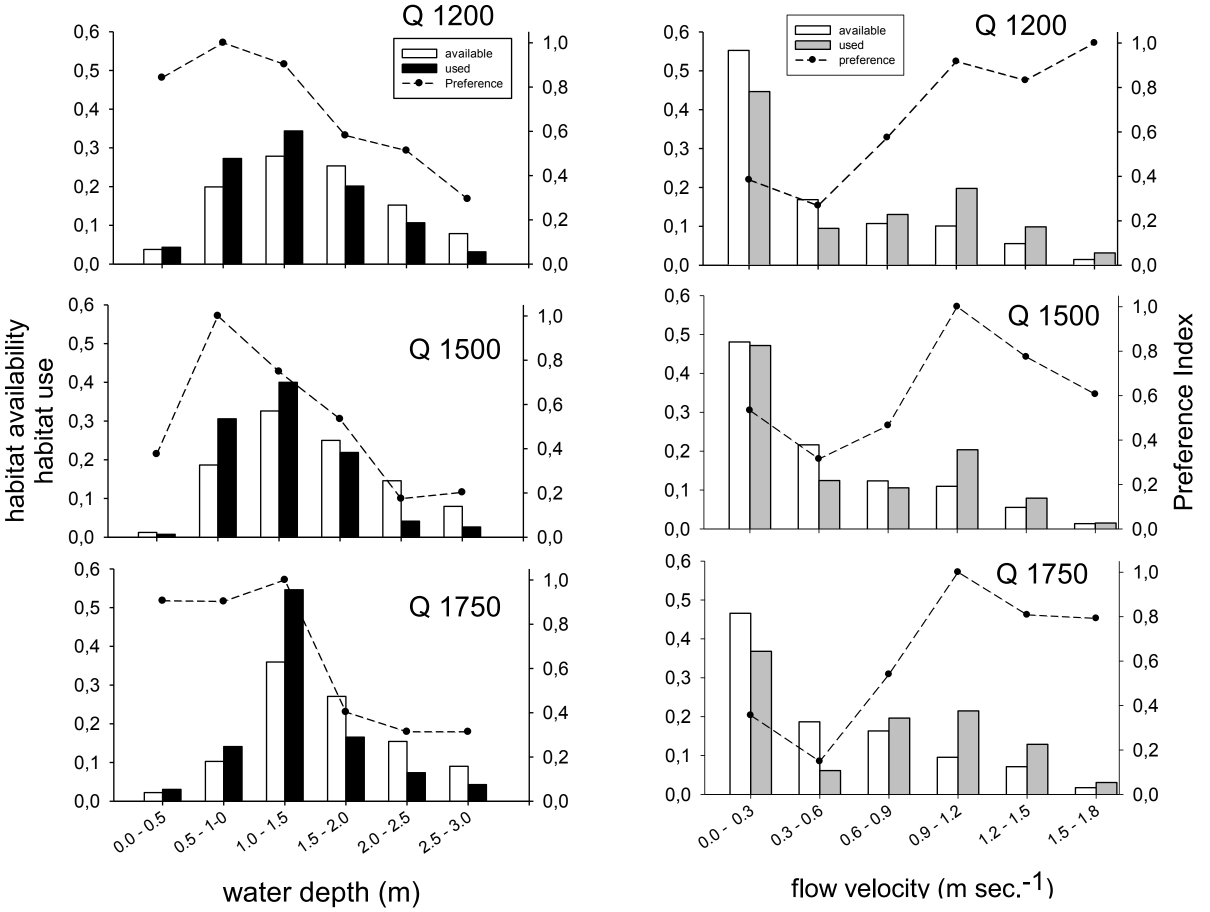

Figure 6: Frequency distributions (left y-scale) of available (white bars) and used water depths (black bars) and flow velocities (grey bars) at different discharge regimes (Q1200, Q1500 and Q1750). Resulting habitat preferences are indicated by symbols and are connected by dotted lines. Habitat preference values refer to the scale of the right y-axis.

Habitat modeling and weighted usable areas

Generally, the riparian zones of each bank showed an almost continuous smaller or wider band of habitats with moderate (≥ 0.4) to highest values (1.0) of habitat suitability of combined depth and flow velocity indices. Large and enclosed areas of high habitat preference values were observed for gravel bars within the test reach (Fig. 7). The areas of highest suitability values within groyne fields were distinctly smaller, unsteady and located upstream of single groynes or related to smaller gravel deposits within the groyne fields. This areal pattern led to overall only small portions of high habitat suitability (areas with a suitability index >0.5) of < 10% at Q1200 and < 5% at Q1500 and Q1750 (Table 2).

Discussion

The sampling design of this study is quantitative and can thus support the future planning of restoration measures in order to improve the ecological condition of the river. It is not, however, appropriate for the analyses of biodiversity, i.e. total number of occurring species (CAO et al. 2001, FLOTEMERSCH & BLOCKSOM 2005, MEADOR 2005, HUGHES & HERLIHY 2007). In a large river like the Danube, a single method may not be appropriate to determine species richness, irrespective of sampling distance, efficiency of the gear and number of samples (CASSELMANN et al. 1990, HAYES et al. 1996, LAPOINTE & CORKUM 2006).

Our sampling sites covered a section of 3 km, which is approx. ten times the average width of the main channel, and our average sample distance of 494 m matches very well with the findings of WOLTER et al. (2004) and FLOTEMERSCH & BLOCKSOM (2005). The latter authors concluded that daytime catches below 4 m water depth and 1000 m along a single bank (or 500 m on a paired bank) is sufficient to characterize sites for bioassessment studies based on quantitative samples. Within the 3 km reach of the regulated main channel, which represents only one type of water body of the whole floodplain (Eupotamon sensu AMOROS & ROUX (1988)), we observed 48 percent of all species recorded in the whole section of the Austrian Danube (total length approx. 270 km) which represented 84 percent of all characteristic species for this type of macrohabitat. The size range and frequency of measured total lengths clearly shows that the sublittoral assemblage is composed mainly of adult individuals. WOLTER & BISCHOFF (2001) found a similar pattern in their study in the main channel of the Oder River. They attributed the presence of bigger fish in the main channel to a habitat preference of older fish for deeper water, and to improved swimming performance with increasing body size. The change of total species number with increasing discharge most notably affected rare species. Nonetheless, other factors such as species-specific reactions to these environmental changes – like movements into other habitats (TAYLOR et al. 1996, WOLTER &

BISCHOFF 2001) – cannot be excluded as underlying factors. The decrease of abundance with increasing water level could be due to a dilution factor or by to movements of individuals from single species into other habitats within the main channel or into connected water bodies of the floodplain, leading to a wider spread of the fish (FLADUNG et al. 2003).

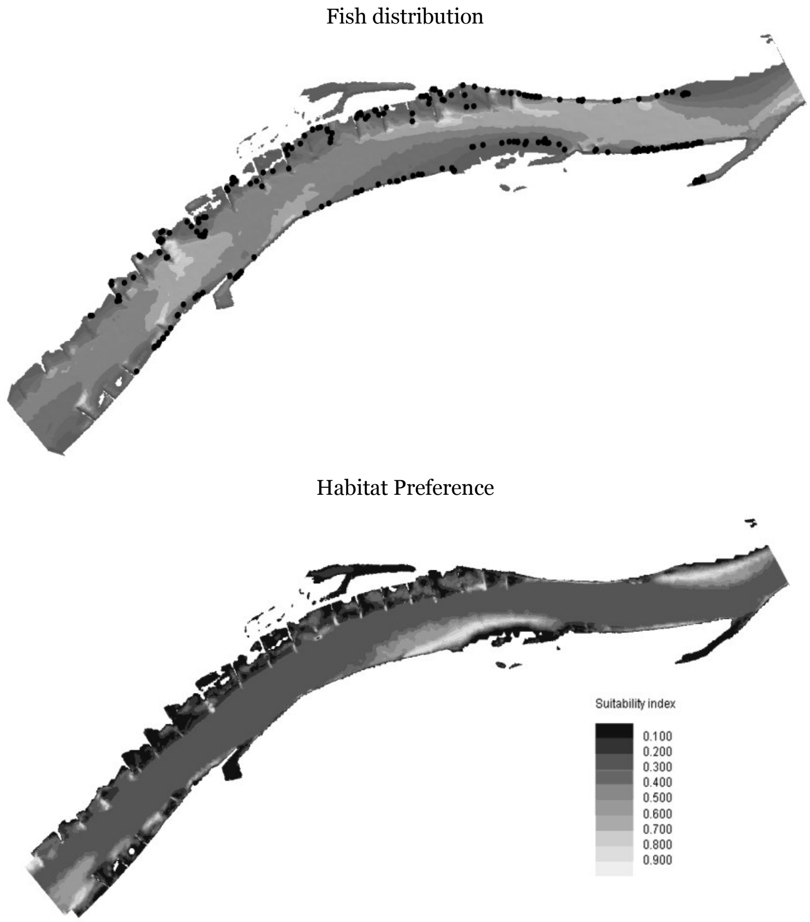

Figure 7: Distribution of areas where fish were caught in the investigated reach at Q1200 (yellow symbols, upper graph) and areas of the reach assigned different categories of habitat preferences (lower graphs) as predicted by the model.

LAMOUROUX et al. (1999) showed that community characteristics in large rivers are strongly influenced by hydraulic niche partitioning: within a geographic region, their statistical hydraulic model explained the large variance of relative species abundance and community structure indices of single reaches. Our study applied a classical instream flow incremental methodology based on a hydrodynamic model with a high spatial resolution and a precise position of caught individuals to estimate the area and position of preferred habitats of the sublittoral fish assemblage in a free-flowing river section. LAPOINTE & CORKUM (2006) recommend studies of habitat use by fish assemblages over studies focusing on single-species. Based on our results, we were able to create habitat suitability curves for water depth and flow velocities for the whole assemblage at three different discharge levels. At all discharges, fish occurred along both sides of the river, indicating a wide use of different habitats. When considering the two variables water depth and flow velocity, however, the habitat model indicated a strong preference for shallow, relatively fast-flowing areas. Projecting the habitat suitability on a 2-dimensional map of the main channel, it turned out that these preferred habitats apply mainly to gravel bars. Such bars represent the few remaining natural structures in the regulated main stem of the Danube. The groynes also revealed areas with highly preferred habitats, especially upstream of the groyne heads, but they are distinctly smaller compared to the gravel bars. Along the inshore areas with rip-rap, the model predicts a thin, continuous line of highly suitable habitats. Artificial structures within a largely modified and regulated river may be the sole sites that provide the required habitat complexity for fish (MADEJCZYK et al. 1998, FLADUNG et al. 2003, BARKO et al. 2004), however, it is unclear whether these structures provide habitat conditions which are required for the long-term development of the populations and for species conservation of the characteristic, native associations. Fish assemblages in regulated rivers often become dominated by generalistic species. Such species can tolerate the changes in habitat availability and structure and can successfully reproduce under these conditions, whereas fluvial specialists disappear or show a declining trend in abundance (SCHIEMER & WAIDBACHER 1992).

Our study revealed the possibility to analyze the patterns of habitat use and habitat preference of a fish assemblage in a large river at different discharges and provides basic information on how flow velocity and water depth – as prominent and easily accessible hydraulic and river morphological variables – relate to fish habitat. The model prediction may help in planning restoration measures, because distinct mesohabitats (gravel bars, groyne fields, rip raps) revealed clear differences in habitat preferences.

Table 2: Areas of different suitability regarding water depth and flow velocities of the pilot reach "Bad Deutsch Altenburg" derived from the hydrodynamic model at different discharge regimes of the Danube River. WUA = weighted usable area; HHS = hydraulic habitat suitability index. WUA (m²) resembles the sum of all areas of single grid cells multiplied by the suitability index of that cell. The HHS (in percent) is related to the total wetted area of a river reach (WUA * wetted area of reach^{-1} * 100).

		water depth		flow velocity		water depth + flow velocity	
	Suitability	Area (m²)	Percent (%)	Area (m²)	Percent (%)	Area (m²)	Percent (%)
Q 1200	0.0-0.1	31795,6	2,5	136147,3	10,6	199012,2	15,5
	0.1-0.2	16874,1	1,3	72168,7	5,6	119441,7	9,3
	0.2-0.3	678768,6	52,7	73000,3	5,7	698088,4	54,2
	0.3-0.4	98697,8	7,7	98469,5	7,7	89933,1	7,0
	0.4-0.5	75017,3	5,8	26284,7	2,0	59961,0	4,7
	0.5-0.6	101899,2	7,9	23888,7	1,9	57860,1	4,5
	0.6-0.7	52581,6	4,1	25096,3	2,0	23240,6	1,8
	0.7-0.8	50980,2	4,0	32164,7	2,5	21960,8	1,7
	0.8-0.9	61233,0	4,8	315202,2	24,5	16489,7	1,3
	0.9-1.0	119182,7	9,3	484607,4	37,7	1042,5	0,1
	Sum	1287029,9	100,0	1287029,9	100,0	1287029,9	100,0
	WUA/HHS	561685,2	43,6	876658,1	68,1	348056,6	27,0
Q 1500	0.0-0.1	47121,7	3,4	107924,2	7,9	259009,1	18,9
	0.1-0.2	158217,3	11,6	68520,7	5,0	886920,6	64,8
	0.2-0.3	812346,3	59,4	52343,7	3,8	79328,5	5,8
	0.3-0.4	54790,2	4,0	98646,4	7,2	57878,9	4,2
	0.4-0.5	49738,4	3,6	104999,9	7,7	29893,1	2,2
	0.5-0.6	51292,3	3,8	28299,3	2,1	21500,7	1,6
	0.6-0.7	55792,6	4,1	624765,9	45,7	16253,7	1,2
	0.7-0.8	58372,7	4,3	153011,5	11,2	11119,1	0,8
	0.8-0.9	49752,8	3,6	90763,9	6,6	5662,8	0,4
	0.9-1.0	30622,1	2,2	38770,9	2,8	479,9	0,0
	Sum	1368046,3	100,0	1368046,3	100,0	1368046,3	100,0
	WUA/HHS	417565,5	30,5	737091,2	53,9	218620,6	16,0
Q 1750	0.0-0.1	21933,9	1,6	158874,2	11,3	261005,2	18,5
	0.1-0.2	13157,1	0,9	88791,4	6,3	122698,8	8,7
	0.2-0.3	11667,1	0,8	123209,2	8,7	896968,2	63,5
	0.3-0.4	1010839,2	71,6	48274,5	3,4	40244,7	2,9
	0.4-0.5	43097,9	3,1	22005,0	1,6	21071,2	1,5
	0.5-0.6	38146,9	2,7	20069,6	1,4	17204,6	1,2
	0.6-0.7	37734,1	2,7	19843,5	1,4	14724,1	1,0
	0.7-0.8	40069,8	2,8	743612,2	52,7	18083,8	1,3
	0.8-0.9	57936,9	4,1	132801,2	9,4	16614,2	1,2
	0.9-1.0	137083,0	9,7	54185,0	3,8	3051,2	0,2
	Sum	1411665,9	100,0	1411665,9	100,0	1411665,9	100,0
	WUA/HHS	594320,0	42,1	850778,1	60,3	325277,5	23,0

Acknowledgements

This research was carried out in the monitoring task of the Integrated River Engineering Project on the Danube East of Vienna, financed by the European Union, the Austrian Ministry of Transport, Innovation and Technology, and via donau. We would like to thank Dominik Altmann, Vinzenz Bammer, Simon Götsch and Hansjörg Hoyer for their assistance in the field work. Michael Stachowitsch improved the English.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 363 - 372

Ground surface temperature and permafrost evolution in the Hohe Tauern National Park, Austria, between 2006 and 2012: Signals of a warming climate?

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Abstract

Permafrost is an important element of high mountain environments and is very sensitive to ongoing present climate warming. Consequently, knowledge about permafrost and its changes are of increasing relevance for the public. Longer time series are necessary to characterise the average ground thermal regime relevant for understanding permafrost distribution and changes. Long-term monitoring of ground temperature is therefore essential. However, so far such data are widely lacking in Austria. Within the project ALPCHANGE, a long-term monitoring program was initiated in 2006 at a number of study areas in the Hohe and Niedere Tauern Ranges in the Central Alps. In this study up to six years of data from five different study areas in the Hohe Tauern National Park with altogether 36 continuous ground temperature measurement sites are presented and discussed. Results clearly show high interannual variations. However, at most sites a trend towards warmer temperature can be observed. This evolution is despite the fact that the sites have big differences in the duration of the winter snow cover strongly influencing the ground thermal regime. Interestingly, the warming trend is very clear and distinct in the western part of the national park (area around Großglocker-Pasterze-Schober Mountains) but substantially weaker in the eastern part (Ankogel Mountains). Permafrost at north-facing slopes can be expected as low as 2500 m a.s.l. whereas on south-facing slopes permafrost is most likely absent below 2820 m a.s.l. Expected warmer ground temperatures during the winter half-year imply for instance rock fall events in periods which are currently thought to be safe for mountaineers and animals in the Hohe Tauern National Park.

Keywords

permafrost, ground temperature change, Tauern Range, Hohe Tauern National Park, global warming, climate change

Introduction

Permafrost in warm climates such as the European Alps is particularly sensitive to the ongoing present climate warming. Permafrost degradation has also a significant impact on people as well as alpine and low-elevated infrastructure considering for instance destabilizing mountain slopes as natural hazards (e.g. HUGGEL et al. 2010, KELLERER-PIRKLBAUER et al. 2012, KERN et al. 2012). Consequently, permafrost existences and its changes are of increasing relevance for the Austrian public. The Hohe Tauern Range with its c.1900 km² large Hohe Tauern National Park houses the highest summit of Austria (Großglockner, 3798 m a.s.l.) and large permafrost areas. Therefore, this national park is of particular interest and significance for permafrost research in Austria.

Permafrost is defined as ground – soil or rock with ice of different origin and organic material – that remains at or below 0°C for at least two consecutive years. Permafrost in mountain areas in mid- and low-latitudes is generally relatively warm with only some degrees below 0°C. Its distribution is closely related to terrain parameters such as elevation, slope orientation, slope gradient, ground material and snow cover characteristics. The top layer of permafrost is seasonally influenced by thawing (summer) and freezing (winter). This layer is termed “active layer”. Its thickness might vary from between some decimetres to meters depending to the ground and topoclimatic conditions of a given site (FRENCH 2007).

Permafrost is much more difficult to delineate compared to for instance glaciers due to its definition by temperature. However, knowledge about permafrost distribution is steadily increasing based on inventories of permafrost evidences (e.g. CREMONESE et al. 2011) or based on permafrost modelling approaches (RISEBOROUGH et al. 2008) at national (EBOHON & SCHROTT 2008), mountain range (BOECKLI et al 2012) or even global scale (GRUBER 2012). Feeding such models depends on field data coming from different sites of the chosen modelling domain (e.g. the Alps). However, the quality of the modelling results also depends on number, quality, type and spatial distribution of the field data. Furthermore one has to keep in mind that variations of the mean annual ground surface temperature (MAGST) within short distances might be some degrees Centigrade even in homogeneous terrain (GUBLER et al. 2011). This further highlights the difficulties in modelling the “real” permafrost distribution and the strong need for good field data.

Furthermore, longer time series covering time-spans exceeding more than one year are needed in order to characterise the average ground thermal regime relevant for permafrost distribution because of thermal inertia of permafrost. Long-term monitoring of ground temperature is therefore essential for permafrost understanding. However, so far such data are widely lacking in Austria. Within the project ALPCHANGE, a long-term monitoring program was initiated in 2006 at a number of study areas in the Hohe and Niedere Tauern Ranges in the Central Alps. The monitoring project was continued within the two projects PermaNET and permAfrost. Five of the study areas are located in the Hohe Tauern National Park. Results from these sites are presented and discussed here. Therefore this paper aims to increase the understanding of the thermal conditions – particularly permafrost – in the Hohe Tauern National Park.

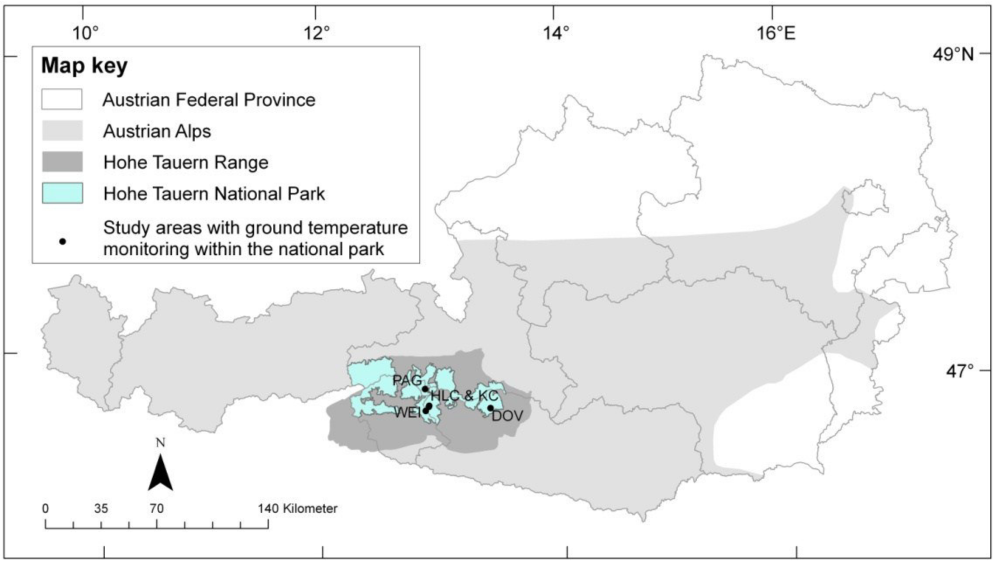

Figure 1: Location of the five study areas within the National Park Hohe Tauern where ground temperature monitoring is carried out since 2006. Abbreviations of the study areas: KC=Kögele Cirque, HLC=Hinteres Langtal Cirque, WEI=Weissen Cirque, PAG=Pasterze-Großglockner area, DOV=Dösen Valley. For available data for each site see Table 1.

Study area

The five study areas relevant here are all located within the area of the Hohe Tauern National Park (Fig. 1). Three study areas are situated in the Central Schober Mountains (Kögele Cirque, Hinteres Langtal Cirque, Weissen Cirque/WEI), one in the Glockner Mountains (Pasterze-Großglockner area) and one in the Ankogel Mountains (Dösener Valley/DOV). Fig. 2 depicts in more detail the topographical situation of the five sites including the locations of the ground temperature sensors relevant for this study.

Kögele Cirque (KC) and Hinteres Langtal Cirque (HLC)

The two neighbouring cirques KC and HLC are located at N46°59´ and E12°47´. The first cirque houses an active rock glacier, the second a debris-covered glacier remnant (Kellerer-Pirklbauer & Kaufmann 2007). The cirques are orientated towards northwest with high crests and mountain tops slightly exceeding the 3000-m level to the south and east. KC comprises 0.31km² and is delineated at its lower end by a distinct Little Ice Age (LIA) latero-terminal moraine. The altitude range of the entire cirque is ca. 2600-3030 m a.s.l. (Fig. 2)

HLC is morphologically dominated by the tongue-shaped Hinteres Langtalkar Rock Glacier. The rock glacier is 900 m long, up to 300 m wide, covers an area of 0.17 km², consists of mica-schist and amphibolites and ranges from 2455 to 2720 m a.s.l.. Its dimensions make this rock glacier one of the larger rock glaciers of the Central Alps. The front of this rock glacier advanced 80 m (horizontal component) from 1991-1998 (Kaufmann & Ladstädter 2010). The annual rock glacier movement variation is in accordance to other monitored rock glaciers in the region or in the entire European Alps (Delaloye et al. 2008) due to the strong relationship between rock glacier velocity and climate (Kellerer-Pirklbauer & Kaufmann 2012).

The mean annual temperature in 2500 m a.s.l. in the Central Schober Mountains – and therefore at KC, HLC and the Weissen Cirque (WEI) – increased from -2.08 in 1961-1983 to -1.35 in 1984-2006 with a significant rise in the mean annual temperature by 1.31 since 1961 (Taucher et al. 2009, Taucher 2010). According to the same authors, mean annual precipitation was about 2000 mm in 2500 m a.s.l. during the period 1961-2006 without a statistical significant trend.

