

S4C

Science for the Carpathians

Research Agenda for the Carpathians 2010 - 2015

Integrating Nature and Society towards Sustainability

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Kozak J., Björnsen Gurung A. & Ostapowicz K. (eds.):
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PREFACE

WHY DO THE CARPATHIANS REQUIRE MORE RESEARCH?

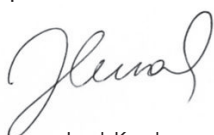
This document is the result of policy- and science driven activities stimulated through the growing recognition of the global importance of mountains. The interplay between those activities, in particular the development of the Carpathian Convention facilitated by the United Nations Environment Program (UNEP), together with the emergence of mountain research networks in Europe enabled the Carpathian science community to take shape. In May 2008, the Institute of Geography and Spatial Management (IG&SM) of the Jagiellonian University, Kraków, Poland, together with Mountain Research Initiative (MRI), European Academy in Bolzano, Italy and UNEP organized a conference inviting scientists from the Carpathian region to discuss the status of research and future needs. On this occasion, the launch of the 'Science for the Carpathians' (S4C) initiative set the first milestone for the development of the present Research Agenda for the Carpathians (Ostapowicz and Sitko 2009).

Departure point for this development process was the Global Change and Mountain Regions (GLOCHAMORE) Research Strategy (Bjørnsen 2006) outlining key research topics at the global level. As mountain ranges differ in their biophysical, ecological, economic and sociocultural characteristics, the GLOCHAMORE Strategy required downscaling and adjustment to the regional scale. For the Carpathians, no comprehensive, joint research agenda had been developed, which would simultaneously address the multifaceted challenges of sustainable development in the region, in particular as the anticipated climate and socioeconomic changes are expected to increase the already existing pressure on the natural and social resources. Therefore, one of the aims of the S4C initiative was to identify key issues for the Carpathian mountain research, while making use of the vast knowledge, which the S4C community collected in the Carpathian region, thereby building a shared vision on a solid scientific base.

To facilitate strategic planning, S4C together with IG&SM organized the 1st Forum Carpaticum on "Integrating Nature and Society Towards Sustainability" in 2010 in Kraków, where scientists and practitioners working in the region were able to share their knowledge and express concern about the future of the Carpathian research. The present document is the first step towards a common vision on how research can generate knowledge and information necessary for informed decision-making. It has been developed on an interdisciplinary background, seeking the dialogue between research and practice. The strategy eventually aims to contribute to the sustainable development of the Carpathians, the 'European Green Backbone', by describing priority research themes for the region while anchoring them in a strategic planning process for a larger Carpathian Research Area.

This document has been coordinated by the IG&SM and the European Program of MRI. We would like to thank those who have contributed to the development of the Research Agenda for the Carpathians. In particular, we acknowledge the contribution made by the S4C Scientific Steering Committee, the Scientific and the Organizational Committees of the 1st Forum Carpaticum and the numerous supporters of the event (see Annexes I-III). Finally, we would like to invite all interested parties to contribute to the implementation of the Research Agenda.

Kraków, 28. April 2011



Jacek Kozak
Chair of the S4C
Scientific Steering Committee



Astrid Bjørnsen Gurung
Co-Chair of the S4C
Scientific Steering Committee



► A view eastwards from the top of Trzy Korony, Pieniny Mts., Poland.

EXECUTIVE SUMMARY

Stretching across eight Central and Eastern European countries, the Carpathians host a unique natural and cultural diversity, exceptional at the European scale. Today, 20 years after the fall of the Iron Curtain, the region still experiences rapid socioeconomic transformation posing numerous challenges to sustainable development.

In this new reality, Carpathian researchers need to provide information adequate to address the pressing questions of today. Equally, they need to think ahead in order to prepare for the challenges mountain societies and their neighbors in the lowlands will face tomorrow. Taking charge of this societal responsibility, the Carpathian science community should go beyond the generation of mere system's knowledge (understanding of how the Carpathians function), attempting to define the target knowledge (consent how the Carpathians should look like) and the necessary transformation knowledge (processes that could lead to the desired state), in consultation with stakeholders. If the three types of knowledge are addressed appropriately, science will be in a position to effectively support stakeholders and decision makers in their efforts to sustainably develop the Carpathian "*Green Backbone*".