Weissen Cirque (WEI)

WEI is a west-facing cirque housing a slowly moving tongue-shaped rock glacier located at N46°57´ and E12°45´ and between 2615 and 2790 m a.s.l. This rock glacier consists of an active upper lobe presumably overriding an inactive lower lobe, hence can be regarded as a polymorphic rock glacier. The rock glacier has a length of 500 m, a maximum width of 300 m, and a surface area of 0.11 km². Different types of mica schist build up the rock glacier. Present mean surface velocities are below 10 cm a^{-1} (Kaufmann et al. 2006, Kellerer-Pirklbauer & Kaufmann 2012)

Dösen Valley (DOV)

The study area DOV is a glacially shaped, W-E trending valley in the Ankogel Mountains at N46°59´ and E13°17´ between 2355 and 2650 m a.s.l.. The upper-most part of the valley is characterised by four north-to-west facing rock glaciers, a cirque floor with a tarn lake and distinct terminal moraines of Younger Dryas age. The rock glaciers in DOV consist primarily of granitic gneiss. The largest rock glacier is an active monomorphic tongue-shaped rock glacier with a length of 950 m, a width of maximum 300 m and a surface area of 0.19 km². Mean surface velocities during the last decades were below 40 cm a-1 (KAUFMANN & LADSTÄDTER 2007, KELLERER-PIRKLBAUER & KAUFMANN 2012).

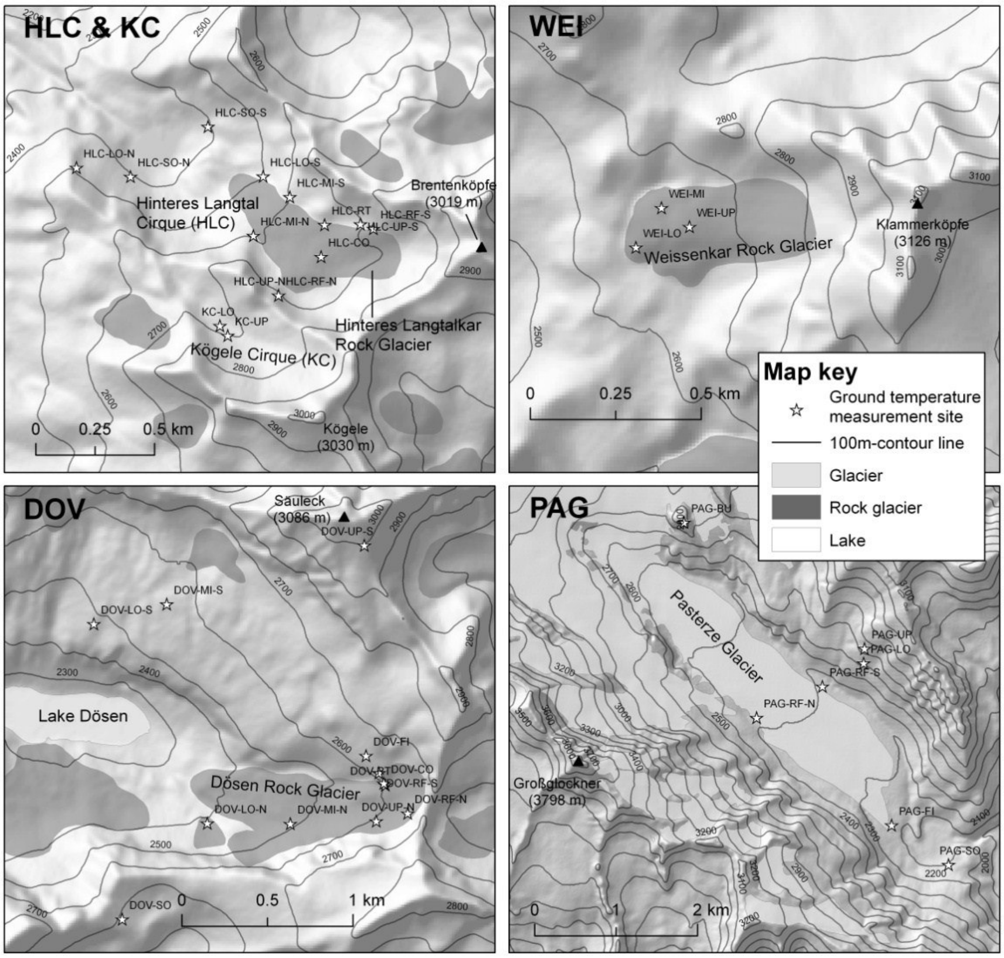

Figure 2: Detailed maps of the five study areas with the locations of all miniature temperature dataloggers (MTD). For details and description of the MTD sites and data series see Table 1. Glaciers are only partly shown in PAG.

Pasterze-Großglockner area (PAG)

The Pasterze Glacier (47˚05'N, 12˚44'E) is situated at the foot of the Großglockner mountain (3798 m a.s.l.) which is highest summit of Austria. Pasterze Glacier is a compound valley glacier fed by a number of tributaries. The glacier reaches a length of 8.4 km, ranges from ca. 2065-3500 m a.s.l. and covers an area of 17.5 km² (in 2002). The glacier is the largest ice mass in Austria and an important site for the tourist industry (famous look-out point Franz-Josefs-Höhe) and hydropower production. For details on the glacier and the surrounding see e.g. KELLERER-PIRKLBAUER (2008), KELLERER-PIRKLBAUER et al. (2008, 2012) or KERN et al. (2012).

Material and Methods

At each study area several miniature temperature dataloggers (MTD) were placed in 2006 at different elevations, aspects, substrates and depths in the ground automatically logging ground temperatures at 1h-intervall. Instrumentation was financed by the nationally-funded (FWF/Austrian Science Fund) *ALPCHANGE* project. Following maintenance was financed by the EU-project *PermaNET* (until 2010) and the nationally-funded (ÖAW/Austrian Academy of Science) *permAfrost* project. The used MTDs are either 1-channel dataloggers (GeoPrecision, Model M-Log1) monitoring with one temperature sensor or 3-channel dataloggers (GeoPrecision, Model M-Log6) monitoring with three sensors at different depths (Table 1). According to the producer, the used PT1000 temperature sensors have an accuracy of ±0.05°C, a range -40 to +100°C and a calibration drift <0.01°C a^{-1}.

Table 1: The 36 sites in the Hohe Tauern National Park where ground surface and near surface temperature is monitored by using miniature temperature dataloggers (MTD). MTD-site DOV-CO (*) was not considered in this study because the nearest sensor to the surface is at 50 cm depth. Substrate: FGM=fine-grained material, CGM=coarse-grained material, BED=bedrock. For locations see Fig. 2.

Area	MTD-site	Description	Substrate	Elevation	Aspect	Slope	Sensor depth(s)	Data series
KC	KC-LO	debris above dead ice	CGM	2690	22	25	0,10,50	120906-230812
	KC-UP	debris above dead ice	CGM	2703	12	28	0,10,20	120906-230812
HLC	HLC-LO-S	debris slope	CGM	2489	245	32	0	130906-220812
	HLC-MI-S	debris slope	CGM	2581	268	19	0	130906-220812
	HLC-UP-S	debris slope	CGM	2696	256	22	0	130906-220812
	HLC-LO-N	rock wall niche with debris	BED	2485	47	45	0	130906-220812
	HLC-MI-N	debris slope	CGM	2601	17	28	0	130906-220812
	HLC-UP-N	rock wall niche with debris	BED	2693	45	52	0	130906-220812
	HLC-RF-S	rock face	BED	2725	241	75	3,10,40	110906-220812
	HLC-RF-N	rock face	BED	2693	45	85	3,10,40	110906-220812
	HLC-RT	flat bedrock site	BED	2650	252	7	3,10,40	110906-220812
	HLC-CO	rock glacier sediments	CGM	2672	338	8	3,10,100	230907-220812
	HLC-SO-S	solifluction lobe	FGM	2391	253	34	0,10,40	130906-220812
	HLC-SO-N	solifluction lobe	FGM	2407	34	33	0,10,40	130906-220812
WEI	WEI-LO	rock glacier sediments	CGM	2652	238	22	0	190808-210812
	WEI-MI	rock glacier sediments	CGM	2662	270	3	0,30,100	250907-210812
	WEI-UP	rock glacier sediments	CGM	2688	241	7	0	250907-210812
DOV	DOV-LO-S	debris slope	CGM	2489	220	22	0	250806-200812
	DOV-MI-S	rock wall niche with debris	BED	2586	213	19	0	020906-200812
	DOV-UP-S	debris slope	CGM	3002	166	33	0	020906-300611 & 160811-200812
	DOV-LO-N	debris slope	CGM	2407	342	22	0	020906-200812
	DOV-MI-N	debris slope	CGM	2501	239	16	0	020906-200812
	DOV-UP-N	debris slope	CGM	2626	331	25	0	020906-200812
	DOV-RF-S	rock face	BED	2628	206	80	3,10,32	010906-200812
	DOV-RF-N	rock face	BED	2638	300	90	3,10,40	280906-230711 & 160811-200812
	DOV-RT	flat bedrock site	BED	2603	255	14	3,10,40	140707-200812
	DOV-CO*	rock glacier sediments	CGM	2606	257	5	100,200,300	310708-200812
	DOV-FI	slope with vegetation	FGM	2644	213	28	0,3,10,30,70,100	010906-200812
	DOV-SO	solifluction lobe	FGM	2578	116	18	3,10,70	030906-160810
PAG	PAG-LO	debris slope covered with vegetation	CGM	2509	194	37	0	210906-250812
	PAG-UP	debris slope	CGM	2628	223	29	0	210906-250812
	PAG-BU	summit plateau	CGM	2932	104	12	0,10,55	200907-260811
	PAG-RF-S	rock face	BED	2216	86	11	3,10,40	210906-111107
	PAG-RF-N	rock face	BED	2255	194	6	3,10,40	210906-240812
	PAG-FI	proglacial sandur plane	FGM	2074	120	11	0,10,75	200906-260811
	PAG-SO	solifluction lobe	FGM	2105	342	19	0,10,55	200906-021107 & 070909-260811

In total 36 MTDs were installed at the five study areas presented in the previous chapter. The highest MTD site is located at 3002 m a.s.l. (permafrost site), the lowest at 2074 m a.s.l. (seasonal frost). The slope at the MTD sites varies from flat (3°) to vertical (90°). Sensors face all slope orientations. However, most sensors face towards S to W (Fig. 3). At 16 sites 1-channel MTDs are used. At further 20 sites 3-channel MTDs are installed. At one site (DOV-FI) two 3-channel MTDs are used with sensor orientation along a vertical profile. The deepest temperature sensor is located 3 m below ground surface in the open voids of coarse-grained rock glacier sediments. Table 1 gives a detailed picture on the 36 MTD sites. For the present study only the ground surface temperature (GST) data were considered, hence data which were measured at 0 or 3 cm below the ground surface. Therefore data from the site DOV-CO were not considered here because the nearest sensor to the ground surface is located at 1 m depth. Generally, for measuring the GST the respective sensor is located on the ground surface sheltered from direct solar radiation by a thin platy rock allowing air circulation around the sensor.

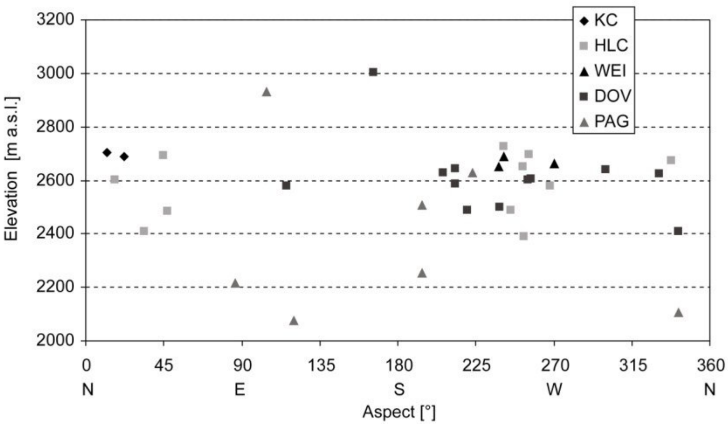

Figure 3: Elevation versus slope aspect for all 36 MTD-sites in the five study areas.

For this study three statistical values were calculated for each GST sites. These are the mean annual ground surface temperature (MAGST), the zero-degree isotherm (ZDI) and the slope of the linear function between mean daily temperature and time (TREND). The MAGST is the mean value for the hydrological year, i.e. October until September of the following year. Most data series end by end of August 2012, hence it was only possible to calculate the MAGST values for five hydrological years spanning 2006-2011. The ZDI is a proxy for permafrost occurrence and was calculated for each sensor using MAGST data and a vertical temperature gradient of 0.0065°C m^{-1}. Surface offset and thermal offset are furthermore relevant for the temperature at the top of permafrost below the active layer. These offsets cause generally cooler temperatures at the top of permafrost relative to the ground surface (SMITH & RISEBOROUGH 2002).

The slope of the linear function between daily temperature and time gives a first hint about ground surface temperature evolution. For this analysis all available mean daily data per MTD site were used. A positive slope indicates warming whereas a negative slope cooling.

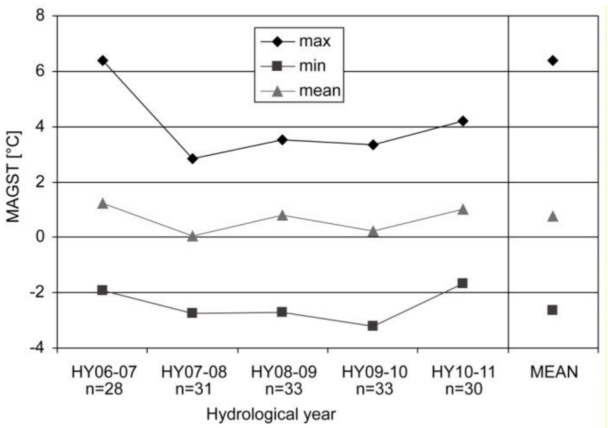

Figure 4: Mean, minimum and maximum MAGST values for each of the five hydrological years as well as the mean value of the five hydrological years based on available MTD-data. Note the differences in available MTD-data for the calculations as indicated by the n-values. Note furthermore the exceptional warm year 2006-2007 as well as a warming tendency after 2007-2008.

Results and Discussion

The results regarding MAGST clearly show high interannual differences (Fig. 4). The hydrological year 2006-2007 was characterised by an exceptional warm winter half-year causing above-average ground temperatures. At most MTD-sites this was the warmest of all five hydrological years measured so far. In contrast, the following hydrological year 2007-2008 was at many MTD-sites the coldest of all years. After 2007-2008 the MAGST values were generally higher compared to this year. The mean value of all sites was 0.0°C in 2007-2008. In contrast, this mean value was 0.2-1.0°C higher during the following three hydrological years.

A generally warming tendency is also indicated by the TREND analysis for all MTD sites. The analysis on the slope of the linear function for all 36 MTD sites revealed the following results: (a) for two sites data were not adequately available for this calculation (DOV-CO and PAG-RF-S), (b) for three sites no trend is indicated by the data (DOV-UP-S, DOV-MI-N, and DOV-RT), (c) for another two sites a slight tendency towards cooling was revealed (DOV-RF-S and DOV-SO). Finally and most importantly, for 29 sites (80%) a slightly positive trend (slope of linear function varied between 0.0001 and 0.0021) was revealed indicative for ground surface temperature warming (Fig. 5). These calculated slopes of linear function mean that mathematically – and only theoretically – the respective MTD sites warm between 0.0001 to 0.0021°C/day (or 0.04 to 0.77°C/year). However, one has to keep in mind that high interannual variations in the thermal regime are usual as described above and hence even longer times series are necessary to provide more robust trend results.

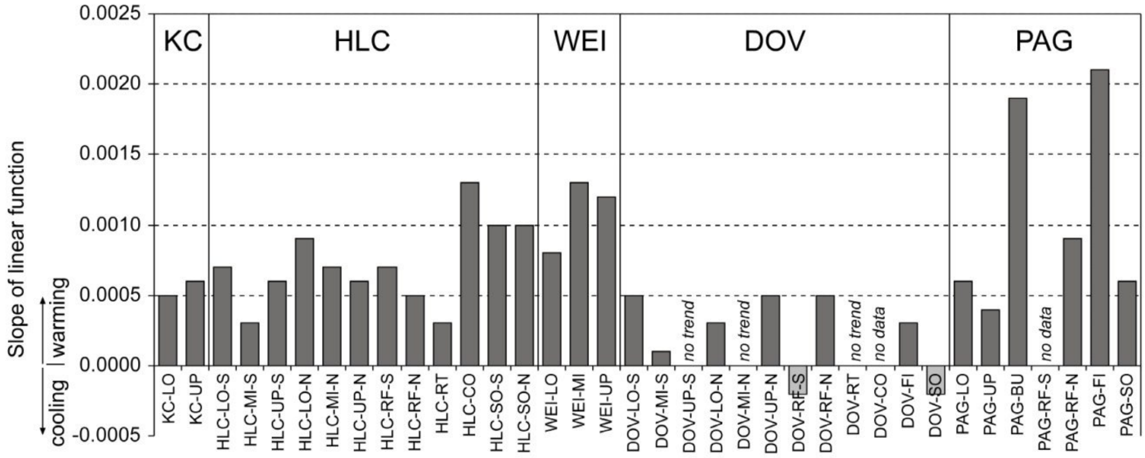

Figure 5: Slope of linear function for ground surface temperature (GST) for all 36 MTD-sites in the Hohe Tauern National Park. The calculated trends are based on all available mean daily temperature data of a given site (see Table 1).

Figure 6 shows two examples of temperature evolution (based on mean daily data) since the beginning of the measurements. One example (HLC-UP-S) reveals a warming trend during the measurement period. This south facing slope located at ca. 2700 m a.s.l. is in a transition from permafrost to seasonal frost. In contrast, the second example reveals no trend at all (DOV-UP-S). The mean ground surface temperature at this south-facing site at ca. 3000 m a.s.l. during the measurement period was -2.6°C, hence a clear – and presumably stable – permafrost site.

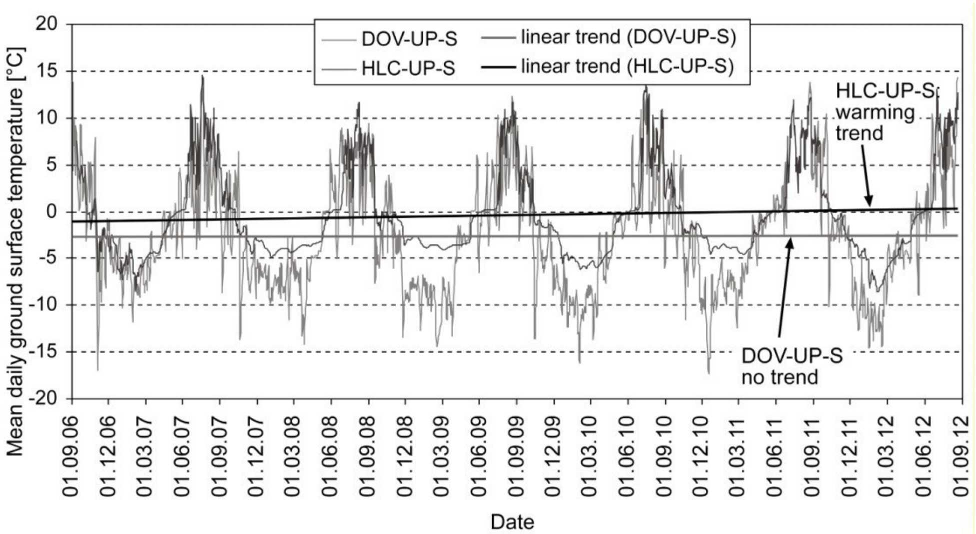

Figure 6: Mean ground surface temperature evolution at two selected MTD sites in the Hohe Tauern National Park. One example indicates no trend and hence warming or cooling of the surface at all (DOV-UP-S), a second example indicates a clear warming trend (HLC-UP-S).

The TREND results strongly suggest a warming trend at most of the sites and in all five study areas of the Hohe Tauern National Park during the last years. Interestingly, this trend seems to be unrelated to snow cover conditions because the MTD sites have big differences in the duration and characteristics of the winter snow cover. The differences in the winter snow cover are indicated by the damping effect of the winter snow cover and the duration of the zero degree isotherm during spring melting as revealed by the available temperature data.

Looking on the distribution in more detail it gets evident that the weakest warming tendency was revealed for the study area in the east (DOV) whereas the strongest warming was calculated for the western-most study areas WEI and PAG. Correlation analyses of the TREND values versus elevation, aspect and slope revealed no clear relationships. Hence elevation, slope and aspect seem to have no influence on the degree of ground surface warming over the last years. Summarising we can conclude that over the last years warming was stronger in the western part of the national park relative to the eastern part influencing all elevations above c.2000 m a.s.l., all slope inclinations, all aspects and unrelated to winter snow cover conditions.

The ZDI approach allows the calculation of all MTD sites to one reference. The differences of the calculated ZDI for each site revealed strong interannual variations with high values for 2006-2007, 2008-2009 and 2010-2011, whereas low values for 2007-2008 and 2009-2010. Obviously this distribution is very much linked to the MAGST values. The box-plot diagram in Fig. 7 clearly shows the exceptional high elevation values for 2006-2007. However, the median values for the ZDI of the two hydrological years 2008-2009 and 2010-2011 where even higher with, respectively 2715 and 2768 m a.s.l.

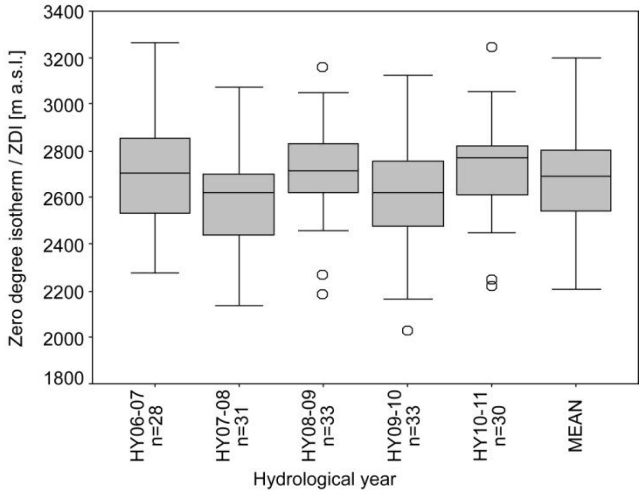

Figure 7: Box plot diagram of the variation of the ZDI for the five hydrological years as well as the mean ZDI values. Outliers are indicated by circles. Note the highest median value for 2010-2011

In Figure 8 the mean ZDI-values per site where plotted against slope aspect in order to analyse and visualise the influence of slope orientation on the elevation of the mean ZDI during the five hydrological years 2006-2011. Furthermore a polynomial function was calculated showing nicely that the ZDI is generally higher in south-facing slopes compared to east- and west- as well as north-facing slopes. This pattern is related to insulation (north-south) as well as cloudiness (east-west) effects. The same calculations where made for the single year data. Results for each hydrological year, each aspect class and mean and range values are listed in Table 2.

As explained above, the mean ZDI values over the last years indicate to some extent also the lower limit of permafrost in the National Park Hohe Tauern although surface and thermal offsets certainly influence these limits. The calculations reveal ZDI elevations of 2821 m a.s.l. for south facing slopes. For north facing slopes a 350 m lower ZDI value was calculated. The calculated mean ZDI for east facing slopes is 55 m higher compared to west facing-slopes (2747 vs. 2692 m a.s.l.) hence they are in between the values for north- and south-facing slopes as expected. These results further imply that permafrost at south facing slopes can be expected above c.2820 m a.s.l., whereas on north-facing slopes permafrost might occur to elevations even below 2500 m a.s.l.

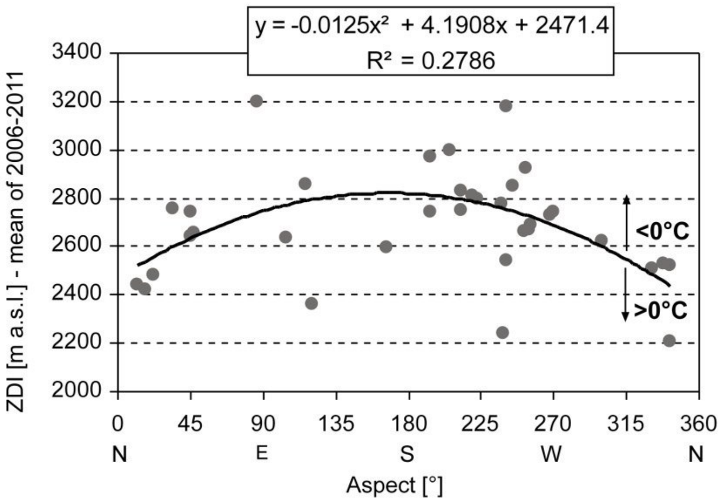

Figure 8: Calculated mean ZDI of the five hydrological years 2006-2011 versus slope orientation for all MTD-sites with GST data. The depicted polynomial function indicates where GST are expected to be above or below 0°C and hence to some extent is indicative for presence or absence of permafrost.

Interestingly the interannual variation in the elevation of the ZDI is substantially smaller at north-facing slopes (only 116 m) compared to the other three main aspect classes. The highest variation in the ZDI was calculated for south-facing slopes with 168 m (Table 2). This indicates that warm years influence to a higher extent warmer, south-facing slopes compared to cooler, north-facing slopes where thermal conditions seem to be more stable.

Conclusions

From the above considerations the following conclusions can be drawn:

Continuous ground surface temperature data with hourly resolution were available for this study from five different study areas in the Hohe Tauern National Park. Data series covered the time span of up to September 2006 to August 2012. These data represent some of the longest continuous time series of ground temperature in the periglacial environment of central Austria and are valuable for understanding permafrost distribution and future changes.

The first measurement year (hydrological year 2006-2007) at the 35 MTD sites with ground surface in the Hohe Tauern National Park was unusually warm and the warmest of all five years with available data. On average ground surface temperatures were 1.2°C warmer compared to the coldest year (2007-2008) and still 0.2°C warmer to the second warmest year (2010-2011). Generally, MAGST values increased since 2007-2008.

Trend analyses of 2006-2012 data showed that in 80% of all MTD sites a clear warming trend was revealed. This warming trend is strong and consistent at the four study areas located in the western part of the national park (Schober and Glockner Mountains). Contrary, in the Ankogel Mountains located in the very east of the national park territory this trend is substantially weaker with MTD sites showing either no trend at all or only weak warming trends. Differences in elevation, slope, aspect and winter snow cover characteristics at the MTD sites seem to have no influence on the degree of ground surface warming over the last years.

The ZDI is a rough proxy for absence or presence of permafrost although surface and thermal offsets as well as high ground temperature variability within short distances in relatively homogenous terrain make permafrost prediction very difficult in sporadic and discontinuous permafrost areas. The analysis of the ZDI revealed again strong interannual variations. Based on polynomial functions, the mean ZDI for the five hydrological years 2006-2011 was calculated for each of the four main slope aspect directions. Results show that permafrost at south facing slopes can be expected above c.2820 m a.s.l., whereas on north-facing slopes permafrost might occur to elevations even below 2500 m a.s.l. The lower limit of permafrost on east-facing slopes is in the order of 50 m higher compared to west-facing slope. This is presumably related to cloudiness effects (no convection clouds in the morning and hence stronger insulation compared to the afternoon on east-facing slopes).

Finally, the results indicate that warm years influence to a higher extent warmer, south-facing slopes relative to cooler, north-facing slopes where thermal conditions seem to be more stable. Warmer years will occur more often in future as indicated by climate model scenarios. This could imply for instance rock fall events in periods which are currently thought to be safe for man and animals in the high mountains of Hohe Tauern National Park.

Table 2: The calculated ZDI for the different hydrological years and slope aspects based on polynomial functions of ZDI vs. aspect. Furthermore, the calculated mean ZDI as well as the ZDI range for each aspect class are listed.

Period	Aspect			
	E	S	W	N
ZDI of HY06-07 [m a.s.l.]	2794	2888	2744	2461
ZDI of HY07-08 [m a.s.l.]	2640	2721	2607	2365
ZDI of HY08-09 [m a.s.l.]	2749	2829	2725	2486
ZDI of HY09-10 [m a.s.l.]	2685	2751	2615	2416
ZDI of HY10-11 [m a.s.l.]	2793	2886	2760	2481
mean ZDI [m a.s.l.]	*2747*	*2821*	*2692*	*2471*
range ZDI [m]	*153*	*168*	*153*	*116*

Acknowledgments

This study was carried out within the project "permAfrost – Austrian Permafrost Research Initiative" funded by the Austrian Academy of Sciences. Furthermore, relevant data were collect earlier within the two projects "ALPCHANGE – Climate Change and Impacts in Southern Austrian Alpine Regions" financed by the Austrian Science Fund (FWF) through project no. FWF P18304-N10 as well as "PermaNET – Permafrost long-term monitoring network". PermaNET is part of the European Territorial Cooperation and co-funded by the European Regional Development Fund (ERDF) in the scope of the Alpine Space Programme.

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Conference Volume | 5th Symposium for Research in Protected Areas, 10 to 12 June 2013, Mittersill | pages 373 - 378

Relict rock glaciers as important aquifers in sensitive ecosystems: The example of the Natura 2000 protection area Niedere Tauern Range, Styria

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Abstract

The hydrological significance of active rock glaciers for water storage is studied since the mid 1970ies. In contrast, the hydrology of relict rock glaciers lacking permafrost today is still poorly understood. Despite this shortage of knowledge, relict rock glaciers and their hydrogeology are important in the alpine landscape of Austria. In this study we focussed on the European protection area (Natura 2000) Niedere Tauern (surface area 1261 km²) located in Styria, Austria. At the regional scale the spatial distribution of relict rock glaciers and their catchment areas were investigated. Results show that the drainage of approximately 9% of the area above 1500 m a.s.l. and 23 % above 2000 m a.sl. are influenced by relict rock glaciers as aquifers. Results of the subunit Seckauer Tauern Range even show 16% above 1500 m a.s.l. and 42% above 2000 m a.s.l. At a local scale the hydraulic properties of a relict rock glacier are investigated at the Schöneben Rock Glacier with a distinct spring at the front. Hydrograph analyses indicate for instance both a fast component on groundwater recharge events with a low storage capacity and a base flow component with a high storage capacity. The spring hydrograph can be decomposed in three exponential recession functions with different recession coefficients depending on the range of discharge. This indicates a multi-storage system. Our results clearly indicate that on a regional scale relict rock glaciers are highly relevant for the drainage system and ecology in the studied alpine region. On a local scale it is shown that rock glaciers are not only essential water buffers in alpine catchments relevant for ecosystems (continuous water supply during dry periods) but also natural hazards (flood-risk reduction after storm events) and are essential groundwater resources.

Keywords

rock glacier catchment, relict rock glacier, alpine water cycle, Natura 2000 protection area, Niedere Tauern Range, Styria

Introduction

Since the mid 1970ies various authors have been working on the hydrological significance of active rock glaciers for water storage (e.g. CORTE 1976, GARDNER & BAJEWSKY 1987, SCHROTT 1998, GIARDINO et al. 1992, BRENNING 2005, AZÓCAR & BRENNING 2010). Research on the hydrology of active rock glaciers in the Austrian Alps was initiated in the late 1990s (e.g. KRAINER & MOSTLER 2002, KRAINER et al. 2007). In contrast, the hydrology of relict rock glaciers received far less scientific attention compared to active ones. Relict rock glaciers contain no permafrost today but indicate past permafrost conditions during cooler periods as for instance the Lateglacial period. Pioneering research work on the discharge behaviour of relict rock glaciers in the Niedere Tauern Range (Austrian Alps) was carried out in the 1990s by GÖDEL (1993), UNTERSWEG & SCHWENDT (1996) and UNTERSWEG & PROSKE (1996) and re-initiated very recently by WINKLER et al. (2010, 2012).

The drainage dynamics and the storage capacity of these large sediment bodies are still poorly understood. LIEB et al. (2010) and KELLERER-PIRKLBAUER et al. (2012) presented data on 1300 “relict rock glacier units” covering 98 km² in the Austrian Federal Provinces of Styria (406), Carinthia (357), Salzburg (237), Upper Austria (1) and the county of Eastern Tyrol (299). These authors used the term “rock glacier unit” in order to describe obviously different rock glacier generations or units composing one rock glacier. For instance a rock glacier might consist of two different units: a younger active rock glacier unit might overrun an older relict rock glacier unit. Therefore, the number of rock glacier units in their inventory (1647) is more than the number of rock glaciers itself (1528). A similar inventory study by KRAINER & RIBIS (2012) revealed 1342 relict rock glaciers for Northern Tyrol alone with a total surface area of 61 km². Therefore, some 2600 relict rock glaciers were mapped in the Austrian Alps so far covering an area of at least 150 km².

Large areas of the Austrian Alps are predominately built up by crystalline rocks as for instance the Niedere Tauern Range. Alpine catchments in crystalline rocks are often characterised by a high number of springs having typically yearly mean discharge rates below one litre per second. However, water economic studies in the 1990ies (UNTERSWEG & SCHWENDT 1996) in the Niederen Tauern Range in Styria showed that springs with higher discharge rates (up to tens of litres) are related to relict rock glaciers. WINKLER et al. (2012) provide preliminary results with regard to the storage capacity and drainage dynamics of relict rock glacier aquifers. The storage capacity has for instance positive implications for flood-risk reduction and the riparian ecology below rock glacier springs. The aquifer base flow provides steadily water during dry periods. The predicted increase of extreme weather conditions such as an increasing number of hot days and heavy precipitation events in Central Europe (e.g. BENISTON et al. 2007) suggest a rising importance of these aquifers with regard to the sensitive ecosystem in alpine catchments. Therefore, increasing the knowledge about these alpine aquifers is important for man and nature due to various reasons.

In this study we focus at a regional scale on the hydrological role of predominantly relict rock glaciers in the European protection area (Natura 2000) Niedere Tauern Range located in Styria, Austria. At a local scale we present hydrogeological data and interpretations of the Schöneben Rock Glacier located in the east of the study area. Preliminary results are presented. With this study we contribute to the understanding of the impact of relict rock glaciers on the hydrology of alpine catchments and therefore the relevance for man and particularly nature.

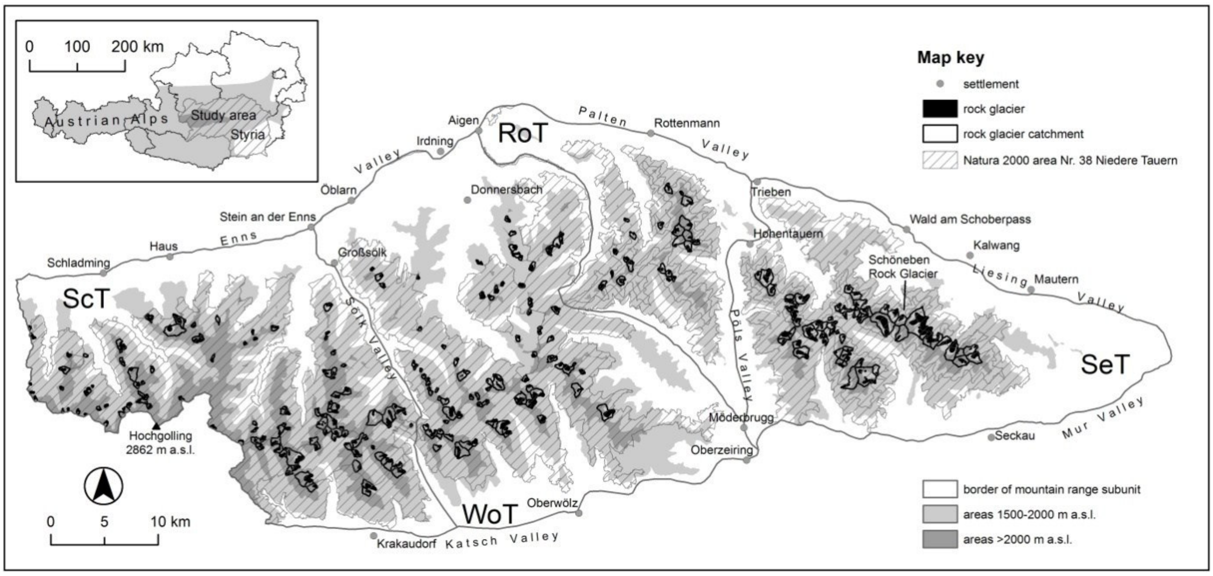

Figure 1: Spatial distribution of rock glaciers (according to Lieb et al. 2010) and their catchments in the Natura 2000 area Nr. 38 Niedere Tauern. Areas above 1500 and 2000 m a.s.l and the delineation of the four different subunits of the Niedere Tauern Range in Styria (ScT-Schladminger Tauern Range, WoT-Wölzer Tauern Range, RoT-Rottenmanner Tauern Range, SeT-Seckauer Tauern Range) are indicated. Furthermore, the locations of the Schöneben Rock Glacier and the highest summit in the entire study area are shown.

Study area

Regional scale: Niedere Tauern Range, Styria

The study area comprises the Styrian part of the Niedere Tauern Range in Austria between 47°11'-47°33'N and 13°35'-15°00'E (Fig. 1). The study area covers an area of 2440 km². Distinct mountain passes along the primarily east-west trending main divide separate the mountain range into four major subunits named from west to east Schladminger, Wölzer, Rottenmanner, and Seckauer Tauern Range hereafter abbreviated as ScT, WoT, RoT and, respectively, SeT. The highest summit is Hochgolling reaching 2862 m located in ScT. About 50% of the total area is located above 1500 m a.s.l. and some 10% exceed an elevation of 2000 a.s.l. Geologically, the study area is built up by two crystalline basement units of the Upper Austroalpine (Silvretta-Seckau nappe system and the Koralp-Wölz nappe system) consisting predominately of different types of gneisses and mica schists (GASSER et al. 2009).

Most of the subalpine and alpine zone of our study area is protect as the "Natura 2000 area Nr. 38 Niedere Tauern". This protection area covers 1260.9 km² and is the largest of all Natura 2000 areas in Styria (Fig. 1) As the Natura 2000 is an important initiative of the European Commission to conserve Europe`s rich natural heritage with its threatened habitats and species, knowledge about groundwater availability at present but also in the future considering the climate change scenarios indicated above is of crucial importance.

Local Scale: Schöneben Rock Glacier

The Schöneben Rock Glacier (hereafter abbreviated as SRG) is located in the eastern most subunit SeT at E14°40'26" and N47°22'31" (Figs. 1, 2). The SRG with a length of about 750 m and a width up to 200 m covers an area of about 0.11km². The SRG ranges 1905 m a.s.l. at the rooting zone of the rock glacier to 1715 m a.s.l. at the front where a distinct spring is located (Fig. 2). The rock glacier is orientated towards NE and consists predominantly of coarse-grained to blocky gneissic sediments at the surface. However, at several locations particularly near the talus slopes finer-grained debris-flow sediments occur. The SRG exhibits a rugged microtopography with bended transverse ridges and furrows several meter deep at its lower part and longitudinal ridges and furrows at its central and upper part. The SRG can be regarded as a relict rock glacier indicated by regional permafrost modelling results (KELLERER-PIRKLBAUER 2005). However, patches of permafrost in the upper part of the rock glacier are feasible considering research results from a neighbouring cirque (KELLERER-PIRKLBAUER 2011).

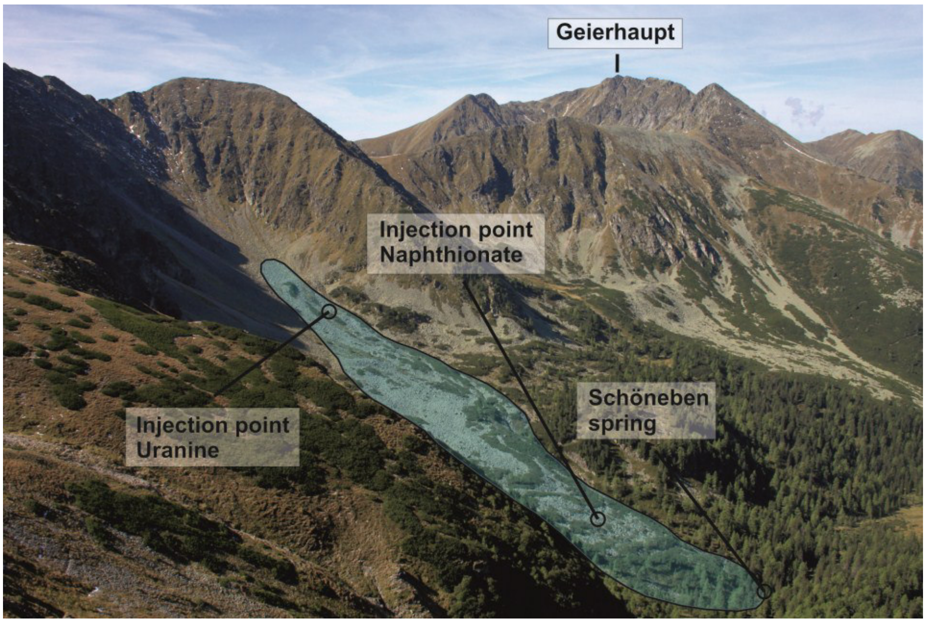

Figure 2: Schöneben Rock Glacier (SRG) is located in the subunit Seckauer Tauern Range (SeT). The rock glacier faces towards NE. View direction of photograph towards W to Mt. Geierhaupt (2417 m a.s.l.), the highest mountain of the entire SeT. The rock glacier spring is located at 1715 m a.s.l. (Photograph by A. Kellerer-Pirklbauer).

Material and Methods

At the regional scale the spatial distribution of relict rock glaciers and their catchment areas were investigated. Based on the polygon-based rock glacier inventory of Central and Eastern Austria (Lieb et al., 2010, Kellerer-Pirklbauer et al., 2012) the catchment area of each rock glacier was delineated manually in ArcGIS10. Frequently, more than one rock glacier is located in one rock glacier catchment (i.e. older rock glacier further below; younger rock glacier at higher elevation). In such instances only the larger, higher-ranked hydrological catchment was delineated. Consequently two or more rock glaciers were attributed to one rock glacier catchment. In a second step an attribute table was generated for each delineated catchment. Various parameters (mainly related to topography) were recorded and listed. In this paper we focus particularly on the hydrological catchment area of the rock glacier and their areal proportion to the rock glaciers in these catchments. A comprehensive rock glacier catchment analysis including climatic and hydrological considerations at a regional scale will be presented elsewhere.

At the local scale the storage capacity and the drainage dynamics of the SRG were investigated. The existing data base comprises the SRG spring discharge continuously monitored since 2002 and, water temperature and electric conductivity continuously measured since 2008. In addition meteorological data – precipitation and air temperature – were provided for the nearby automatic weather station "Hochreichhart" (HZB-number 123274). This station is operated by the Hydrographic Service of Styria and located at 1500 m a.s.l. in the neighbouring valley 2.5km to the east of the rock glacier.

Based on indications that relict rock glacier springs show a similar discharge behaviour as Karst springs (Gödel 1993, Untersweg & Schwendt 1996) hydrograph analyses and natural and artificial tracer tests were performed to investigate the rock glacier aquifer properties. Recession curves of the spring hydrographs are analysed for periods of no or negligible recharge in order to identify the base flow component applying e.g. the analytic solution of Maillet (1905). The time series of the electrical conductivity and water temperature were used as natural tracers to differentiate the two discharge components recently recharged water (event water) and the base flow. Furthermore an artificial tracer test with two injection points at the rock glacier surface using fluorescent dyes (Naphthionate and Uranine; see Fig. 2 for locations) was conducted to characterize the storage capacity of the rock glacier.

Table 1: Summary statistics for the rock glacier catchment inventory according to number, area and percentage of areas above 1500 m a.s.l. and, respectively, 2000 m a.s.l.

Mountain range subunit	Rock glacier catchments [n]	Area median [m²]	Area mean [m²]	Area total [km²]	Percentage of areas >1500 m a.s.l. [%]	Percentage of areas >2000 m a.s.l. [%]
ScT	119	170,693	290,756	34.6	8.1	18.1
WoT	86	171,241	279,070	24.0	5.7	20.4
RoT	22	319,483	390,909	8.6	6.3	27.3
SeT	68	382,606	600,000	40.8	15.6	42.0
Total	*295*	*239,078*	*366,102*	*108.0*	*8.6*	*22.7*

Results and Discussion

Results from the regional study revealed that 295 rock glacier catchments with 376 rock glacier units are located in the study area (Table 1, Fig. 1). Almost all of these rock glacier catchments are also located in the Natura 2000 area Niedere Tauern. Most of these catchments are located in the westernmost subunit ScT. However, the generally largest rock glacier catchments are in the easternmost subunit SeT (Fig. 3a). The rock glacier catchments in the subunit RoT are of similar size to the ones in the SeT. In contrast, the rock glacier catchments in the two subunits to the west (WoT and ScT) are substantially smaller with median and mean values for rock glacier catchments of, respectively, about 0.17 km² and 0.28-0.29 km². Therefore, the pattern with small rock glacier catchments in the west and the increasing size of these catchments towards the east is similar to the pattern for rock glaciers. 108 km² or 4.4% of the Styrian part of the Niedere Tauern Range belong to rock glacier catchments. Considering only areas above 1500 m a.s.l. and 2000 m a.s.l., the percentage values increase to 8.6% and 23% respectively. Results of the subunit SeT even allocate 16% of the total area above 1500 m a.s.l. and 42% above 2000 m a.s.l. to rock glacier catchments. The largest rock glacier catchment is also found in the subunit SeT with an area of about 3.5 km² (Fig. 3a). The high values in subunit SeT can be explained by the existence of very large rock glaciers (also on global scale) which started to form already early in the Lateglacial period and continued to grow for thousands of years until the early Holocene where they turned to relict rock glaciers.

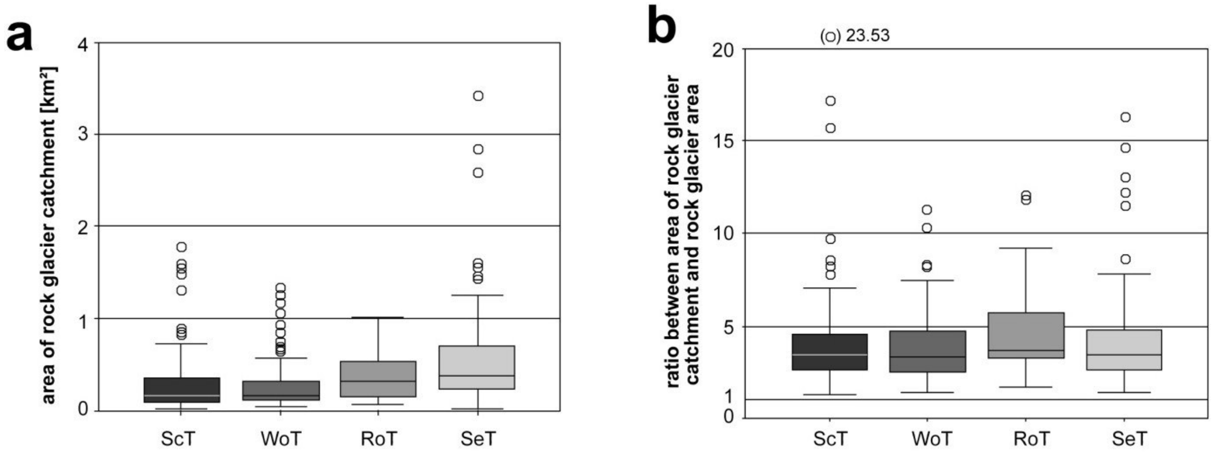

Figure 3: Box plot diagrams of (a) the surface area of rock glacier catchments and (b) the ratio between the surface area of the rock glacier catchment and the surface area of one to more rock glaciers within this catchment differentiated for the four different subunits of the study area; o=outliers. One outlier outside scaling range is indicated with the value.