To achieve such a vision enhanced collaboration is required. As for science, it is clear that global environmental and socioeconomic problems cannot be addressed by individual researchers or institutes anymore, but require an overarching system understanding and joint solutions as a product of interdisciplinary work. In the Carpathians, although ample disciplinary mountain research in geography, biology, history, anthropology and other disciplines has been carried out since at least the 19th century, national and international research coordination remains insufficient and pan-Carpathian projects have been almost absent. Therefore, information exchange with the global mountain research communities needs to be intensified in terms of involvement in EU-funded research projects, peer-reviewed publications and participation in international conferences. In regard to transdisciplinarity, the dialogue and information transfer between research, policy and practice is still inadequate.

To catalyze the described changes the Science for the Carpathians (S4C) network launched the Forum Carpaticum, an open interdisciplinary mountain conference devoted to the Carpathian region. At the 1st Forum Carpaticum held in 2010 in Kraków, almost 200 participants from 13 countries, mostly scientists but also practitioners and stakeholders, discussed the current status and emerging themes for future research. The 1st Forum Carpaticum not only contributed to the visibility of the Carpathians in the global change research agendas for mountains but also induced new research ideas and activities with an attempt to link research and practice. For this decade, the S4C community identified several research priorities in various fields related to the sustainable development of the Carpathian region, ranging from climate change to the preservation of traditional knowledge.



The effects of **climate change** on the temperature, precipitation patterns and the occurrence of extreme events have not been sufficiently assessed at the pan-Carpathian scale. Future climate research requires better international collaboration, common protocols and downscaling to make predictions reliable and thus relevant for planners and mountain dwellers.



Although much high quality research has been done on monitoring and understanding of **air and water pollution**, the limited availability and access to data hampers system understanding and model development. Efforts must be made to organize a network of Carpathian field stations and to develop integrated long-term monitoring systems for the chemical environment, including also below ground factors. Both ecosystem-level research and large-scale studies across catchments are needed to understand spatial distribution of pollution and mechanisms of its impact on ecosystems.



To add value to the still very disciplinary and fragmented small-scale case studies on **water**, coordination, data sharing and information exchange with other disciplines is needed. Proper water management in the region should be achieved via the establishment of a 'Water-environmental information and monitoring system' embracing Carpathian river network and experimental, representative and semi-natural basins. Hydrological changes in the Carpathian catchments have to be further monitored and quantitatively assessed, with more attention paid to trans-boundary river basins. Research efforts should lead to the improvement of future ecological state of watercourses in the region.



Natural hazards are a growing concern to mountain communities. Public authorities and researchers would benefit from closer cooperation, as research could allow informed decision-making and contribute significantly to development of the early-warning systems. A key question is the elaboration of standardized quantitative and qualitative methods of risk assessment, and development of interdisciplinary approaches linking various natural hazards with changing human pressures. Special attention should be paid to monitoring of extreme events.



With respect to rapid socio-economic changes instigated by the fall of the Iron Curtain and EU accession, the provision of homogeneous information on past and future **land use and land cover change** and its drivers is important for both research and policy. Continued monitoring at the pan-Carpathian scale complemented with results from small-scale case studies and supported by sound socioeconomic knowledge (e.g. on urbanization processes and depopulation

of rural areas, accessibility and economic performance) could contribute to the necessary understanding of coupled human – environmental systems. Going one step further, homogenized datasets with improved thematic and spatial resolution spanning all Carpathian countries are needed.



Forests are one of the most important natural resources in the Carpathians. As spruce dieback is the most pressing concern for the entire region, ongoing monitoring of forest health with traditional and new techniques has to be continued, to improve numerous adaptation measures that have been taken in response to the dieback problem. Anticipating the future of forests with implications for proper management requires an assessment of various stressors, such as environmental pollution and climate change, and their interactive effects on key tree species. Future forest research has to be put in a wider context of public perception of forest importance and ecosystem services.



Land use changes, in particular decline of mountain agriculture and land abandonment, have a strong impact on **biodiversity**. Accordingly, comparative and retrospective biodiversity studies with pan-Carpathian coverage are a high priority while paying special attention to endemic species, threats and suitable conservation approaches (e.g. assessing the effects of ecological networks). Biodiversity studies in native forests should provide a reference for managed forests. For policy implementation at the local and regional level, the identification of suitable biodiversity indicators to be used in cultural landscapes, forests and aquatic systems is required.



The **ecosystem services** (ESS) concept could offer an organizing paradigm stimulating the dialogue between research and policy, with climate change and biodiversity as cross-cutting themes. Activities organized around the ESS approach include the analysis of governance as well as local knowledge, both of which could lead to more active public involvement in decision-making. Different scientific disciplines are needed to invent novel methods for ESS valuation. The ongoing habitat degradation and exploitation of wildlife, for example, stir the question of how carbon credits and ESS payments could generate funding for natural resource management and biodiversity conservation.