Results regarding the ratio between the surface area of the rock glacier catchment and the surface area of rock glaciers within the catchment are depicted in Fig. 3b. Generally, the median of the ratio value is very similar in each of the four ranging from 3.3 (in WoT) to 3.7 (in RoT). This indicates that rock glacier catchments are generally about 3.5 times larger compared to the surface area covered by rock glaciers alone. However, the boxplot diagram in Fig. 3b also clearly depicts the large scatter in the data for all four subunits. This is in contrast to the debris-supply area of rock glaciers which are (according to inventory data from other mountain regions; e.g. Wahrhaftig & Cox 1959, Janke & Frauenfelder 2007) only some 1.4 to 2.0 times larger compared to the rock glacier below the rock faces.

Because of the lack of comparable studies on rock glacier catchments in other regions in Europe and elsewhere it is difficult to bring our results in a broader context. One approach to overcome this lack of similar studies is to compare "our" rock glaciers with rock glacier sizes from other regions. The largest rock glaciers in our study area are located in the subunit SeT with an average value of 84,000 m². This value is similar compared to rock glaciers in the Front Range of Colorado, USA, with 83,000 m² (Janke & Frauenfelder 2007), but more compared to talus-derived (57,000 m²) or glacier-derived rock glaciers (79,000 m²) in the Eastern Swiss Alps (Frauenfelder et al. 2003). Furthermore, this value is also substantially more than for rock glaciers in the Sierra Nevada, USA with 20,000 m² on average (Millar & Westfall 2008). These comparative figures illustrate that our study region is an area with large rock glaciers even on a global scale and – based on the strong correlation between rock glacier area and rock glacier catchment area (Kellerer-Pirklbauer et al. unpublished) – with some of the largest rock glacier catchments worldwide.

The hydrograph analyses of the Schoeneben rock glacier spring indicate both a very fast discharge component after precipitation events and a slow base flow component (Winkler et al. 2012). The spring hydrograph can be decomposed in three exponential recession functions with different recession coefficients (Fig. 4). This drainage dynamics are comparable to complex heterogeneous aquifer-types such as Karst aquifers indicating two or more aquifer components with diverging storage capacities.

The water temperature and the electric conductivity of the rock glacier spring show seasonal variations between 1.7 and 2.36°C and 35 µS/cm and 61 µS/cm, respectively. Both parameters respond almost simultaneously after a time lag of about three hours on recharge events with decreasing values representing the fast discharge component with a very low storage capactity.

Tracer experiments with the fluorescent dyes support the results especially the recession coefficients of the base flow (α ranges of 0.003 to 0.006 [d^{-1}]) with an averaged retention time of 79 to 108 days after the tracer injection.

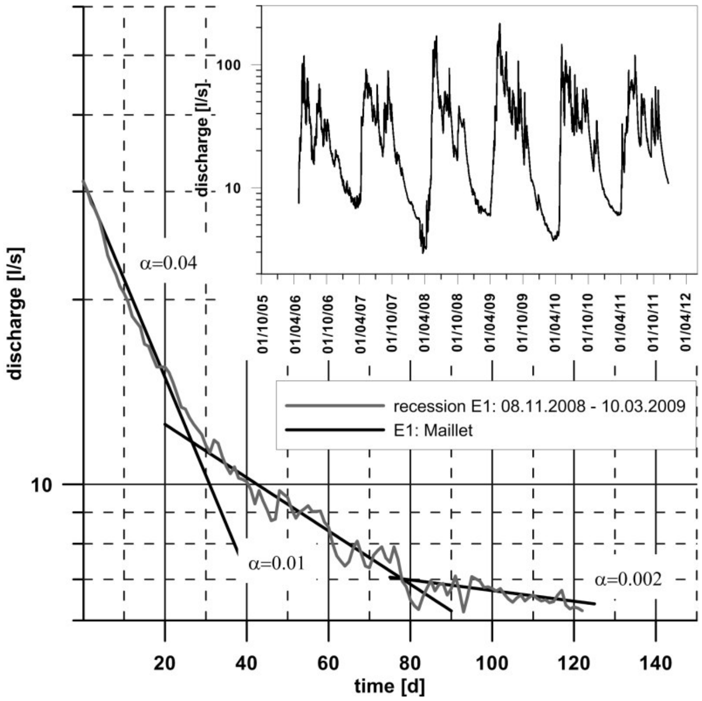

Figure 4: Selected long time recession over the winter period with the fitted recession coefficients based on the exponential model (Maillet 1905) in black including the recession coefficients for the three differentiable recession parts.

Conclusions

Most of the 295 identified rock glacier catchments in the Styrian part of the Niedere Tauern Range are located in the Natura 2000 area.

Some 8.6% of the entire area above 1500 m a.s.l. in the Styrian part of the Niedere Tauern Range is drained through rock glaciers. This values increases to 42 % if we focus on the areas above 2000 m a.s.l. in the eastern-most subunit SeT.

Rock glacier catchments are on average about 3.5 times larger than the respective areas covered by rock glacier sediments in the catchment. However, in extreme cases the catchment is 11.3 and 23.5 times larger than the rock glacier hence very large catchments drain over relatively small rock glaciers. This emphasises the importance of these sediment accumulations and there hydrogeological properties.

On the one hand the storage capacity of these aquifers enhances a buffering of the water amount coming from heavy precipitation events thereby reducing the intensity of natural hazards as flood events. On the other hand the aquifers represent an essential groundwater resource especially during dry periods to provide the existence of the sensitive ecosystems in alpine catchments.

Thus we conclude that relict rock glaciers are highly relevant for the drainage system and in further consequence for the water ecology in the Natura 2000 area Niedere Tauern.

Acknowledgments

This study was carried out within the framework of the project *Water Resources of Relict Rock Glaciers* co-funded by the Federal Government of Styria and the European Regional Development Fund (ERDF). Please visit http://www.uni-graz.at/hydro-blogle for further details. GIS data have been provided by the Federal Government of Styria, administrative office GIS-Steiermark.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 379 - 384

River-bed degradation and overbank deposition: A human induced geomorphic disequilibrium in the Donau-Auen National Park

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Abstract

The Danube east of Vienna is the 'lifeline' of the Donau-Auen National Park. In the last about 140 years it has been strongly altered by river engineering and, in a second stage, by a bed load deficit due to hydropower plants in the upper reaches of the river and its tributaries. As a consequence the river is degrading, with deepening rates between 2 and 3 cm/a in most parts of the study reach. On the other hand, overbank deposition and natural levee formation lead to an aggradation of the floodplain, the channel and its floodplain are diverging. In natural rivers, overbank deposition usually is balanced and restricted by side erosion and lateral channel migration. However, the banks of the Danube are fixed by riprap, thus the overbank deposits cannot be eroded, and distinct 'natural' levees are formed. Both river-bed degradation and overbank deposition are aspects of a geomorphic disequilibrium, and the system will further depart from the natural state.

Keywords

Danube; fluvial morphology; dynamic equilibrium and disequilibrium.

Introduction

Natural alluvial rivers, similar to other geomorphic systems, are assumed to be in a state of dynamic equilibrium, or, at least, in a quasi-equilibrium (LEOPOLD & MADDOCK 1953; LANGBEIN & LEOPOLD 1964): In case of disturbances opposing tendencies and feedback mechanism secure the system's stability by adjustments to cross-sectional form (WOLMAN 1955), channel pattern (LEOPOLD & WOLMAN 1957) or channel gradient (KNIGHTON 1998); thus the system is in a 'steady state' (LANGBEIN & LEOPOLD 1964).

However, heavy impacts, exceeding critical thresholds, may drive the system to a new equilibrium, and the transition is related to a phase of disequilibrium. Such impacts often and also in case of the Danube River have been caused by river engineering and by bedload deficit due to the construction of hydropower plants (SCHMAUTZ et al. 2002). As a result, such river reaches are subject to bed degradation, and the frequency and duration of floodplain inundation is reduced (TOCKNER et al. 1998), which is a key-problem in the Nationalpark Donau-Auen; these effects are there further increased by overbank deposition and the formation of natural levees (KLASZ et al. 2012).

The Danube east of Vienna, pre-regulated state and human impacts

The Danube River, crossing the Vienna basin between Vienna and Hainburg, is a large gravel-bed river and strongly influenced by human impacts since the last about 140 years. However, it still shows major functional attributes of a natural river such as the dynamics of water level fluctuations and bedload transport (TOCKNER et al. 1998) and associated biodiversity. It thus has become part of the National-Park Donau-Auen (established in 1996). In its unregulated state it can be classified (according to the schema of NANSON & KNIGHTON 1996) as a gravel-dominated, laterally active anabranching river with a medium-energy non-cohesive floodplain, i.e. wandering gravel-bed river floodplain (HOHENSINNER et al. 2008).

In it's natural state the river had in some sections one and in other sections two main channels and several side-arms. There were both smaller, unvegetated, more transient bars, and larger, well-vegetated (even forested), more stable islands, which could persist for many years or some decades (MOHILLA & MICHLMAYR 1996; KLASZ et al. 2012). This river-floodplain system was characterized by high morphological dynamics and hydrological connectivity, a highly variable flow regime, high loads of coarse bed material, and effects of ice jams in winter and large woody debris (HOHENSINNER et al. 2008).

Between 1870 and about 1900 the river was straightened, concentrated into one main channel and channelized; the banks of the Danube were armoured and fixed by riprap, thus erosion can only proceed in form of incision;

most side arms were separated from the main channel by artificial levees, and large parts of the floodplain were narrowed by a flood protection dyke (Marchfeldschutzdamm). Beginning from 1955 most upstream stretches of the Austrian Danube were subject to further massive impacts by hydropower plants. The last of it, Vienna-Freudenau (river-km 1921) was put into operation in 1997. The study reach remained a free flowing river, but due to the retention of bedload (bedload deficit) in the upper parts of the river basin and some of its tributaries the present river regime is dominated by degradation. In Table I, hydrological and hydromorphological characteristics of the river reach are listed.

Table 1: Hydrological and hydromorphological characteristics of the Danube River east of Vienna (river-km 1920 – 1880)

A_D	Drainage area (km^2)	≈ 100'000	([a]
Q_m	Mean annual discharge (m^3s^{-1})	≈ 1'930	([a]
Q_{maf}	Mean annual flood (m^3s^{-1})	≈ 5'930	([a]
Q_{bf}	Estimated bankfull discharge (m^3s^{-1})	≈ 4'800 … 5'000	([a]
D_{50}	Median surface bed-material size (mm)	20 … 25	([a]
D_{90}	Bed-material size of which 90% is finer (mm)	50 … 70	([a]
B_{bf}	Bankfull top width (m)	≈ 353	([a]
H_{bf}	Bankfull mean depth (m)	≈ 5.75	([a]
S	Channel slope ($m.m^{-1}$)	≈ 0.00041	([a]
G	Mean annual bed-load (m^3a^{-1})	≈ 370'000	([b]

Data sources: a: Klasz (2010), b: Klasz et al. (2012)

Bed degradation: hydrographic evidence

Changes and trends of characteristic water levels are reliable indicators of bed stability. Characteristic water levels of the Austrian Danube ('KWD') have been determined by hydrographic observations and published for certain years (Bundesstrombauamt 1951, 1959, 1970, 1978; Wasserstrassendirektion 1986, 1998; via donau 2012), providing an overview over the last ~60 years. "RNW" (low navigable water level; in German: "Regulierungs-Niederwasser") is the water level reached or exceeded on 94% of days over a long-time reference period (KWD-2010: 20 years). "MW" (mean water level) is the water level corresponding to the arithmetic mean of the average annual discharges for the reference period. In Figure 1a the temporal trends of the RNW- and MW-data for five gaging stations are plotted. MW-differences to the first reference (MW-1949) are plotted for all gaging-stations, step by step and in the longitudinal section in Figure 1b (including data of the reach upstream, until this reach was impounded by the hydropower plant Greifenstein in 1984).

All data indicate a decrease in the last decades (Fig. 1a/1b). In the period before 1976 the degradations were more significant upstream of Vienna. In the 1980s and 1990s the reaches in Vienna and east of Vienna were affected stronger. Recent deepening rates are ranging between 2 and 3 cm/a.

Downstream of the confluence of the Morava the water levels are influenced by the impoundment of Gabčikovo since 1992. The KWD-2010 indicate a further increase of the MW there (for instance in Wolfsthal), which can be seen as a sign of aggradation in this upper part of the impoundment.

To get a long-term perspective, the lowest water levels (NW) and mean water elevation (MW) of each year were plotted against time for the gaging station Hainburg (river-km 1883, 92, data since 1846; Hydrographisches Zentralbüro 1895-2009; Hydrographisches Zentralbüro 1958), see Figure 2. The fluctuations are caused by dry and wet years, but the moving average (n=10) provides information on the stability of the riverbed. Before the regulation the water levels seemed to be stable (however, the period is too short for a certain conclusion); between about 1870 and 1890 (during the upstream regulation works) the water levels were increasing by ~1 m; the first half of the 20th century was nearly a phase of equilibrium, followed by a phase of rising degradation rates after about 1960. Similar results have been found by SCHMAUTZ et al. (2002).

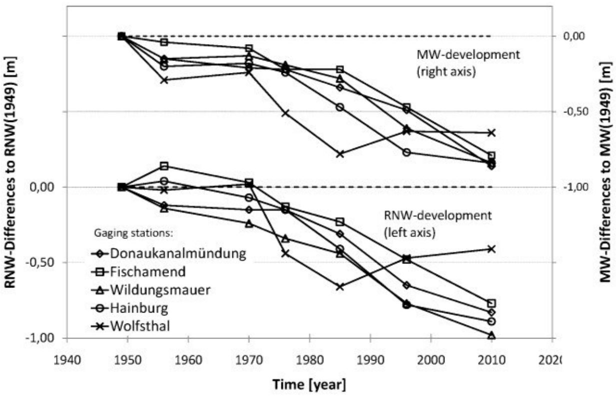

Figure 1a: Differences of MW (mean water level) and RNW (low navigable water level) to reference level (1949) for five gaging stations

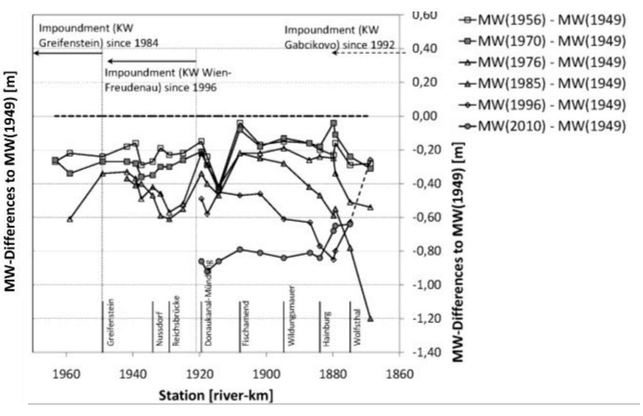

Figure 1b: Differences of MW (mean water level) to reference level (1949) in the longitudinal section

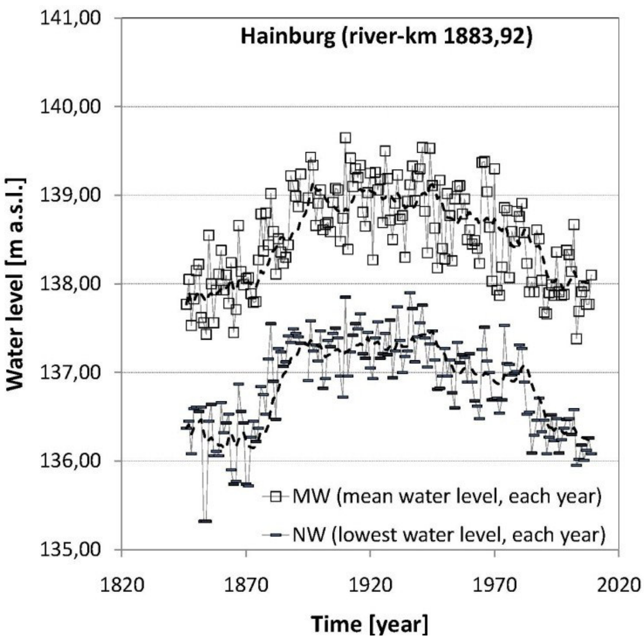

Figure 2: Mean water level (MW) and lowest water level (NW)
of each year; time period: 1846-2009; gaging station: Hainburg

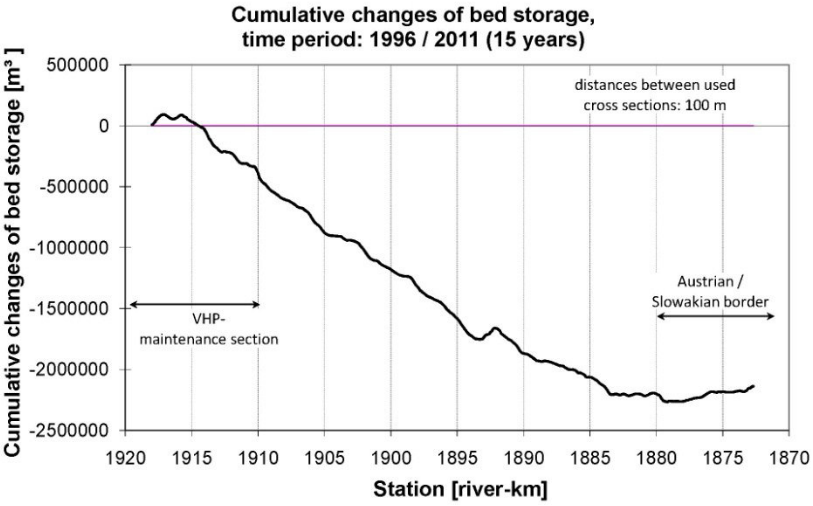

Figure 3: Cumulative changes of bed storage (=bedload output); time period: 1996-2011

Direct evidence on degradation is given by comparisons of cross sections from different dates, obtained by riverbed surveying. The difference of cross sectional areas between two points of time multiplied by the “thickness” of the cross section (that is, the half distance to the next upstream cross section plus half distance to the next downstream cross section) provides ΔV(i,j), the change of the bedload storage of the particular cross section i and time interval j; finally the cumulative bedload output (over the time interval j) is derived by integration of these partial volumes in the flow direction. In Figure 3 this is shown for the time period between 1996 and 2011 for the reach between river-km 1918 and river-km 1873 (Wolfsthal). Time-averaged annual degradation rates per unit length are almost constant between river-km 1915 and 1890, with a value of ~5’400 $m^3km^{-1}a^{-1}$); in the section between river-km 1884 and 1880 a saturated state is reached, followed by an aggrading reach, influenced by the impoundment of the hydropower plant Gabčikovo.

To avoid additional degradation by the hydropower plant Vienna-Freudenau and based on the licensing requirements the operating company (Verbund Hydro Power) has dumped an average of ~190’000 m^3 gravel per year (artificial bedload supply) downstream of the hydropower plant (Schimpf et al. 2009). Thus it was possible to maintain a stable riverbed in the upper part of the reach, but the degradation process war not stopped on the whole.

From the bedload output of the entire reach (~2.3 million m^3 in this time period, see Fig. 3; that is, ~150’000 m^3a^{-1} and the averaged artificial supply of ~190’000 m^3a^{-1} the transport capacity and entire bedload deficit of this reach can be calculated to lie between 340’000 and 350’000 m^3a^{-1}. These values are in good agreement with previous estimations (Gruber 1969; Zottl & Erber 1987; Kresser 1988; Klasz 2002), but they are supported by more and higher quality data than they had in the past.

Some effects of degradation on side-arms and gravel bars

By degradation the main channel and the floodplain are gradually disconnected, duration and frequency of the inflows into the side-arms are decreasing, and their morphological dynamic is reduced. If the connectivity falls below a critical value, bushes and trees are growing quickly, and in interaction with siltation these side-arms are transformed into riparian forest.

Degradation may also undermine the success of restoration projects. For example, the large-scale 'Regelsbrunn / Haslau-'project, realized between 1996 and 1998, should reestablish hydrological connectivity and dynamics of an 8 km long side-arm by lowering parts of the riverside embankments (TOCKNER et al 1998); the deepest inlets were set at an elevation of MW-0,5 m. However, the mean water MW was derived by the KWD-1985, and in the meanwhile (over the last about 25 years) this water level has declined by ~60 cm there, see Figure 4. Thus, the duration of inflowing was reduced from 216 d.a-1 to ~143 d.a-1; if this tendency will go on, the hydrological effects of this restoration project would be transient.

Figure 4: Duration curve, water level (for river-km 1901.1) versus time [d/a], the indicated value was equalled or exceeded; situation in 1985 (KWD-1985) and 2010 (KWD-2010)

The interaction between incision and vegetation can also concern gravel bars within the main channel. Contrary to the deeper parts of the river, most alternate and point bars are not eroding, thus they are gradually growing up relative to the declining mean water level. Similar to the side-arms, dense vegetation (bushes and trees) is developing as soon as the frequency of inundation falls below a critical value. In the last years this process can be observed on a large point bar between river-km 1884.5 and 1883 (left side of the river, opposite of Hainburg). Thus, there is a shift from gravel-bed areas to forested areas even within the channel. Dense vegetation can stabilize and protect such gravelly areas against the tractive forces of floods, and siltation is supported there; as a result, the active width of the channel is gradually reduced: The bankfull channel becomes deeper and somewhat narrower.

Overbank deposition and natural levee formation

In the study reach distinct natural levees have been formed. Based on airborne laserscanning data a sequence of n=111 cross sections perpendicular to the flood protection dyke was derived, an example is given in Figure 5a, and by that method a mean levee height of ~1.31 m can be determined. In Figure 5b the characteristic elevations (H_1: highest elevation near the river bank, that is, the crest of the natural levee; H_2: elevation of floodplain near the dyke / inside the inundation area; H_3: elevation near the dyke / outside the inundation area) are plotted along a longitudinal profile; the differences H_1-H_3 are strongly varying, which can be partly explained by the floodplain flow situation (inflow / outflow sections) (KLASZ et al. in prep.).

The magnitude of these natural levees can be understood as a further symptom of disequilibrium. In natural and laterally active rivers overbank deposition is usually balanced and restricted by side erosion and natural channel migration. However, if the banks are fixed (by riprap), which has been the case for more than a century along the Danube east of Vienna, the overbank deposits cannot be eroded, and distinct 'natural' levees are formed. These levees will develop and grow further and affect both flood protection and floodplain ecology (KLASZ et al., in prep.).

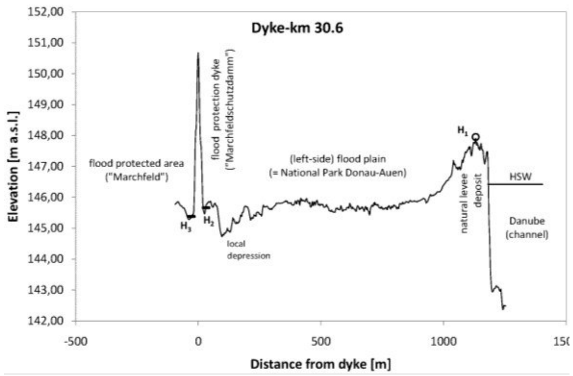

Figure 5a: Characteristic transect, definition of the characteristic elevations H1, H2, H3

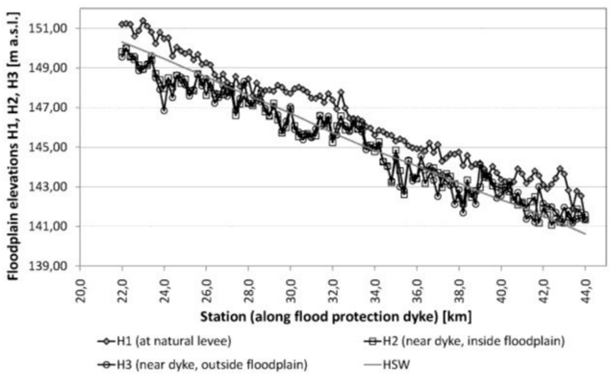

Figure 5b: Longitudinal profile of the left-side floodplain of the Danube; the characteristic elevations H_1, H_2 and H_3 for all transects are projected on the dyke-section; in addition, the characteristic water level 'HSW', which is nearly the bankfull stage, is plotted

Conclusions

The development and biodiversity of riverine ecosystems is controlled by hydrological and morphological dynamics and the connectivity between river and floodplain (WARD et al. 2002). A key factor in natural systems is also a dynamic stability. However, in the National-Park Donau-Auen the ability for self-regulation has been reduced by human impacts such as the stabilization and fixation of the banks (by riprap) with consequences such as bed degradation, natural levee formation, and siltation of side-arms. From a geomorphic point of view, the present system is far away from a dynamic equilibrium.

Taking this into account, the conception of restoration projects should include effective measures to reduce bed degradation and to improve the dynamic stability of the system; artificial bedload supply and the removal of bank stabilization (riprap) wherever possible must be key elements of such projects. Otherwise many parts of the National park will steadily lose its alluvial and riverine character.

Acknowledgments

The authors wish to thank the National Park Donau-Auen for funding parts of this research. We also thank the via donau – Österreichische Wasserstrassengesellschaft mbH. for providing necessary hydrographic and topographic data.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 385 - 388

Horrible dynamics in old conservative systems? Undercooled scree slopes in the Austrian Alps – Spider fauna, significance and threat in times of climate change (Arachnida: Araneae)

Christian Komposch, Martin Hepner & Norbert Milasowszky

Preliminary remark

Here we present an elaborated abstract of our investigations and talk. The long version of this publication will be printed under the same title in the Arachnologische Mitteilungen, volume no 45.

Keywords

Ice cellars, ice holes, ice age, climate warming, endemics, cold-stenothermic species, Styria, Eastern Alps

Introduction

Undercooled scree slopes, also referred to as „ice cellars“ or „cold holes“, are special types of habitats, which have been documented in many places of the Eastern Alps. Due to the formation of basal ice during the winter, the supercooled scree slopes emit cold streams of air during the warm season. Regarding the origin of ice cellars, the most probable explanation holds that they developed as the result of postglacial landslides. From an animal ecological perspective, these habitats house a cold-adapted, stenotopic, arthropod fauna consisting of alpine elements, glacial relicts, endemics and disjunctly-distributed species. However, the specialized micro-fauna of these cold locations is increasingly threatened by global warming, as well as by local factors.

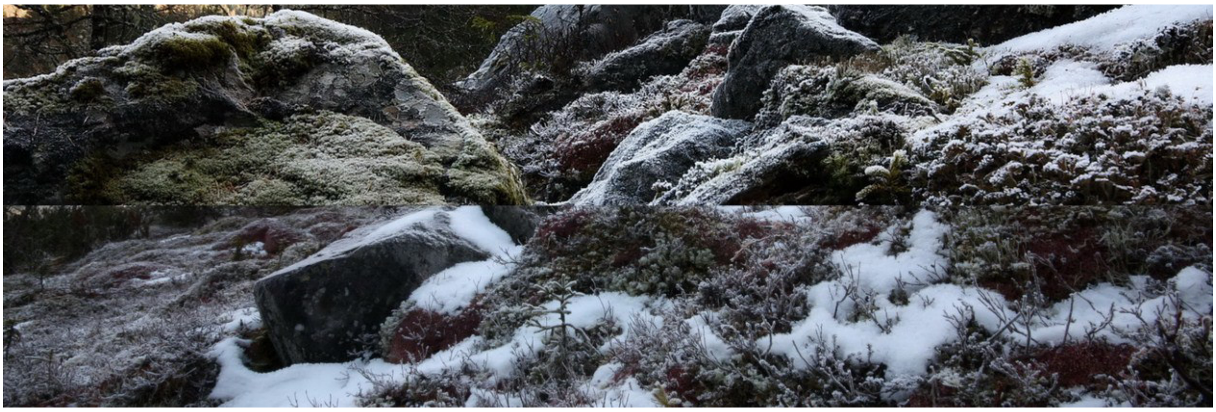

Figure 1: Supercooled scree slopes at the site Untertal near Schladming at the 20th Nov. 2009. Photos: Ch. Komposch/ ÖKOTEAM

Investigation area and methods

The invertebrate fauna, including spiders, of the interstitial was investigated with pitfall traps at 5 selected talus-sites in the Eastern Alps of Styria, Austria: Bräualm, Kreuzsteg near St. Nikolai im Sölktal, Klammhöhe, Pfarrerlacke near Tragöß and the largest study site, the Steilhangmoor Untertal near Schladming, a Natura-2000-site inside the Nature Park Sölktäler.

Results

In all five study sites a total of 116 spider species and 2.515 individuals respectively belonging to 18 spider families was found. First records to Styria are besides others *Robertus lyrifer, Diplocentria bidentata, D. rectangulata, Oreonetides vaginatus, Sisicus apertus, Walckenaeria dysderoides, Pardosa sordidata, Coelotes terrestris, Clubiona kulczynskii* and *Xysticus obscurus;* other remarkable species are *Troglohyphantes novicordis* and *T. tauriscus*.

i) Spiders of boulder fields and rocky screes slopes: Summit-areas in the alpine zone, boulder fields and cave habitats are the only suitable habitats for stenotopic cold-adapted spider communities in Central Europe. ii) Alpine elements, endemics, glacial relicts and cold stenothermic species: Survival in “Massifs de Refuge”, in caves and – in rare cases – on inneralpine nunataks which are peaks not covered with ice or snow within or at the edge of an ice shield or glacier. In the study sites the proportion of specimens of (sub)endemic spiders accounted for only 4.3 % of the total number of specimens. The most abundant endemic species were the troglophilic linyphiid spider *Troglohyphantes subalpinus* and the epigeic hahniid spider *Cryphoeca lichenum lichenum*. iii) Species diversity: The 116 species of spiders found in the present study represent about 18.4 % of the known spiders from Styria and 11.5 % from Austria. iv) Similarity of coenoses: A hierarchical cluster analysis of spider assemblages however, shows no distinct clusters, e. g. between neighbouring traps, which indicates that at this very small scale, microclimatic parameters might be more relevant for spider site affinities than geographical location criteria. v) Temperature-dependent species: Based on a subset of species in the "Steilhangmoor Untertal" two guilds can be distinguished: "cold air spiders" and "warm air spiders". The first group shows a preference for cold-air exits and includes *Diplocentria rectangulata*, *D. bidentata, Agroeca brunnea, Lepthyphantes antroniensis, Alopecosa taeniata* and *Ozyptila trux* while the second group which prefers warm-air exits consists of *Histopona torpida, Ceratinella brevis* and *Neon reticulatus*. A third group of species such as *Troglohyphantes subalpinus* and *Cybaeus tetricus* seems to prefer intermediate habitat conditions. The dominance of the cold-adapted taxa in the habitats studied is illustrated by the following results: from a total of 39 spider species nearly 50 % of the total inventory can be attributed as cold-stenotherm or at least psychrophilic. One way to represent the two different temperature guilds (thermophilic versus psychrophilic species) is to focus on the occurrence of the boreoalpine and cold stenothermic dwarf spider *Diplocentria rectangulata* and the euryzonal and thermophilic forest spider *Cybaeus tetricus*. *Diplocentria rectangulata* prefers cold-air exits and *Cybaeus tetricus* prefers "normal temperature" reference sites. vi) Proportions of species and specimens of Red-listed spiders: The number as well as the proportion of Red-listed species is higher in cold air sites than in the reference sites. Thus, the spider assemblages of cold air sites should be considered as highly valuable for nature conservation.

Figure 2: The "Steilhangmoor Untertal" near Schladming: warm-air site with an accelerated thaw of snow at the 27th Oct. 2010 (above left) and at the 20th Nov. 2009 (above right), cold-air site with a delayed thaw of snow at the 20th Nov. 2009 (below left) and the reference site at the same date. Photos: Th. Frieß, G. Kunz & Ch. Komposch/ ÖKOTEAM

Conclusion

i) Singularity and nature conservation value of the coenoses: Based on literature data at least 13 spider species seem to be restricted to supercooled boulder sites and scree slopes. The record of *Troglohyphantes novicordis*, an endemic species which was previously known only from one cave habitat in Austria, the "Raudnerhöhle" near Stiwoll is absolutely remarkable. Of the 116 species found in this study a proportion of 36 % must be considered as endangered. The occurrence of the two boreoalpine dwarf spider species of the genus *Diplocentria* in comparatively very low altitudes (*Diplocentria rectangulata*: 1000-1020 m, *D. bidentata*: 1000-1160 m) demonstrate the importance of supercooled block and scree slopes as special habitats for the survival of cold stenotopic glacial relicts at lower altitudes. In sum, the nature conservation value of the spider assemblages of the supercooled boulder sites and scree slopes goes beyond the national to the international dimension due the presence of several endemic and subendemic species, the occurrence of zoogeographically remarkable species and the presence of a high proportion of Red-listed species. ii) Dynamic processes meet conservative systems – endangering and protection measures: During the last Ice Age few spider species managed to adapt to low temperatures. These acquisition of these adaptations required a relatively long period of evolution. The current climate warming, however, is characterised by a relatively rapid increase in global warming. Evidently, psychrophilic species will not be able to develop physiological adaptations in such a short time. The stenoecious arachnid fauna of the supercooled boulder sites and scree slopes is literally entrapped in these isolated locations without the alternative of other suitable habitats. The effects of climate change on these habitats which are characterised by a stable microclimate regimes over thousands of years are, thus, well predictable: The loss of the ice nucleus of the undercooled scree slopes due to climate warming will lead probably to a warming of the microclimate, the termination of undercooled scree slopes, habitat loss of the cold-adapted invertebrates and a partial or total loss of the local populations.

Therefore, the need for action and management is necessary and urgent at two different levels: At the international level, it is urgent to stop climate warming by reducing Co_2-emissions significantly. The second plan of action to save these precious treasures of biodiversity is the strict avoidance of local endangerments. Potential threats at the investigated sites are timber harvest, construction of farming and forestry roads, other mechanical impacts on the moss cover and anthropogenic effects on hydrology.

Figure 3: Recorded spider species: Harpactea lepida. Troglohyphantes subalpinus. *T. tauriscus. T. noricus. Meta menardi. Alopecosa pinetorum.* A. *taeniata. Pardosa palustris. Xerlycosa nemoralis. Drassodes sp. Zora spinimana. Ozyptila atomaria* (from above left to blow right). Photos: Ch. Komposch/ ÖKOTEAM

Acknowledgements

We would like to thank our colleagues Thomas Frieß, Helwig Brunner, Werner Holzinger, Jördis Kahapka, Brigitte Komposch, Gernot Kunz and Wolfgang Paill from the ÖKOTEAM – Institute for Animal Ecology and Landscape Planning as well as our project partners Reinhold Lazar, Manuel Borovsky, both University of Graz, Harry Komposch, OIKOS and Bettina Maurer, Naturpark Sölktäler for the success of this interdisciplinary project. Kristina Bauch invited us to present these results at her traditional and unique research symposium in Mittersill; Johanna Gandler took care of the publication – thank you girls! Furthermore we are grateful to John Plant for checking the English. This work has been supported by the Austrian Climate Research Program ACPR (project no A963495).

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 389 - 398

Natural Hazards – Hazards for Nature? Avalanches as a promotor of biodiversity.

A case study on the invertebrate fauna in the Gesäuse National Park (Styria, Austria)

Christian Komposch, Thomas Frieß & Daniel Kreiner

Abstract

Avalanches are feared by humans and considered "catastrophic" due to their unpredictable and destructive force. But this anthropocentric perspective fails to capture the potential ecological value of these natural disturbances. The Gesäuse National Park is a model-region for investigations of such highly dynamic events because of its distinct relief and extreme weather conditions. This project aims to record and analyse the animal assemblages in these highly dynamic habitats as well as document succession and population structure.

1) Dynamic processes lead to one of the very few permanent and natural vegetationless habitat types in Central Europe outside the alpine zone – i. e. screes and other rocky habitats at various successional stages. In addition to the tight mosaic distribution of a variety of habitats over larger areas, avalanche tracks also offer valuable structures like dead wood and rocks. Remarkable is the sympatric occurrence of the three harvestmen species *Trogulus tricarinatus*, *T. nepaeformis* und *T. tingiformis*, a species diversity peak of spiders, true-bugs and ants; and the newly recorded occurrence of *Formica truncorum*.

2) The presence of highly adapted species and coenoses reflect the extreme environmental conditions, specific vegetation cover and microclimate of these habitats. Several of the recorded taxa are rare, endangered and endemic. The very rare dwarf spider *Trichoncus hackmani* is a new record for Styria and the stenotopic and critically endangered wolf-spider *Acantholycosa lignaria* is dependent on lying dead wood. The true bug *Phytocoris intricatus* is a new occurrence record for Austria. The ant species *Myrmica lonae* is an extremely rare recorded ant species in Styria for which avalanche tracks are considered to be its preferred habitat.

3) Avalanche tracks in southern exposition are azonal heat islands providing suitable environmental conditions for thermophilic and heliophilous species as well as those normally considered to have more southern distributions. The surprising inneralpine presence of several southern and submediterranean species reflects these unique microclimatic conditions, e. g. the vulnerable spider species *Atypus piceus* and the grasshopper *Myrmecophila acervorum*. Furthermore, high alpine species disperse via avalanche tracks to lower-altitude sites. Some arachnological examples are the mountain-jumping spider *Sitticus atricapillus*, Austrian subendemic gnaphosid spider *Zelotes zellensis* and the scree inhabiting wolf spider *Pardosa nigra*. Examples among true bugs more typical for subalpine grasslands include *Calocoris alpestris*, *Nithecus jacobaeae*, *Eurydema rotundicollis* and *Carpocoris melanocerus*.

Avalanche tracks play a major role in the survival of rare and endangered arthropod species and coenoses and are important refuges of endemic species. Vascular plant diversity averaged 70 species per 20 m² plot. Such biodiversity hotspots deserve protection. Avalance tracks are additionally considered essential corridors of vertical migration during periods of rapid climate change. While more research is needed to fully understand the ecological importance of these habitats, it is clear that acceptance and protection of these unregulated dynamic processes is required and directly promotes the protection of biodiversity.

Keywords

dynamic, erosion, Northern Alps, endemic, climate change, avalanche tracks, protection, natural processes, spiders (Araneae), harvestmen (Opiliones), true bugs (Heteroptera), plants (Tracheophyta)

Introduction

Avalanches are feared by humans and considered "catastrophic" due to their unpredictable and destructive force. But this anthropocentric perspective fails to capture the potential ecological value of these natural disturbances. Avalanche tracks and other erosion areas are – aside from natural river banks – the most important dynamic biotope types in Central Europe. In general, people have difficulty accepting uncontrolled environmental conditions and thus dynamic landscapes have largely vanished from settled areas.

Erosion areas, especially dynamic and low-altitude carbonatic scree slopes as well as dynamic processes are endangered (IUCN-category EN) in the Northern Alps and in Austria respectively (Essl & Egger 2010). The very last examples of such habitats within the Alps are found especially in alpine zones of National Parks.

What animal and plant species are settling in these extreme, diverse, rare and endangered biotopes? We hypothesize that these extreme environmental conditions result in habitats that shelter stenotopic, rare and endangered species. The Gesäuse National Park is a model-region for investigations of highly dynamic events because of its distinct relief and extreme weather conditions. The presented project aims to record and analyse the animal and plant assemblages in these highly dynamic habitats as well as document the zoological and vascular plant diversity and succession.

Figures 1-4: The Gesäuse National Park with its impressive geomorphology and erosion areas: Lugauerplan. Sulzkarhund with the Hochzinödl. Haindlkar with the Hochtor. Kainzenalblschütt with the Großer Ödstein. Photos: Ch. Komposch/ ÖKOTEAM

Investigation area, material and methods

The investigation area is the Gesäuse National Park in the Northern Calcareous Alps, Styria, Austria. The vertical-extension of the National Park and Natura-2000-area reaches from 480 up to 2369 m a. s. l. The area is characterised by the frequent occurrence of dynamic natural processes – on the one hand by the partially unregulated Enns River and its tributaries, especially the Johnsbach, and on the other hand by avalanche tracks and other erosional areas like rock screes and windfalls.

Figures 5-8: Investigated avalanche tracks in the Gesäuse National Park: Tamischbachturm. Kalktal. Lugauerplan. Kalktal. Photos: Ch. Komposch (3x) & K. Geßlbauer/ ÖKOTEAM

Faunistic investigations were carried out using hand collecting, sweep nets, a suction sampler, a soil sifter and pitfall traps on about 40 person-days in the field between the end of June and the beginning of November from 2006 to 2011. Pitfall-traps were only used from July to August 2011. We emphasize that these mappings and analyses are largely qualitative and opportunistic and thus are not necessarily representative nor provide quantitative insights. The data nonetheless provide an initial insight into the diversity and structure of the arthropod coenoses of these erosion tracks.

The herewith presented data are based on the following projects:

- "Lawinenrinnen als bedeutsame Lebensräume im Nationalpark Gesäuse" (ÖKOTEAM 2007): Kalktal: 47°36' N, 14°43' E, 500-740 m, Scheibenbauernkar: 47°36' N, 14°42' E, 760-940 m
- 9. GEO-Tag 2007: "Johnsbachtal" (Langgriesgraben: 47°33' N, 14°34' E, 670-710 m), KOMPOSCH et al. (2008), FRIEß (2008)
- 10. GEO-Tag 2008: "Tamischbachturm" (Kalktal: 47°36' N, 14°43' E, 500-740 m, Scheibenbauernkar: 47°36' N, 14°42' E, 760-940 m), KOMPOSCH (2009a), KOMPOSCH & PLATZ (2009), FRIEß et al. (2009)
- 12. GEO-Tag 2010: "Kalktal, Ennsufer und Hieflau" (Kalktal: 47°36' N, 14°43' E, 505, 560, 690 m (KOMPOSCH 2011, KOMPOSCH & HORAK 2011), FRIEß & BRANDNER (2012)
- "Zoologische Erstuntersuchung in Dauerbeobachtungsflächen im Nationalpark Gesäuse" (ÖKOTEAM 2012): 10 monitoring sites (amongst others avalanche track Hochkarschütt: 47°36' N, 14°42' E, 1070 m, screes Langgriesgraben: 47°33' N, 14°34' E, 750 m, rock- and scree-areas Haindlkar: 47°35' N, 14°36' E, 590 m, rock- and scree-areas Kühgraben: 47°35' N, 14°36' E, 845-860 m).
- 13. GEO-Tag 2011: "Zwischen Bruckstein und Buchstein" (Brucksattelrinne: 47°35' N, 14°35' E, 1.070 m (KOMPOSCH 2012a, b), KORN & FRIEß (2012)

Mapped habitat types are natural avalanche tracks (including debris avalanches) poor in or lacking vegetation in southern or eastern exposures. Some of these avalanche tracks reach from the high alpine zone down to the gravel banks of the Johnsbach (Langgrießgraben, debris avalanche) or Enns (Kalktal) rivers. The plant community mosaic ranges from tall herb vegetation through beech and pioneer pine stands up to open, rock-poor grassland and calcareous screes and rocks free of vegetation.

More or less intensively investigated zoological taxa are: harvestmen (Opiliones), spiders (Araneae), true bugs (Heteroptera), leaf- and planthoppers (Auchenorrhyncha), ants (Hymenoptera, Formicidae) and beetles (Coleoptera part.). The material has been collected by Thomas Frieß, Katharina Geßlbauer, Peter Horak, Jördis Kahapka, Brigitte Komposch, Christian Komposch, Gernot Kunz, Franziska Maier, Christian Mairhuber, Laura Pabst, Wolfgang Paill, Alexander Platz, Herbert C. Wagner and Philipp Zimmermann. Biotop mapping was done by Heli Kammerer and Barbara Emmerer (KAMMERER 2006, 2011a, 2011b); permanent plots for vegetation and relevés were done by Andreas Bohner (BOHNER et al. 2009). Some examples were taken from the results of the GEO-Tag 2010 (LAMPRECHT & WERSCHONIG 2011).

Figure 9: Usually the bellflower *Campanula pulla* is found in alpine habitats. Photo: J. Greimler

Results and discussion

Dynamic processes create rich structured habitat mosaics in avalanche tracks and other erosion areas, which again leads to an outstanding high diversity of species. A main reason for this diversity is the occurrence of stenotopic, rare and endangered taxa with both thermophilic and cold-stenothermic ecological demands. Furthermore avalanche tracks are azonal sites exhibiting side-by-side occurrence of alpine and lowland species. These phenomena occur across a variety of taxa as supported by the following examples involving spiders, harvestmen, true bugs and some vascular plants.

1) Biodiversity reaches peak values in avalanche tracks

Dynamic processes lead to one of the very few permanent open habitat types at low altitude areas in Central Europe – screes and other rocky habitats at various successional stages; these include rocky xerotherm grassland, tall herb vegetation, shrub areas and pioneer stands, and primary successional sites free of vegetation each year.

In addition to this tight mosaic of highly variable habitats over large areas, avalanche tracks also offer valuable structures like dead wood and rocks.

- Flora: Biotop mapping of avalanche tracks show a high percentage of threatened biotope types. 40 to 50 % of the investigated area is covered by threatened biotope types like calacareous scree or grassland. The average number of vascular plant species in one plot of 20 m^2 is 70. This can be considered as very high species richness.
- Opiliones: Remarkable is the sympatric occurrence of three of the four Styrian trogulids, namely *Trogulus tricarinatus*, *T. nepaeformis* und *T. tingiformis* (KOMPOSCH 2011). These species feed on land snails and are therefore dependent on limestone soils.
- Araneae: Epigeal and thermophilic spiders have been recorded in the avalanche tracks with dozens of species by means of hand-collecting, sweeping and a suction sampler, whereas stenotopic hygrophilous and cold-adapted inhabitants of the "underworld" are still missing in our inventories due to the fact that pitfall traps were generally not used.
- Heteroptera: True bug diversity in Central European landscapes reaches maximum values in open and semi-open dry grasslands and fringe habitats; the avalanche track Kalktal has been identified as a hot-spot-of bug-diversity. Furthermore an analysis of the true-bug-fauna shows a variety of different ecological guilds in these unique habitats. The richness in dead wood enables the survival of at least four aradid-species.
- Formicidae: WAGNER (2009, 2011) shows that ant diversity in avalanche tracks and other screes is higher than in neighbouring bush- and forest communities. Worth mentioning is the record of *Formica truncorum* in the Kalktal-track (WAGNER 2011) and Langgriesgraben from a forest-edge community and fine debris and rocky pine and elfin woodland (WAGNER unpubl., ÖKOTEAM 2012).

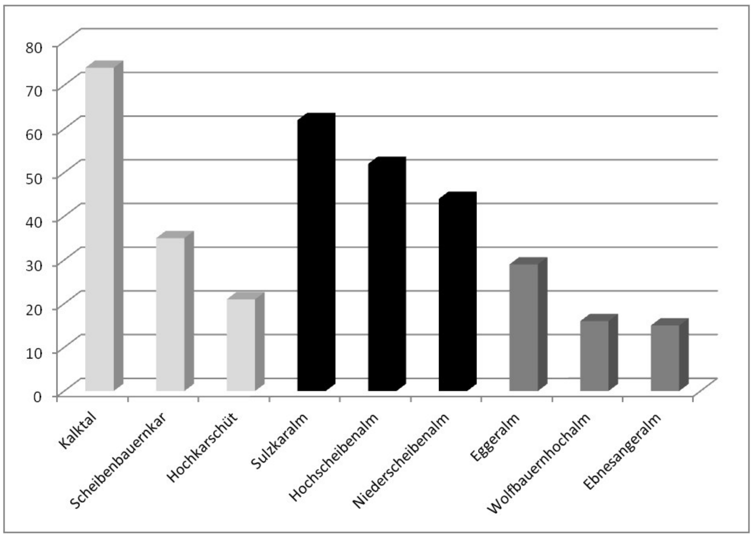

Figure 10: True bug species numbers in avalanche tracks (light grey), pastures (black) and abandoned pastures (dark grey) in the Gesäuse National Park. The graph shows a comparison between the avalanche track Kalktal as an azonal habitat-complex and the grasslands of alpine pastures. Highest diversity in a grassland is found in the Sulzkaralm (62 spp.), followed by the Hochscheibenalm (52 spp.) and the Niederscheibenalm (44 spp.). These species numbers will not be reached by the investigated abandoned pastures like the Eggeralm (29 spp.), Wolfbauernhochalm (16 spp.) and Ebersangeralm (15 spp.) (FRIEß 2006, unpubl.). Despite the cursory sampling, the avalanche track Kalktal takes first rank with 74 species of Heteroptera; it is expected to shelter about 100 true bug species.