Current **regional policies and land management practices** have enormous significance for the maintenance of various values of the Carpathian region, e.g., cultural landscapes, agricultural or forest biodiversity. There is a need to integrate planning across sectors and spatial scales, linking local and regional policies. Unification of data and methods in various parts of the region is required to achieve a coherent vision of the Carpathian region.



Urban and rural development and well-being of inhabitants is strongly affected by the spatial accessibility. Large enterprises have rather a limited impact on local development, as they are located in areas where economic growth is anyway rapid and driven by multiple factors. In studies on sustainable development, more advocacy is needed for integrated approaches of practitioners, planners, scientist, politicians and local people to achieve the best results. Similarly, pan-Carpathian research also needs to be fostered.



The way mountain **tourism** in the Carpathians developed was a direct result of the particular model of the past socialist period (social holiday, mass construction of second homes). Today, the appropriate response to global and local driving forces impacting employment and the balance between economic development and environmental protection pose a challenge for sustainable tourism. Opportunities exist in the development of protected areas (biosphere reserves, geoparks) or long-distance hiking trails (e.g., *Via Carpatica*), especially in the trans-border context. The production of management tools for sustainable tourism in the Carpathians based on good practices would be a useful future target combining research and practice, allowing the evaluation of possible development scenarios (spa tourism, ski investments, agrotourism, cultural tourism).



Traditional knowledge, a threatened value, is vital to the understanding of local societal and landscape changes and to development planning and nature conservation in rural areas. To prevent the disappearance of traditional cultural landscapes with the entailed loss of traditional knowledge systems is a key concern that might be addressed through the careful maintenance of existing cultural landscapes.

* * * * *

Implementation of the Research Agenda for the Carpathians requires several measures, which would strengthen the overall capacity of the sustainability science in the Carpathian region and allow constructing the Carpathian Research Area. First, further discussion on the agenda is needed in the vast interdisciplinary setting to refine the goals and research plans. Next, funding is required to support projects aiming at networking activities in the Carpathian region, and to develop integrated environmental information systems, providing common platforms for standardized pan-Carpathian data acquisition and sharing. Finally, researchers and stakeholders should be encouraged to work together to combine practice-oriented activities with a solid base of scientific knowledge.



Geographers at work; Babia Góra National Park – one of the springs on the southern slopes; Poland.

1 THE NEED FOR A RESEARCH AGENDA FOR THE CARPATHIANS

Several factors contribute to the high importance that is attached to mountain regions worldwide. Mountains cover one forth of the Earth's terrestrial surface and provide goods and services to more than half the humanity (Messerli and Ives 1997). Together with adjacent foothills and valleys, they are home to one forth of the global population (Meybeck et al. 2001). Important goods and services include: the supply of freshwater, hot spots of biodiversity, major terrestrial carbon pools, primary source of forest products, protected areas and refugia for threatened species, and unspoiled recreation areas for a rapidly growing and urbanized world population, to name a few.

In many mountains, including the Carpathians, the ability to provide these goods and services to mountain people and lowland communities is jeopardized by the concerted effects of environmental and anthropogenic driving forces. In addition, globalization, i.e. the growing global integration of social, political, and economic relationships, affects mountain environments. Although natural drivers of change might be less perceptible at the moment, their importance will reach or even exceed the importance of globalization as a driver of change in the near future (Björnsen et al. 2005).

In addition to their importance, mountains are considered as highly complex systems; partly due to the strong environmental gradients along their slopes, which results in compressed 'life zones' making them hotspots of biodiversity; and partly due to the socio-economic gradients associated with varied access to limited resources, and rapidly changing land use, economic and political circumstances, which is particularly true for the Carpathians.

Fuelled by both, the recognition of the critical role of mountains in the functioning of the global geosphere-biosphere system, but also by the acknowledgment of their complexity, mountains have become the focus of a growing body of global change research in recent years. The inclusion of mountains in Chapter 13 of Agenda 21 during the 1992 United Nations Conference on Environment and Development underscored the significance of mountains as a "*major ecosystem [...] essential to the survival of the global ecosystem.*" On this background it became clear that disciplinary thinking became obsolete in view of the complexity of the Earth System, mountains in particular. Even if basic research will remain very important, it must be accepted that the impacts of global change in mountains are complex, in particular if humans become a significant and sometimes dominating environmental force.