2) Presence of faunistic and floristic peculiarities

The extreme environmental conditions, vegetation cover and microclimate result in the presence of highly adapted species and coenoses. Several of these stenotopic taxa are rare endangered and endemic. Moreover, some of these species have not been recorded for Styria before.

- Flora: In the avalanche tracks we find some endemics that are also found in more alpine habitats like *Campanula pulla*, but there are no highly specialized ones.
- Opiliones: *Lacinius dentiger*, a south-eastern-European-mediterranean species (MARTENS 1978), shows a wider distribution in southern Carinthia, southern Styria and the Pannonian parts of Eastern Austria. However, in the inner part of the Alps it is only found occasionally along the bigger valleys (KOMPOSCH & GRUBER 2004). An example is the Gesäuse National Park, where this phalangiid can be found in avalanche tracks e. g. on the southern slope of the Tamischbachturm (KOMPOSCH 2011).
- Araneae: The dwarf spider *Trichoncus hackmani*, classified by WIEHLE (1960) as heliophilous-xerobiotic, has been known from Austria exclusively from the Apetlon´s common pastures (MALICKY 1972). In the Gesäuse National Park this very rare species was found in fine scree areas of the Langgriesgraben (KOMPOSCH et al. 2008) and in the avalanche track Brucksattelrinne of the Buchstein mountain (KOMPOSCH 2012a). One of the rarest wolf spiders of Austria, previously known only from an uncertain record in Styria, is *Acantholycosa lignaria*. Classified as Critically Endangered for Austria this stenotopic spider species is dependent on the presence of lying dead trunks. The blocky and dynamic parts of the avalanche track Kalktal have to be considered a refugium of deadwood-inhabiting species (KOMPOSCH & HORAK 2011) – comparable to the occurrence of the cerambycid beetle *Rosalia alpina*.

- Heteroptera: The true bug fauna of the Styrian Enns valley is well known based on intensive investigations of the last century. Nonetheless, species records of faunistic interest occur regularly. In the site Langgriesgraben *Phytocoris intricatus* could be documented for the first time for Austria; in the avalanche track Kalktal we were successful with the two new species for Styria, *Phytocoris austriacus* and *Stygnocoris cimbricus* (Frieß & Brandner 2013). Examples for red-data-list species (after Frieß & Rabitsch 2009) are the endangered tingid *Oncochila simplex* and the vulnerable taxa *Megalonotus hirsutus* and *Dicranocephalus medius*.
- Formicidae: *Myrmica lonae* is an extreme rare recorded ant species in Styria; avalanche tracks are considered to be preferred habitat types (Wagner 2011).

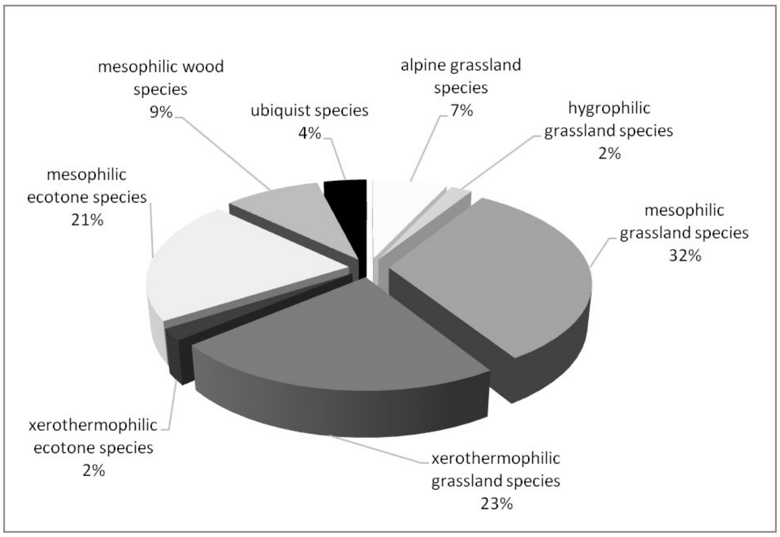

Figure 11: Classification of Heteroptera to different ecological types within the avalanche track Kalktal.
In total the species of mesophilic open grassland are dominant (32 %); they are concentrated in the ruderal vegetation and the shrubby slope extensions with mainly eurytopic species. Further 30 % of the species belong to the mesophilic edge- and forest species – witnesses of the diversity in structures and the tendency of forest-growth on the brim of the erosion tracks. One fourth of the species is xerothermophilic – a quite high value for an inneralpine montane locality. Remarkable is the well represented guild of xerophilic, epigeal bug species. Four (7 %) montane-alpine species of open land complete this rich bug coenosis.

Figures 12-15: Harvestmen (Opiliones) of avalanche tracks in the Gesäuse: *Trogulus tricarinatus*. *Trogulus nepaeformis*. *Trogulus tingiformis*. *Lacinius dentiger*. Photos: Ch. Komposch/ ÖKOTEAM

3) Avalanche tracks as azonal sites

a) Avalanche tracks and other erosion areas offer suitable environmental conditions for thermophilic, heliophilous and southern species

Avalanche tracks in south-exposition are due to the dynamic and consequently consistent lack of trees as well as the dominance of rocks and scree slopes, which lead to the occurrence of thermophilic and heliophilous species. Rocky habitats have a higher heat capacity than the soil and therefore, early on, were known to lead to higher temperature sums and provide suitable conditions for arthropods (FOREL 1892). The surprising inneralpine presence of several southern and submediterranean species reflects these special microclimatic conditions.

- Flora: At the species level, occurrences that are rare or even missing in other areas of the National Park because they require the thermal conditions found on the lower parts of the avalanche tracks with south-eastern exposition. Examples include *Primula veris veris, Seseli libanoti*, *Agrimonia eupatoria*, *Geranium pyrenaicum* and *Echium vulgare*.
- Opiliones: The phalangiid *Phalangium opilio* is one of the few European harvestmen that prefers open and light exposed habitats (MARTENS 1978). Avalanche and other erosion tracks like the Kalktal tracks or on southern slopes of the Buchstein consistently offer these conditions (KOMPOSCH 2011, 2012b).
- Araneae: Both thermophilic araneid spiders *Mangora acalypha* and *Hypsosinga sanguinea* find suitable conditions in the avalanche track Kalktal. *Philaeus chrysops* is thermophilic, heliophilous and bound to rocky habitats with a just disjunctive occurrence in Central Europe; this striking salticid finds suitable conditions in some avalanche tracks of the Gesäuse National Park, e. g. in the Kalktal site (KOMPOSCH & HORAK 2011). Most surprising is the current record of *Atypus piceus* in a small meadow quite close to the avalanche track Kalktal (KOMPOSCH & HORAK 2011). With one single exception from the Haller Mauern, all previous records of this nationwide vulnerable species are situated in the South-Eastern Alpine foothills. In addition to this sun-adapted coenoses, contrasting environmental conditions are found just under the surface of avalanche tracks – but they are still quite unexplored in the Gesäuse National Park – the chasmocolous linyphiid *Porrhomma convexum* for example has been recorded from the Kalktal (KOMPOSCH & HORAK 2011) –, as well as in all the other National Parks.
- Heteroptera: Several thermophilic bug species have been collected in the avalanche track Kalktal, which occur in these inneralpine areas exclusively on isolated xerothermic sites. They are character species of calcareous dry and rocky grasslands with a narrow trophic relationship to plant species of xerothermic habitats. Selected examples are (feeding plant in brackets): *Copium clavicorne* (*Teucrium chamaedrys*), *Oncochila simplex* (*Euphorbia cyparissias*), *Megalonotus hirsutus* (*Teucrium*, *Thymus*), *Dicranocephalus medius* (*Euphorbia* spp.) and *Thyreocoris scarabaeoides* (*Viola* spp.).
- Saltatoria: The thermophilic species *Myrmecophila acervorum* was found in a nest of *Tetramorium impurum* in the Kalktal site at an altitude between 520 and 620 m a. s. l. (WAGNER et al. 2012); this is the countrywide most inneralpine record of the smallest grasshopper of Austria.

Figures 16-19: Spiders (Araneae) of avalanche tracks in the Gesäuse: *Philaeus chrysops. Harpactea lepida. Acantholycosa lignaria* (2x). Photos: Ch. Komposch/ ÖKOTEAM

b) Species of the (high) alpine altitudinal zone go downhill via avalanche tracks to lower-altitude localities

Both plants and animals are known for using avalanche tracks as sliding transport corridors. Rockfalls seems to be a quite common, quick and frequent way of downhill transport for nests of eggs, juvenils and adults. This dangerous dispersal mechanism inside avalanche tracks offers the advantage that the arrival area contains a wide spectrum of different habitat types and microclimatic niches. Therefore the chance of finding suitable conditions is quite good to establish long-lasting populations. Furthermore, the valley-populations of these alpine species can count on a regular supply of new colonists from higher elevation habitats.

Figures 20-23: True bugs (Heteroptera): *Aradus versicolor* is fungicolous on beech-deadwood. *Copium clavicorne* is xerothermophilic and lives on *Teucrium chamaedrys*. *Dicranocephalus medius* ist xerothermophilic and lives on *Euphorbia*. *Oncochila simplex* can be found on *Euphorbia cyparissias* in warm and dry habitats. Photos: Ch. Komposch/ ÖKOTEAM, G. Kunz (2x), E. Wachmann

- Flora: There are several species in the avalanche tracks with their source populations at higher altitudes, like the previously mentioned endemic species *Campanula pulla*, but also *Arabis alpina* and *Linaria alpina*. They appear together with species from lower and thermophilic stands like *Teucrium chamaedrys* or *Allium lusitanicum*.
- Opiliones: From the Southern Alps the above described phenomenon is documented for *Mitostoma alpinum* on the northern slopes of the Koschuta, Karawanken (Martens 1978) and the nature reserve and Natura-2000-site Vellacher Kotschna in the Steiner Alps (Komposch unpubl.). It can be expected that this rare nemastomatid species in the steep northern avalanche tracks in the Gesäuse mountains shows similar patterns of distribution at a small scale. Specific research is required!
- Araneae: We know several examples for low altitude populations of high alpine spider species; some prominent ones are listed below. The mountain-jumping spider *Sitticus atricapillus* is known from 1600 m a. s. l. and is considered to be a high alpine species (Kronestedt & Logunov 2003). The current finding, together with the Austrian subendemic *Zelotes zellensis* (Komposch 2009b), in the lowest section of the Langgriesgraben at not more than 700 m a. s. l., are textbook examples of this phenomenon (Komposch et al. 2008). The detection of several individuals of each is good evidence for the presence of established populations. The same with *Pardosa nigra*, normally occurring in the alpine and nival zone up to 3500 m (Austria), has been collected in the avalanche and erosion tracks Brucksattelrinne and Kühgraben on the Buchstein-slopes at 1070 and 1000 m a. s. l. (Komposch 2012a). The subalpine and alpine scree-theridiid *Rugathodes bellicosus* is currently documented from just 520 m a. s. l. in the Kalktal (Komposch & Horak 2011).
- Heteroptera: Some typical species of open grasslands of the subalpine altitudinal zone could be found in submontane sites, e. g. *Calocoris alpestris*, *Nithecus jacobaeae*, *Eurydema rotundicollis* and *Carpocoris melanocerus*.

Figure 24: The thermophilic true bug *Phytocoris austriacus*, living on *Melampyrum pratense*, has been recorded in the Kalktal; it is new to Styria. Photo: E. Wachmann

Conclusions

Due to their consistent dynamic nature, avalanche tracks and similar erosion areas are among the very few sites in Central European landscapes that offer permanent treeless or even vegetationless habitats. These important extreme environments offer a wide spectrum of mosaic-like habitat-structures and microclimatic conditions, especially rocky areas and deadwood. They are considered to be primary refuges for several thermophilic and heliophilous species, from which they can disperse into the surrounding cultural landscape. Therefore they play a major role in the survival of rare and endangered arthropod species and coenoses and are important refuges of endemic species. As a hot-spot of biodiversity they are deserving of protection.

Figure 25: A surprising inneralpine presence of *Atypus piceus* in the Gesäuse National Park. Photo: Ch. Komposch/ ÖKOTEAM

In times of climate change they are considered to be essential paths for vertical migration, due to their extension through several altitudinal zones with similar habitat types and environmental conditions.

Continuing scientific investigations are necessary. Representative and semi-quantitative data are urgently required to gain an overview of the whole species spectrum, coenoses and guilds. The application of pitfall-traps is essential to record the ombrophilous, hygrophilous, cold-adapted and crevice- and cave-species (KOMPOSCH 2010).

Figures 26-27: Side-by-side occurrence of the heliophilic harvestman (Opiliones) *Phalangium opilio* and the hygrophilous *Gyas titanus* – avalanche tracks offer suitable conditions for both. Photos: Ch. Komposch/ ÖKOTEAM

Nature reserves and national parks are among the very few areas where even the possibility exists for such unhindered dynamic processes. But even in these so called “strongly” protected natural landscapes, general acceptance of natural dynamic processes resulting from variable river flows, wind or avalanches is not to be taken for granted. In fact, due to security issues concerning hydroelectric and wind power production facilities, forest resources and potential bark beetle “damages”, such habitats raise consistent and controversial discussion. A clear commitment to the acceptance of unregulated dynamic processes in these rare protected areas, amidst our otherwise highly restricted cultural landscape is required! Finally the long-term protection of biodiversity can be reached through a deeper understanding and protection of dynamic processes.

Figures 28-29: The impact of dynamic processes: an avalanche track and a forest on the southern slopes of the Tamischbachturm. Photos: B. & Ch. Komposch/ ÖKOTEAM

Acknowledgements

We would like to thank the Nationalpark Gesäuse GmbH, especially Alexander Maringer, Petra Sterl, Lisbeth Zechner and Werner Franek for friendly support over many years, our zoological collectors Katharina Geßlbauer, Peter Horak, Jördis Kahapka, Brigitte Komposch, Gernot Kunz, Christian Mairhuber, Laura Pabst, Wolfgang Paill, Alexander Platz, Herbert C. Wagner and Philipp Zimmermann, furthermore Gernot Kunz and Ekkehard Wachmann for photo material, Steven Weiss for language assistance and last but not least Kristina Bauch, Nationalpark Hohe Tauern, for her great organisation of this unique and wonderful symposium.

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Conference Volume | 5th Symposium for Research in Protected Areas, 10 to 12 June 2013, Mittersill | pages 399 - 402

Educational opportunities of Austrian National Parks as a sustainability-oriented adult education – comparative analysis of the "Nationalpark Gesäuse" and "Nationalpark Kalkalpen"

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Nationalparks Austria Science Award 2013

Abstract

This present thesis examines – in terms of a comparative analysis – the educational offers of two Austrian national parks regarding their contribution towards a sustainability-oriented adult education.

Besides the core tasks of national parks, such as conservation and exploration of nature, national parks also fulfill an extraordinary educational function. Parts of this educational initiative are directed towards adults.

The idea originated due to personal interest but also because of the fact that we're presently situated within the UN-decade of education for sustainable development (2005 to 2014). Therefore this thesis wants to examine the results of the interaction between adult education and sustainability-oriented learning. Representing the educational efforts of the Austrian national parks, the relevant educational opportunities of the Nationalpark Gesäuse and those of the Nationalpark Oberösterreichische Kalkalpen were investigated applying different methods (participating observation, analysis of programs and written questioning of the service providers).

For this investigation particularly developed categories (values / attitudes, aspects of implementation, ethic principles, pedagogic principles, way of learning, results of learning and inner systematic) and indicators of analysis were applied. The results of the analysis show that within the educational opportunities for adults in question many elements have already been fulfilled, respectively are to some extent available, so that you can already talk about a sustainability orientation of both educational programs. The instruments developed in this thesis should enable both objects to orientate themselves even more clearly towards a sustainability-oriented adult learner in the future. This perspective of sustainability orientation and adult education as well as the developed and applied model of analysis could also be put into use by comparable educational institutions.

Keywords

Nationalpark Gesäuse, Nationalpark Oberösterreichische Kalkalpen, sustainability, education for sustainable development, sustainable learning, sustainable education, adult education, lifelong-learning, sustainability-oriented adult education

Introduction, Research Question

The aim of the author was to surpass the sheer benefit of classification by answering the research question.

With the help of the core question of concrete research "Where do we find educational opportunities for adults within the programs of the Nationalpark Gesäuse and Kalkalpen that are oriented towards sustainability and how could this complex concern be strengthened?" an instrument of planning, designing and evaluation should be created which could also be utilized by initiators of comparable institutions.

Possibly the especially for this investigation developed concept of "sustainability-oriented adult education" establishes a further development and enforcement of the concerns of the present UN decade of education for sustainable development.

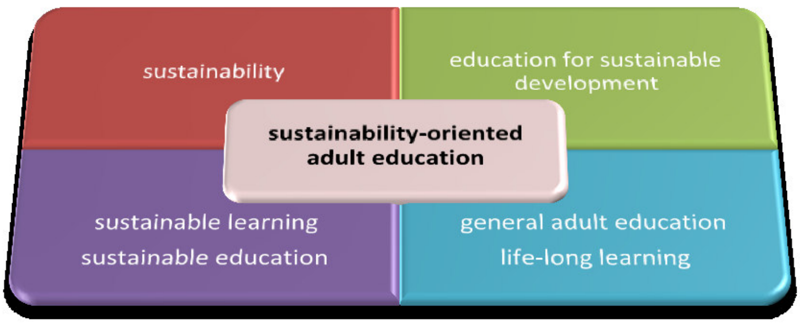


Figure 1: sustainability-oriented adult edcation and its concepts (Ref.: own representation)

Methods

In order to answer the research question several methods of research were chosen in terms of a "triangulation" (cf. FLICK 2009).

The basis is constituted by an extensive description of the main concepts of this thesis and their connections. Furthermore the concept of sustainability-oriented adult education was created.

Already before and during the comparative description of both objects to be investigated and the analysis of the relevant educational opportunities for adults of both national parks (legal year of 2010) regarding the sustainability orientation, three participating observations of selected educational opportunities were executed within both national parks.

With the help of standardized questionnaires the self-image of altogether 83 service providers and at the same time their self-evaluation were explored concerning the aspect of sustainability within their offers.

In order to contextualize the results of the program analysis and the questioning even more, selected educational opportunities were observed from a participant's point of view during the entire research process. *"Sustainable learning, exclusive of observing the setting of foreign monitoring, involves the danger of searching for requirements and causalities, assuming that from the learner's acting independent ideal conditions for "right" and "successful" learning existed."* (SCHÜẞLER 2007)

Figure 2: research situation, participating observation (Ref.: private picture (C. Habersack 2013))

The applied research methods and their interaction are shown by the ensuing graphic.

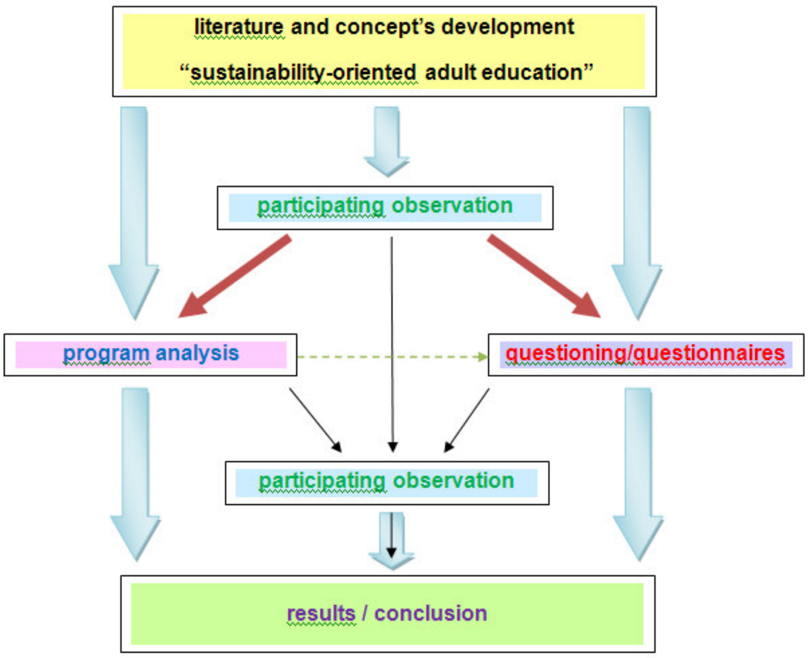


Figure 3: research approach (Ref.: own representation)

Conclusion

The results of this multi-staged investigation show to a great extent a concurring image of both national parks regarding their sustainability orientation as far as adult education is concerned. Since it has never been the aim of this thesis to establish a winner, the results hereinafter will not be displayed according to the national park (a concrete and differentiated analysis can be found in the full version of this thesis):

- The investigated educational opportunities don't represent fixed programs, but are designed as a supporting program bearing in mind the participants' requests concerning content and organization. At the same time participants are invited to take the initiative themselves.
- The educational opportunities show in their concepts a clear orientation towards their target group of adults and are therefore "real" adult educational opportunities.
- Within the educational opportunities action-oriented way of learning and lively and activating methods of learning are applied in different places. Participants therefore can get active themselves to a large extent.
- The service providers don't emphasize the value of entertainment, but emphasize the values of education and adventure. It is to assume that the offers in question provide more than just "having a good time" and that the participants can help shaping their learning processes.
- Several educational opportunities fulfill both ethic principles of "respect for future generations" and "respect for the natural resources of our planet".
- The service providers themselves estimate the value of education and sustainability of their programs as quite high.
- In more the 50% of the educational opportunities multiple perspectives can be communicated and passed on.
- In almost all educational opportunities the service providers expect different background knowledge and enable discussions and tests of the learning revenue.
- At least 10% of all educational opportunities contain future-oriented educational issues.
- In about 90% of the educational opportunities the service providers try hard to establish a positive learning atmosphere and regard themselves as member of the group.
- At the same time almost all educational opportunities create a sense of belonging.
- Virtually all educational opportunities aim at a permanent effect for the participants. As far as this effect is concerned, about half of the service providers are skeptical.
- Almost all educational opportunities provide "a constant benefit in terms of an enhancement of the participants' knowledge of orientation and appliance, values and attitudes".
- All service providers think about "personal ideas whether the educational opportunities have an effect and benefit on the participants". Unconsciously (?) a sustainability-oriented principle of inner systematic of sustainability has already been applied: the orientation towards constant benefit and permanent effect of the educational action itself.
- As expected ecological aspects are treated within all educational opportunities.
- Social, economic and those integrated aspects are not really seen by the service providers themselves in their self-evaluation.
- Almost all educational opportunities "support the creation or development of a ecologic consciousness".
- The issues of "protection of nature and environment" as well as "sustainability" are seen as requests by service providers. A bit more discriminately seen is the concept of "protection of the creation", although it isn't clearly textually present within any of the programs.
- The service providers agree to a great extent with the idea that their educational opportunities contribute to a life-long learning of the participants.
- The service providers also have a high opinion of their own professional skills, nevertheless they also agree that their offers "live on the questions and different approaches of the participants".
- A significant part of the service providers has already "participated in general adult educational opportunities within the last two years" and has already "participated in educational opportunities of the national parks themselves".
- To a high extent the service providers share the opinion that they "contribute with their educational opportunities to a fairer, and more environmentally compatible world development that also includes a more considerate management of natural resources".
- According to program analysis and participating observation the investigated educational opportunities are of a high local relevance.
- Almost all educational opportunities point out – apart from primarily ecological issues – the aspects and requests of the national park.

Results

As a result of the research one can claim that both Nationalpark Gesäuse and Nationalpark Oberösterreichische Kalkalpen apply several categories and indicators of sustainability-oriented adult education.

Within some areas both investigated national parks are "on the right track": the concept of educational opportunities as real educational opportunities for adults, local relevance, the combination of theoretical and practical perspectives and contents, action-oriented ways of learning, the value of sustainability and education within the events (self-evaluation of service providers), the contribution towards a fair and environmentally compatible world development that also includes a considerate management of natural resources.

Concerning other areas, both investigated national parks are “on their way”: a constant benefit and a permanent effect of the educational opportunities, a psychological profit of the educational opportunities.

A potential in development can be seen within the areas of gender equality in the proposal management, registration of learning revenue of the participants, economic and social aspects as well as linking them with ecological aspects in the educational opportunities.

All in all one can – after the three-part investigation of both national parks – discern an image that shows and proves that many elements of the educational opportunities have already been compiled and designed in a sustainability-oriented way of thinking. Here one can see the products of a professional approach towards the issue of education, especially adult education, an inspiration for nature and environmental aspects and a system-immanent orientation towards issues of sustainability by both national parks.

Furthermore the concrete way of research enables profit regarding an actual and far-reaching way of “sustainability training” and at the same time of up-to-date adult education.

In conclusion, it needs to be recorded that by using the concept of “sustainability orientation” the complex issue of sustainability, especially within the context of educational subjects and processes, becomes more comprehensible and the people responsible for education in national parks and similar institutions can be encouraged to realize the principle of sustainability along with its three referring areas (ecology, economy and social affairs) more clearly.

Further Perspectives

The results of this thesis enable both investigated objects and also similar educational institutions to consider their adult educational opportunities from the perspective of sustainability orientation (we’re presently located within the UN decade (2005 to 2014) of education for sustainable development!) and if demanded, design new educational opportunities on the basis of the within this thesis developed indicators of a sustainability-oriented adult education.

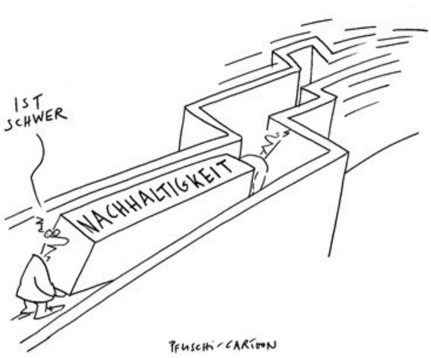
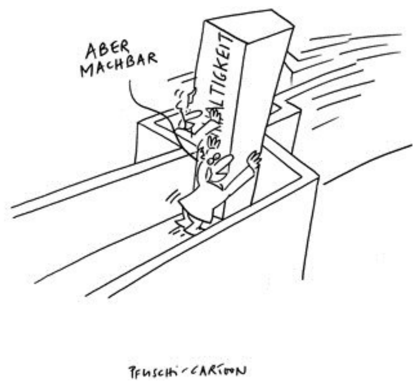


Figure 4: Cartoon Sustainability is heavy
(Ref: Universität Bern, Interfakultäre Koordinationsstelle für Allgemeine Ökologie, o.J.)



Illustr. 5: Cartoon Sustainability is feasible
(Ref.: Universität Bern, Interfakultäre Koordina-tionsstelle für Allgemeine Ökologie, o.J.)

A closer look shows that two classic issues of sustainability-oriented learning remain unsettled: the permanent effect and the constant benefit of the investigated educational opportunities for its participants.

Furthermore an investigation of the participants’ way of learning within the concrete educational opportunities of adults of both national parks would be appropriate and could enable – together with the results of this thesis – a more complex and differentiated description of this special education process.

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 403 - 406

Long term monitoring of grazing in salt habitats on the eastern shore of Lake Neusiedl

Ingo Korner

Keywords

Lake Neusiedel, National park, grazing management, long-term monitoring, reed management, halophile vegetation, restoring salty sites, reducing competitive species,

Abstract

The landscape of the Lake Neusiedel and the Seewinkel was shaped by centuries of grazing. After the virtual collapse of the grazing in the 1960s there was a gradual increase in fallow land in the Seewinkel and on the shores of Lake Neusiedl. As a result of decreased grazing the reed (*Phragmites australis)* spread massively and displaced in vast areas a large number of endangered plant and animal species that have benefited from the earlier grazing-regime.

The resumption of the grazing with cattle and horses is aimed at restoring a preferably shrub- and reed-free landscape. Within the National Park Neusiedler See - Seewinkel the grazing of the lakeshore of Lake Neusiedl in the so called "cultural landscape zone" is mainly carried out by herds of horses and cattle.

The main problem at the beginning of the management, was the then widely held view - even among nature conservationists - that in large protected areas, like National parks, man should protect natural processes, but not help to maintain man-made conditions also. The impetus for a more intense and coordinated management came from ornithologists who noticed a sharp decline in stocks of water birds and meadow breeding birds. It was quickly identified that the lack of grazing of the lake shores was the main cause for it. In 1990 a monitoring program has then been established, which should monitor the effects of grazing and regulate the grazing intensity in different focus areas.

In this presentation the results of long-term monitoring from 1990 to 2011 are presented for one exemplary site at the paddock of Podersdorf. The paddock is situated at the southern edge of Podersdorf and extends over a length of approximately 2.5 kilometers to the lookout tower in the "Illmitzer Hölle". The width of the grazed shoreline of Lake Neusiedl is between 110 and 220m and varies with the water level of the lake by another 20 to 30 meters.

The pastures are dominated by stands of purple moor grass (*Molinia caerulea*) and head rush (*Schoenus nigricans*), which is in phytosociological terms called *Junco obtusiflori-Schoenetum nigricantis*. These stands gradually intersperse with the reeds of the shoreline, integrating a narrow strip of *Cladium mariscus*. Landwards salty meadows (*Scorzonero parviflorae-Juncetum gerardii, Atropidetum peisonis*) are following, which had been extended significantly by grazing. Beginning with 1999, a scientific monitoring program has been established there which documents the effects of grazing on vegetation, in other parts of the National Park Neusiedler See – Seewinkel monitoring started in 1990. Trends are detected and interpreted on fixed plots of 2x2 meters.

By grazing, the reed (*Phragmites australis*) was pushed back from the shoreline and the landward salty meadows to the permanently water covered sections of the lake by about 200m in about only 10 years.

Looking at the trends in one individual study area, it is evident that the vegetation cover of highly competitive species such as reed or creeping bentgrass (*Agrostis stolonifera*) declined sharply, while typical salt plants recovered and benefited.

Table 1: trends of the vegetation cover of plants in the permanent plots

	1999	2001	2004	2005	2007	2011
Phragmites australis	62,0	12,0	7,3	8,0	4,5	
Agrostis stolonifera	44,0	30,0	11,3	6,5	2,5	
Cladium mariscus	6,0	4,0	1,3	0,8		
Bolboschoenus maritimus	2,9	1,0	1,0	0,3	0,4	
Tripolium pannonicum	1,5	0,2	23,3	38,0	12,0	0,2
Juncus gerardii			0,9	1,0	0,3	1,5
Carex distans			1,9	1,4	2,2	0,4
Spergularia maritima					4,5	0,9
Crypsis aculeata						0,4
Chenopodium chenopodioides						0,3
Salicornia prostrata						0,2

The reed was above 60% coverage in the first year of observation and declined to 4.5% in 2007. By the rise of water level in 2009 and 2010 the site was completely flooded yearover and the reeds has died out entirely at this site.

Figure 1: open shoreline south of Podersdorf with salt habitats

Considering the occurrence of Pannonian Salt-Aster (*Tripolium pannonicum* = *Aster tripolium*), the species is very rare prior to 2001 and shows only a 0.2 to 1.5 % cover. In the years with intensive grazing the coverage values increased up to 38%. But *Tripolium pannonicum* is not only dependent on the presence of open land induced by granzing, but also on the water level of Lake Neusiedl. Between 2006 and 2009, the riparian zone under monitoring was almost all year round water flooded. So *Tripolium pannonicum* can spread only in periods of low water level, but the rate of increase is clearly accelerated by the reduction of reed.

Remarkably, however, is the re-establishment of strict halophytes in the riparian zone. By grazing, not only open ground was created by phsyical displacement of the reed, but also the accumulation of soda in the soil is favoured. A study of soil chemistry (KRACHLER et al. 2012, in preparation) shows that there is a negative correlation for an intact salt budget with the density of vegetation cover. Vegetation prevents the capillary rise and crystallization of soda on the soil surface. The increase in soda causes that typical halophytes can establish in locations where they would otherwise not occur for competitive reasons.

Species indicative for high salt concentrations - such as the greater sea spurrey (*Spergularia maritima*) have established themselves after several years beginning in 2007. In subsequent years further pioneer species of habitats with high salt concentrations followed, so that the developement of a *Crypsido aculeatae - Suaedetum maritimae* could be initiated. Characteristic species of this association such as glasswort (*Salicornia prostrata*), the grass *Crypsis aculeata* and thick leaf goosefoot (*Chenopodium chenopodioides*) have just been recorded in the growing season 2011. Due to the decline of reed and bent grass (*Agrostis stolobifera*), there was a greater extent of open soil, which was enriched in salts in consequence to higher evaporation. The best evidence for the successful restoration of a typical salty site was the occurrence of large-seepweed (*Suaeda pannonica*), which was also first recorded in 2011.

Figure 2: salt habitats with glasswort (*Salicornia prostrata*)

The grazing of the reeded lake shore for about 13 years resulted in the the opening of the vegetation cover. Beside highly endangered salt plants species, numerous bird species that prefer low growing and sparse vegetation also benefited from the grazing. Species such as Kentish Plover, little ringed plover, common redshank, avocet and greylag geese (the latter with large populations) are found again in the restored habitats of the lakeshores.

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Research in protected areas funded by the Austrian Academy of Sciences

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Keywords

Man and the Biosphere, UNESCO, biosphere reserves, Earth System Sciences

Abstract

The Austrian *Man and the Biosphere (MAB)* programme, now part of the newly formed *Earth System Sciences* programme, is financed by the Austrian Ministry for Science and Research and administered by a national committee established at the Austrian Academy of Sciences (ÖAW). The Austrian MAB committee consists of renowned scientists and representatives of several Ministries and federal organizations. The national committee advises and supports those responsible for the biosphere reserves on scientific and technical issues, and coordinates and finances research activities. The work is designed to support the biosphere reserve managers in the implementation of their tasks, but also to use the areas as objects for both basic and applied research. Furthermore, the national committee is the link to the MAB office at UNESCO Headquarters in Paris. The national committee has focused its scientific activities on the needs of Austrian biosphere reserves but also encourages cooperative projects with biosphere reserves in other countries.

Since 2008 the national committee has financed numerous research projects with a total budget of over 1.3 million euros. MAB-related online publications and project reports can be downloaded from the homepage of the Austrian Academy of Sciences Press (http://epub.oeaw.ac.at/mab).

The *Earth System Sciences* (ESS) programme integrates the former seven international research programmes and is administered by three national committees: Man and the Biosphere, Global Change, and Geo/Hydro Sciences. In the near future funding for research in protected areas (e.g. national parks, landscape conservation areas, nature conservation areas, nature parks as defined by national law, Natura 2000 areas) is also available via themed project calls. Further details can be found on the *Earth System Sciences* homepage (http://www.oeaw.ac.at/deutsch/forschung/programme.html).

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 409 - 412

Mountain ecosystems in a changing environment

Christian Körner

Keywords

Alps, biodiversity, climatic change, CO_2, geographical information systems, land use, nitrogen, water

Abstract

This essey summarizes some of the major drivers of environmental change in mountain ecosystems, highlights a few examples of plant and ecosystem responses to these changes, and will place these findings, the land use aspects in particular, in a longer term context. First, I will summarize a few basic characteristics of the world's mountains.

In a strikt sense, when rated by their ruggedness, the mountains of the world cover ca. 16 Mio km² or 12.5 % of the terrestrial surface outside Antarctica (KÖRNER et al. 2011). Of that area, a global fraction of 2.6 % falls in the life zone above the climatic treeline, the alpine and nival belt. These highest elevation biota are overproportionally rich in species, with an estimated 4 % of all angiosperm taxa above the treeline, largely as a result of topographic diversity (KÖRNER 2004). The treeline that separates the alpine from the montane belt is one of the most prominent **biogeographic boundaries** globally, and is defined by a minimum warmth during the growing season (a ca. 6 °C isotherm of the seasonal mean temperature), with the length of the growing season at treeline varying between 90 days at the polar circle and 365 at the equator (KÖRNER 2012). Its almost exclusive setting by temperature makes it a prime candidate for responses to climatic warming.

One of the often overlooked key features of any mountain is the trivial fact that the land area is gradualy shrinking upslope with increasing elevation. Given the gradual reduction of temperature by ca. 0.55 K/100 m, mountains offer an exceptional diversity of thermal life conditions over very short geographical distances. For that reason, mountains are often considered an 'experiment by nature'. The close proximity of bioclimatic zones that might otherwise be found across several thousands of kilometers of latitude, is one of the main reasons why mountains accumulate more biodiversity per unit land area than their surroundings. Not surprisingly, mountains are hotspots of biological richness worldwide and thus, **prime target regions for conservation**. These aspects have to be kept in mind when discussing the likely consequences of global environmental changes in mountains.

What is subsumed under **global change** includes a broad variety of changes of global dimension, of which 5 major changes are particulary relevant for high elevation ecosystems: (1) the rise in mean temperature, (2) associated changes in water (and snow) relations, (3) atmospheric CO_2 enrichment as a direct influence on vegetation, (4) nitrogen deposition, and (5) changes in land use. In the following, I will briefly comment each with a focus on the European Alps, and will than address land use changes in more detail.

Climatic warming in the Alps is evident by meteorological records (a 1.5 K warming during the last century), the massive retreat of glaciers, and the lengthening of the snow free season, at least below 2000 m of elevation. Given that mountain climates are considered generally cold, climatic warming is thus, viewed as the central and most impacting facet of global change in mountains. However, this is a too simplistic view. What weather stations measure is not necessarily what all organisms experience. While trees operate very close to ambient temperatures, and are indeed experiencing better growth conditions than they might have faced during the last 500 years (PAULSEN et al. 2000), low stature vegetation produces its own microenvironment. Using infrared thermography and hundreds of in situ sensors, it could be shown that topography (shelter and exposure to the sun) creates a multitude of climatic niches that may differ more on a single alpine slope than any worst case climatic warming scenario for the next 100 years (SCHERRER & KÖRNER 2010, GRAHAM et al. 2012). As a consequence, these low stature plants and their animal and microbial partners are living in a mosaic of life conditions that offers microclimatic alternatives over the distance of a few meters. In fact, it was estimated that a 2 K warming on such a slope would remove merely 3 % of the coldest habitat types, which are inhabited by organisms that are abundant at higher elevations. It may be speculated that the richness in topography-driven climate variation over short distances is one of the reasons, why mountains were always **refugia** when climatic conditions changed. From that it may be expected that the relative proportion of the area of climatic microhabitats will change, but the taxa confined to such habitats are unlikely to go extinct or have to migrate over long distances to find suitable survival conditions. Hence, warming is largely an issue for trees and large animals. Trees have clearly responded to the warmer conditions as evidenced by treering data (PAULSEN et al. 2000), and it is only a question of time for the treeline to expand upslope into the lower alpine belt.

Water relations will be affected by climatic change in several ways. A warmer air exerts more evaporative forcing. More precipitation will fall as rain than snow at lower elevations, snow duration will be reduced at lower than treeline elevation, but since a warmer air also carries more moisture to mountains, the winter snow pack may actually increase at high elevation, with the net balance difficult to predict. What is termed heat waves at low elevation, commonly translates into particularly 'good' summers at high elevation, given that moisture is not commonly limiting in the upper montane and alpine belt. Hence periodic drought will exert minor impacts on high elevation biota. The regional water balance will on average become more positive as annual precipitation increases, but regional differences may be substantial. A direct water stress-related impact on alpine biota and the treeline are highly unlikely in the Alps.

Direct influences of **elevated atmospheric CO_2**, the prime food of plants absorbed during photosynthesis, had been expected to be particularly influencial in high elevation terrain because of the low atmospheric pressure and thus, partial pressure of CO_2. However the evidence to date suggests no or even negative effects on alpine vegetation, that is aparently not carbon limited at current atmospheric concentrations (INAUEN et al. 2012). The negative effects that were observed may be transitory, and most likely relate to excess carbohydrate exudation by roots, that stimulates rhizosphere organisms, which become competitors for soil nutrients. Responses of high elevation forest trees were explored in two projects, with one study in montane *Picea abies* showing absolutely no growth effect of elevated CO_2, but rather a negative effect on tree nutrition for the reasons as described above (HÄTTENSCHWILER & KÖRNER 1998), and the others at the treeline, again showing no effect, in this case on *Pinus cembra*, but a stimulation of growth in isolated saplings of *Larix decidua*, that was tied to particularly warm summers, with a tendency to decline with time. Differential effects were seen in dwarf shrubs, with the montane *Vaccinium myrtillus* showing a stimulation, but the alpine *Empetrum hermaphroditum* and *Vaccinium uliginosum* remaining unresponsive (DAWES et al. 2013). So, while alpine grassland and glacier forfield vegetation is clearly not taking any advantage from elevated CO_2, some species in the montane belt may profit, potentially causing some abundance changes. As a caveat, it needs to be recalled that all these experiments are exposing vegetation to a step-change in CO_2 at a time in the recent history at which CO_2 concentration has already increased by 40% compared to pre-industrial levels.

Nitrogen deposition in the form of NO_x or NH_4 is often considered a lowland problem, closer to industrial/urban areas and intense agriculture. Indeed mountains receive much less N-deposition than lowlands, but the vegetation is much more sensitive, given its selection for coping with poor nutrition. HILTBRUNNER et al. (2005) assessed N deposition accumulating in snow in the Swiss Central Alps and arrived at an estimated overall current deposition of 5 kg N per hectare and year. Alpine plants have been shown to respond sensitively to rates of nitrogen deposition as low as 5-10 kg of N per hectare and year, with species exhibiting differential responses (sedges particularly responsive; E. Hiltbrunner pers. comm.). Hence, N deposition is clearly more likely to induce changes in alpine vegetation than elevated CO_2.

Mountain biota are under **landuse pressure** worldwide (SPEHN et al. 2006). The Alps are a region known for its sustainable landuse practices at high elevation. Millennia of traditional landuse have in fact ‚produced' highly diverse, stable ecosystems of high conservation value (high biodiversity, no soil erosion). Undesired changes go in several directions: (1) destructive over-utilization followed by soil erosion, a problem of over-populated mountain regions mainly in developing countries, (2) a rapid under-utilization or abandonment leading to unstable transition stages that neither exert the benefit of the former cultural landscape nor the advantage of the original montane forests (avalanche protection, slope stabilization; TASSER et al. 2003). (3) Easily accessible (valley) terrain gets converted to species-poor, intensively used farmland with high fertilizer input. (4) under humid conditions many high elevation pastures become overgrown by native, but invasive species such as *Rhododendron ferrugineum*, *Calluna vulgaris* and other types of small as well as tall shrubs such as *Alnus viridis* (with accompanying *Salix* and *Sorbus*). These novel and extensive shrublands are unwanted for several reasons. First, they ruin the former grassland. Second, they slow or even prevent forest succession. Third, in the case of *Alnus*, N-fixing symbionts cause ecosystem N eutrophication, with a lush herb layer effectively suppressing tree seedling establishment, and polluting runoff water with excess nitrate. These thickets are most effectively battled against by specialized browsers such as goats or an old breed of sheep, the Engadine sheep (Bühlmann et al. in press).

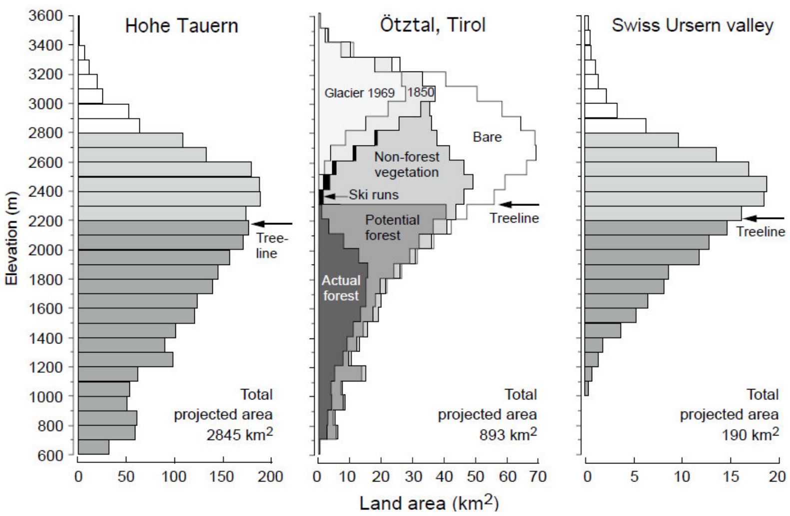

Figure 1: The elevational stratification of land area in three high mountain regions. (a) The Hohe Tauern region across a N-S transect from the Salzach to the Drau Valley; (b) the Ötztal region in Tirol, illustrating land cover categories, including ‚new land' released by glacier retreat (from Patzelt 1996 as modified in KÖRNER 2003); (c) for the Swiss Ursern Valley in the upper Reuss catchment. Note the climatic treeline in each area, separating the montane from the alpine belt.

The potential land area likely to undergo such successional stages is large. Geostatistics of land area per elevation evidences that the largest fraction of land area in the Alps is situated in the upper montane and lower alpine belt, the areas most likely facing declining landuse within the coming decades (Fig. 1).

Such statistics are best not confined by political boundaries (such as boundaries of countries, districts or national parks) but cover defined transects as set by geology and rivers (Fig. 2) as exemplified for the Hohe Tauern region. Using coarse **land cover statistics** for this area as assessed in the 1960s and 1970s, illustrates the situation close to the starting conditions before the most rapid phase of land abandonment is likely to have taken place (Fig. 3). As shown by the grid-specific land cover categories, 23% of the landscape was under extensive agricultural use below the treeline ba that time. A large fraction of this terrain will undergo successional land cover changes toward shrubland and montane forest. During the census in the area in the 1960s and 1970s (total selected area 2845 km² = 100%), 14.8% were covered by glaciers, rock and scree, 22.9% by alpine vegetation, 7.8% by lower alpine dwarf shrub heath, 2.7% by tall shrubs such as *Alnus* bush, 23.7% by coniferous forest, 2% by deciduous broad-leaved forest, 16.3% by pastures, and 6.7% by hay meadows. Agricultural cropland and settlements cover 3% of this area. If the trends are similar to those in the Swiss Alps, the tall shrub fraction should have doubled at least since then, and the area covered with forest will approach 30% at the cost of grassland.

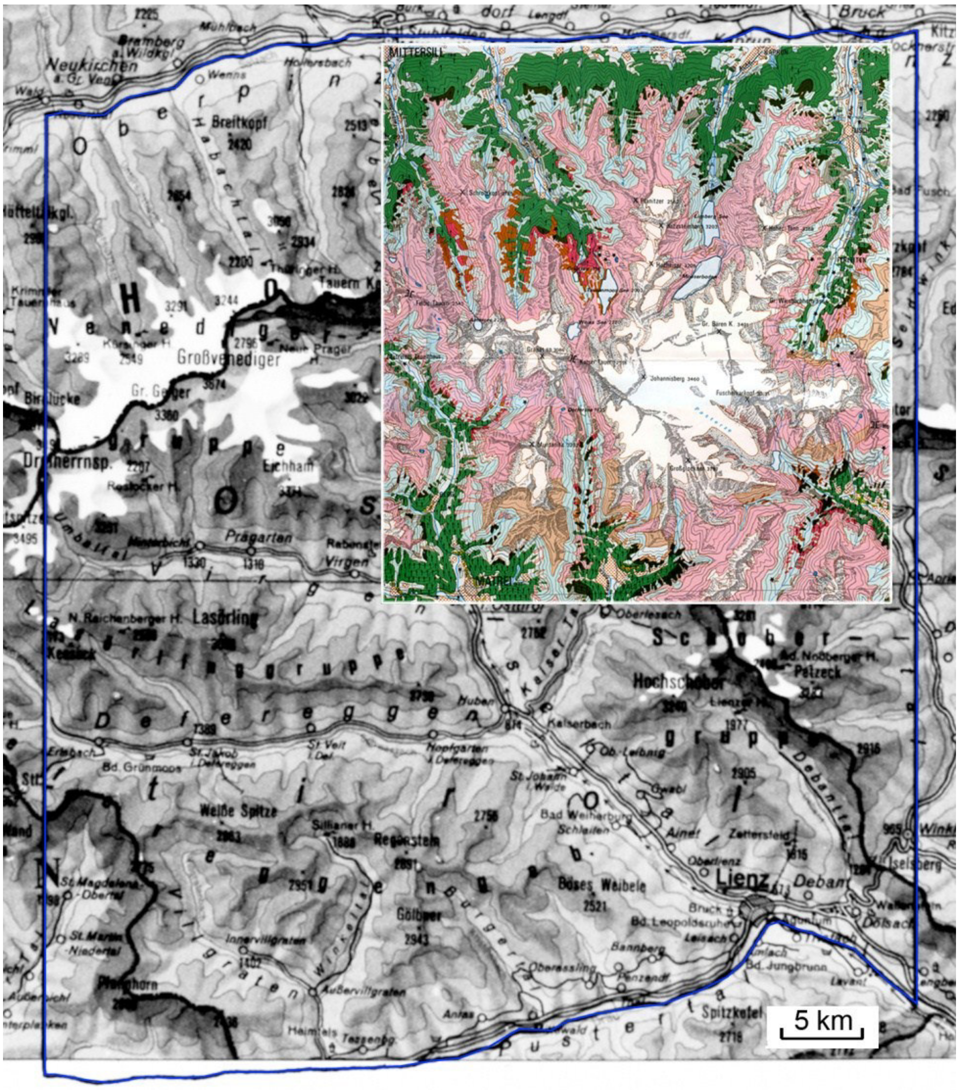

Figure 2 Geostatistical analysis of mountain terrain should be based on tectonic/geomorphological units (inset showing a transect from the Salzach to the Drau line (see Fig. 1a). The colored map shows the land cover categories as assessed by Ozenda (1975, 1984; see KÖRNER 1989).

The policy against such practically near to irreversible land cover changes takes its motivation largely from preserving a cultural heritage, maintaining farming activities for their own sake, or from a conservation point of view (biodiversity). There is evidence that such landuse changes have negative **hydrological implications** that so far are not accounted for in a more holistic consideration. First assessed in a pilot study in the Hohe Tauern region (KÖRNER et al. 1989, KÖRNER 2003), it is now confirmed across elevations that land abandoment causes evapotranspiration to increase by about 12% in the alpine belt, corresponding to similar reductions in runoff and thus hydroelectrical potential (INAUEN et al. 2013, T. van den Berg et al. unpublished). These losses of hydroelectrical potential need to be considered in management decisions for the maintenance of high elevation grassland. Overall, landuse changes are likely to exert the greatest impacts on high elevation biota in the Alps compared to all before-mentioned facets of global change.

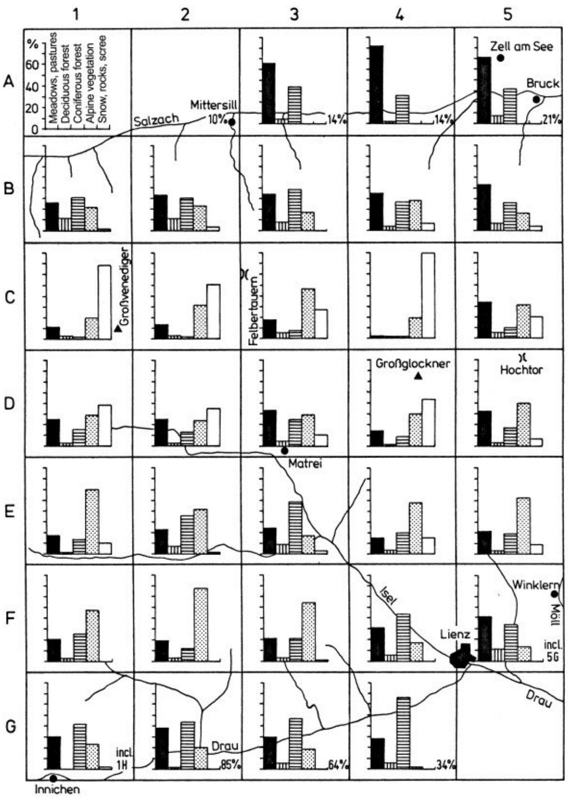

Figure 3: Land cover statistics for the Hohe Tauern region (area as in the inset of Fig. 2) using maps as shown in Fig. 2 (KÖRNER 1989).

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Conference Volume	5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill	pages 413 - 414

Distributed water balance modeling in the Berchtesgaden National Park

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Keywords

water balance, Alpine, karst, distributed hydrological modeling, snow, National Park

Abstract

The variability of meteorological parameters, a complex hydrogeology and heterogeneous snow cover dynamics affect the water balance in high alpine terrain. Distributed hydrological modeling is facing challenges in those environments and therefore needs to be adapted to the given conditions. We apply the deterministic hydrological model WaSiM-ETH (SCHULLA & JASPER 2007) to analyze the water balance and to focus on snow cover and groundwater modeling in an Alpine catchment.

The test site for our study is situated in the Berchtesgaden National Park (Bavarian Alps, Germany). It is characterized by extreme topography with mountain ranges covering an altitude from 607 to 2713 m.a.s.l.. The mountain ranges in the region consist of soluble limestone with a high number of subsurface pathways (karst) ending up in springs, highly affecting both the soil and groundwater storage. The model setup is based on a spatially dense network of meteorological stations at different elevations, discharge data from nine gauges and furthermore extensive land use and soil data.

To improve the modeling of snow deposition and ablation processes, we have complemented the hydrological model WaSiM-ETH with principles derived from the high-alpine specific snow model AMUNDSEN (STRASSER 2008). The new approach calculates the energy balance of the snow cover considering the terrain-dependent radiation fluxes as well as lateral snow transport processes. Results show that the reproduction of the spatial and temporal dynamics of the snow cover is improved (WARSCHER et al. 2013).

Hydrological modeling is resulting in systematic mismatch of modeled and measured runoff in discharge curves at the outlet points of neighboring high alpine subbasins. Tracer experiments and spring research showed that this can be attributed to the karst aquifer and the heterogeneous soil water transport, which is leading to strongly deviating runoff quantities in those neighboring subbasins (KRALLER et al. 2011). We present an artificial neural network extension that allows to account for subsurface karst water transfer within the hydrological model and increases model performance at subbasin scale (KRALLER et al. 2012).

The model system is forced with scenario data of a regional climate model (RCM: WRF 7 km, GCM: ECHAM5-MPI/OM T63/L32, Scenario A1B, 1970-2000/2020-2050) to assess potential impacts of a changing climate on the regional water balance. Results show a significant, elevation-dependent decreasing trend in snow cover duration. However, the consequent absolute changes in seasonal snowmelt and runoff amounts are projected to remain relatively small.

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Conference Volume	5th Symposium **for Research in Protected Areas** 10 to 12 June 2013, Mittersill	pages 415 - 420

Scientific Research of Škocjanske Jame Caves (UNESCO World Heritage) – since Antiquity to Modern Times

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Abstract

Posidonius (135-50 BC) studied springs of the Timavus River and he was the first to state, to be later repeated by Strabo, the hydrological connection between Škocjanske Jame Caves and ?karst springs. One of the earliest water tracings that proved the mentioned connection was published by F. Imperato in 1599. Valvasor only mentions the caves but due to heavy access he did not make any research. In the middle of the 19th century modern exploration of caves started with purpose to find out where the underground river is flowing. The task was fulfilled at the end of the century. When the members of the cave department of the DÖAV Section Küstenland took over the exploration they already have scientific observations in mind. They regularly measured temperatures outside and in the caves. Meteorological (speleometeorological) research continues through the 20th century and turned out to regular monitoring. Different methods of water tracing were carried out from the beginning of the 20th century. Škocjanske Jame hydrology was the topic of the first doctoral thesis in 1924 already. Its attraction for doctoral studies continued and still today there are advanced-degree candidates working on the caves. Regarding the fact that caves are near the border, they were object of some bilateral research projects too. Partly published bibliography of Škocjanske Jame contains 399 works and many of them are results and reports of scientific research. As for the conclusion it can be said that more research and scientific data are gathered, more interest and need for new and deepened researches occur.

Keywords

Karst, cave research, cave history, Škocjanske Jame Caves, UNESCO Natural Heritage.

Introduction

Škocjanske Jame Caves with its underground river, discharge reaching nearly 300 m^3/s^{-1} when full, with immense underground voids (Martel's Chamber over 2 millions m^3), and underground canyons, are the most important and impressive caves of the larger region. Therefore it is not surprising, that man took interest in them very early; almost 200 years they are open for tourists, and they are among the first caves inscribed on the UNESCO List of World Heritage, as a Natural Heritage (1986). Palaeolithic man used them for shelter, during later periods, during the Iron Age especially they served as a sort of sacred place, used for a cemetery and for special funerary ceremonies (Beltram et al. 2012).

Archaeological researches prove that man in prehistoric times descended to the bottom of collapsed dolines, to the entrances of the caves, and to the sinking river at their bottom. It is not sure that later people ventured so far. Valvasor (1689) for example knew the caves just from the surface and did not report that people visited the bottom or the river. Not earlier as at the end of the 18th century the painter's Cassas illustrations showed the view from the bottom of the 160 m deep collapsed doline at the caves' entrance (Lavallée 1802). Due to technically very difficult exploration the first researcher-caver known entered the caves few years before 1818 (Hoppe & Hornschuch 1818). Attempts to follow the underground river in years 1839-1840, and in 1851 offered no important result until the foundation of the Cave Department of the "Section Küstenland" of the "Deutsche und Österreichische Alpenverein" at Trieste in 1884 (Pazze 1893). To 1893 they explored the main parts of the caves and reached the final siphon; in 1904 the so called "Tiha Jama (The Silent Cave)" (upper levels of the caves) was discovered, and in 1991 the final siphon was dived through and the channels behind it were seen by the man for the first time (Morel 1992). This speleological research as heroic as it was cannot be called scientific research although a real scientific research aimed to inventory or monitoring is impossible without previous serious speleological research, including the survey. The last detailed and accurate plan by the help of laser telemeter and profiler was achieved during 1990-ties (Mihevc 1995).

Scientific Research

Hydrology

Definition of the scientific research depends upon the time and the type of society or its evolution. Therefore some old authors can be mentioned although their work and writing is not conformal to the modern sense of scientific research. For the scholars who could not enter the caves, the sinking Reka River was of the main interest. This is also the reason why the hydrological research of Škocjanske Jame and the Reka-Timavo River are emphasized in the present paper. The very first we know till now that had mentioned Škocjanske Jame was Poseidonios of Apameia (135 – 50 BC) who studied the springs of the Timavus River on the Adriatic coast on account of his interest in tide. He writes that "...a river, the Timavus, runs out of the mountains, falls down into the chasm, and then, after running underground about 130 stadia, makes its exit near the sea." By the chasm are meant Škocjanske Jame. Did he ascertain this hydrological connection, that the river from Škocjanske Jame flows underground to the springs of Timava River by the field study or he just "knew" it, we do not know. The next who studied Škocjanske Jame hydrology was Ferrante Imperato (1525? – 1615?), an apothecary of Naples, who in his work on Historia Naturale (Imperato 1599) writes that he unsuccessfully tried to prove the connection between Škocjanske jame and Timava springs by "floaters". Also the first attempts of water tracing by different "colorants" can be attributed to Škocjanske Jame study. P. Kandler (1804-1872) who said by himself that he "explored as much as possible the underground and surface river courses" (Merlato 2013), traced the sinking Reka River by "blue dye", that is indigo, in 1864, but the result is unknown. It was F. Müller who was the first to make a successful tracing by Uranine in 1891. The first aim was thus achieved: the connection between the Reka River in Škocjanske Jame and the springs of the Timavo was proved. But to find out hydrological details, quantities of water, different effluents, water velocity, chemical composition, etc. many years and many researches were needed. At the beginning of the 20th century tracing experiments with lithium chloride and radioactive substances were performed by Timeus and Vortman, later (1961-1964) tritium was used (D'Ambrosi 1964). Beside very special research the general works on hydrology were published. One of the first and really detailed was Oedl's in 1924; at the same time, his work was probably the first dissertation having hydrology of Škocjanske Jame as the thesis (Oedl 1924). Among the complete published studies the book Il Timavo must be mentioned as it includes all the previous data (Boegan 1938). Hydrological research continued up to nowadays. Some researches are more oriented towards general characteristics, as are water balance and watershed calculations, while the others are more specific, often related to general trends of the period. Such examples are studies of water pollution and protection, hydrochemistry, percolation water (Fig. 1). More and more attention is paid not to singular measurements but to monitoring of different parameters (Cucchi et al. 1997) or different events (Gabrovšek & Peric 2006) (Fig. 2). Although now is the time of very detailed and sophisticated analyses the general works and works of synthesis are not missing, as shows recently published book on water tracing of the Timavo (Galli 2012). The above mentioned studies on hydrological research are based on publications. But observations and researches which were never published exist also. Such an example is so called "Höhlenbuch" (Cave Book), hand written diary of the Caving Department of the "Section Küstenland". Marinitsch who visited caves practically every Sunday, measured air temperature on the surface and on different points in the caves as well as the temperature of the Reka River and noted the data beside other information in the mentioned "Höhlenbuch", for the period 1886-1914. I am sorry to say that the last traces of this book are from the "Haus der Natur" in Salzburg, but where the book is now is unknown to the author. In recent times there were projects which included hydrological research but the results were never published, such as the international IGCP-UNESCO Program No. 299 Geology, Climate, Hydrogeology and Karst Formation.

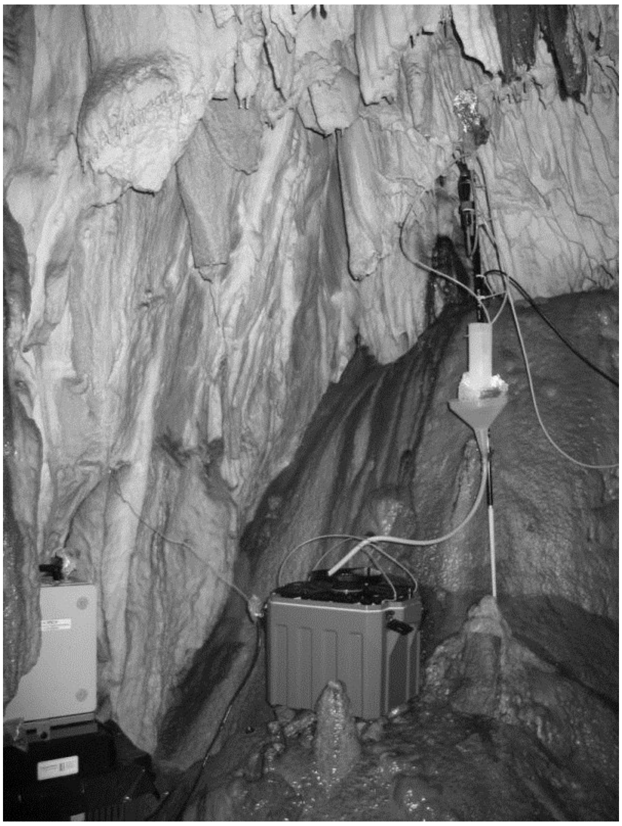

Figure 1: Automatic sampling of percolation water (Photo J. Kogovšek).

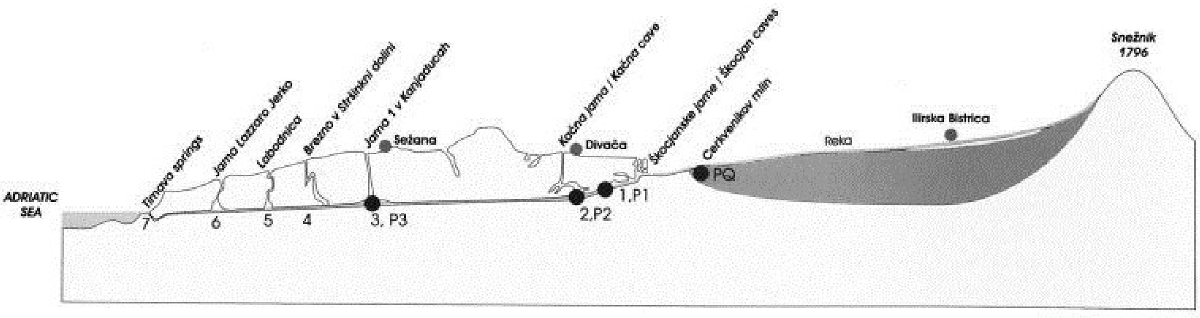

Figure 2: Measurement points for the flood pulse observation downstream the underground Reka River (after GABROVŠEK & PERIC 2006).

Other Physical Characteristics

Since 1956 deepened geological researches of the caves themselves or of the larger region, including the caves started. Geological research does not mean just traditional geological mapping and defining the type and age of a rock, but it includes special researches. Special attention was paid to the study of bedding planes in the entrance wall of the caves, to find out which and why galleries developed along the specific bedding planes. The result of the research was the doctoral degree in geology and the publication of the book on this topic (KNEZ 1996). The importance of Škocjanske Jame can be seen by research techniques and methods used. The first electromagnetic research was performed in 1931 already (SOLER 1931) and followed in the years 1954 and 1957. Study of sediments merit to be mentioned separately, both study of chemical sediments – flowstone, and of fluvial ones. There was research of speleothem forms, intensity and principles of its deposition. It included also the dating of speleothems, one of the first performed on the karst of Slovenia (GOSPODARIČ 1981). "Ponvice" (Massive Gours) are a sort of symbol of Škocjanske Jame and recently specific research project was proposed: "Gours in Škocjanske Jame – condition, protection, and regeneration" (Fig. 3). Fluvial sediments carried by the river into the caves were studied mostly in 1980-ies and a part of gathered data and analyses were used for the preparation of a doctoral thesis in geography (KRANJC 1989). Climatic or better speleoclimatic or microclimatic observations at the end of the 19th century were already mentioned. According to the instruments available at the time, first monitoring of microclimate in the caves started in 1928 (VERCELLI 1931). In the collapsed doline the temperature inversion was observed in 1960-ies and detailed study of temperatures along the underground river was performed in 2000 (KRANJC & OPARA 2002) (Fig. 4). The gathered data were the base for the preparation of the university diploma. Regular temperature monitoring is performed nowadays as a part of general monitoring system, but it cannot be treated as the scientific research any more, this is just useful and necessary practice. The cave air was the object of other observations too – the content of the radon and the composition of aerosol, started in 1979. In the recent time it too became a part of regular observations.


Figure 3: "Ponvice" (Gours) at Škocjanske Jame (photo Archive of Park Škocjanske Jame).

Biology

The first researchers interested in speleobiology have dealt mainly with the study of Copepods (KIEFER 1930). Also later efforts in 1960-ies and 1980-ies were dedicated to Copepod studies. Proteus practically does not live in the caves in a strict sense and therefore it is seldom mentioned. Research was focused on eels and their migrations with the aim to use them as a natural tracer for underground water connections (SELLA 1929). Škocjanske Jame are wintering place for bats, their population began to be seriously followed in 1971 (FRANK 1971). It seems unusual that a lot of work was consecrated to the study of flora and speleoflora especially. In collapse dolines where some of caves entrances open, the temperature inversion occurs and they contain so called relict flora, while mosses and lichens penetrate deeper in the passages. Thus these types of flora representatives were studied mostly and even started early (MORTON 1935). Recently the research is oriented to smaller living creatures as are algae, bacteria, and meiofauna (GERIČ STARE et al. 2004). This research is performed as the basic research as well as directly applied or useful research for cave managers and cave protection regarding algae growth and “Lampenflora” in general (MULEC et al. 2007; MULEC & KOSI 2009).

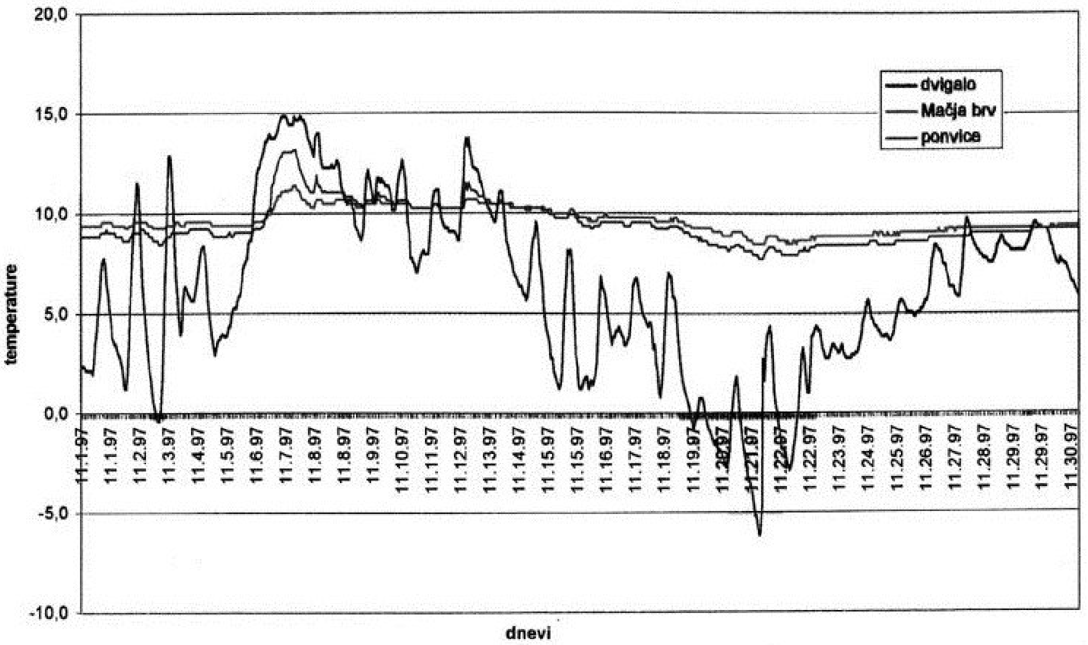

Figure 4: Hourly air temperature curves (October 1997) (KRANJC & OPARA 2002).

Archaeology

Regarding the fact that interest in Škocjanske Jame can be traced far back, through prehistorical and historical periods it is normal that the traces of man activities can be found in the caves, at the caves’ entrances, and on the surface above the caves. Therefore Škocjanske Jame are an important archaeological object. The first known archaeological research started in 1888 (MARCHESETTI 1889) and the investigations continued through Austro-Hungarian (SZOMBATHY 1913), Italian (BATTAGLIA 1924), and Yugoslav (LEBEN 1956) periods to present (POHAR 1995). In the Park Škocjanske Jame the museum collections are sheltered and put into the exhibition also as a result of special research project. General topographic names are material remains just when cut in the rock or written on a durable plate, nevertheless they constitute an important part of cultural heritage which is evident especially in the case of Škocjanske Jame. Local Slovene names existing before the Cave Department of “Section Küstenland” took over the explorations were assigned just for the caves and surface features around and above them. During the exploration and simultaneous preparation of tourist walkways the cavers named passages and chambers as well as small geomorphological details in German language. Under the Italian period (1921-1943) all the names, Slovene and German were translated in Italian or completely altered and in Yugoslav period Slovene names appeared (KRANJC 1994).

Conclusions

It is impossible to enumerate all the scientific researches performed in Škocjanske Jame during the last four centuries. For the past periods the access to original reports if they were ever made at all is very difficult or even impossible. For the recent period, let us say for the last few decenniums, they exist but even now it is quite difficult to find them in various libraries, institutes, ministries and local departments... So this review is based mostly on publications up to 1986 when Škocjanske Jame became the World Natural Heritage. In the bibliography of Škocjanske Jame (KRANJC 1996), which cannot be complete, there are 399 entries, most of them are reports of researches or based on such researches. In addition to this bibliography, published 5 years later, there are another 191 entries (KRANJC 2001). It is difficult to establish their number after 2000, in any case there are many of them. Just for the illustration: in the journal Acta carsologica, published in Slovenia but having international character, there are 37 papers related to Škocjanske Jame published in 41 volumes.

It is well understandable that after 1986 the number of (proposed) projects for Škocjanske Jame research augmented. They are at least 15 having as a topic general (complex) research “Škocjanske Jame and its surrounding” for example, to very specialized as “Waste removal and reconstruction of the walkway in Hanke’s Gallery”. These projects were financed by local or central administration, through INTERREG (Slovenia-Italy) or through international (IGCP No. 299) projects, often supported by Slovenian Commission for the UNESCO. What is it possible to see from this short review of research? That important caves are intimately connected with research – the cave which has no base in scientific research cannot be of great importance, especially not World Natural Heritage, and the important cave has great opportunity and means to initiate and to support scientific research. And more research are done, more scientific data gathered, greater is interest and need for new and deepened research.

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