Focusing on a sub-system of the Earth system, such as mountain areas, is a first step towards meeting the challenge presented by global change. The second step is the establishment of a dialogue between scientists, policy-makers and stakeholders to communicate current knowledge and to guide future research. The launch of the Mountain Research Initiative (MRI) in 2001 goes back to a workshop in 1996 that recognized that mountain systems "are at risk and need special attention, in particular with respect to the possible impacts of global change." The report further states that: „Intensified, collaborative and co-ordinated research is required, which can be fostered through an international research program" (Becker and Bugmann 2001). The International Human Dimensions Programme on Global Environmental Change (IHDP), the International Geosphere-Biosphere Programme

(IGBP) and the Global Terrestrial Observing System (GTOS) joined forces during the following years to collaboratively define the objectives, approach, and activities of this new research program – the Mountain Research Initiative (MRI). Today, the MRI has been endorsed by the Global Land Project and became a well known information node for almost 7000 global change researchers worldwide.



The GLOCHAMORE project, a Specific Support Action of the EU's 6th Framework Programme on „Sustainable Development, Global Change and Ecosystems”, which was coordinated by the University of Vienna and the MRI, translated the global goals of the MRI into much more specific disciplinary objectives coupled to a recommendation for inter- and transdisciplinary research approaches targeted on UNESCO Mountain Biosphere Reserves around the world. The GLOCHAMORE Research Strategy (Björnsen 2006), the project's final product, is an integrated and implementable research strategy to better understand the causes and consequences of global change in mountain regions around the world. The Strategy is a consensus document developed through con-

sultation with the international community of scientists and Biosphere Reserve managers.

In 2006 the MRI moved from strategy development to implementation through the initiation and support of regional networks of global change researchers. The European Program (MRI-Europe) was launched in 2007. It aimed to connect and support global change researchers working in different mountain regions in Europe. In this context, the Carpathians, the long mountain arc spanning through Central and Eastern Europe have become a focus region for the MRI-Europe for several reasons. First, the Carpathian region hosts a unique natural and cultural diversity, exceptional at the European scale. At the same time, more than 20 years after the fall of the Iron Curtain, it still experiences rapid socioeconomic transformation posing numerous challenges to sustainable development, attracting in this way a number of researchers from outside. Finally, the Carpathians have been for a long time an area of study for many academic and research centers in the region, and may prove a long record of scientific activities embracing biology, earth and social sciences. However, in the new political reality scientific efforts in the region are still fragmented among domains and countries, with relatively weak links to the global mountain research community and insufficient knowledge exchange among interested researchers and across the science-practice interface.

As a result of both, the need of the Carpathian science community for enhanced communication and the extraordinary commitment of a handful of individuals, the Science for the Carpathians (S4C) network has been initiated and developed at an unprecedented speed. In spring 2008, a group of researchers with a mandate from the Interim Secretariat for the Carpathian Convention (ISCC, UNEP-Vienna) requested the MRI's assistance in organizing a scientific network in the Carpathian region. MRI

worked with the Institute of Geography and Spatial Management (IG&SM) of the Jagiellonian University in Kraków, the European Academy Bolzano (EURAC), Joanneum Research, the University of Applied Sciences Eberswalde, and the Humboldt Universität zu Berlin to organize the first S4C meeting in May 2008 in Kraków, Poland. The goal was to set the first milestone for a new science network for global change research in the Carpathian mountains. The workshop aimed at defining the current status of global change research in the Carpathians, at drafting a research agenda for topics relevant to the region, and at establishing an active science network (Ostapowicz and Sitko 2009). Few weeks later, the S4C initiative received the support of the Conference of Parties of the Carpathian Convention at their meeting in Bucharest in May 2008. Today, the activities related to S4C are also supported by the Institute for Mountain Research: Man and Environment of the Austrian Academy of Sciences.

The S4C network clearly benefited from the conducive spirit of the global and regional mountain research communities and the

political environment set by the Carpathian Convention. The 1st Forum Carpaticum, following the example of the „Forum Alpinum,” is a testimony of the spirit of optimism of the Carpathian research community to work towards concerted activities in international, inter- and transdisciplinary research.

Although the 1st Forum Carpaticum was devoted exclusively to the sustainable development in the Carpathian region, the need to link and coordinate regional activities with initiatives outside the Carpathians, i.e. to strengthen international research partnerships, has been recognized. Enhancing the visibility of Carpathian research within the global mountain research community by networking and publication activities is a high priority to prepare the ground for international research collaborations at the European and global scale. Consequently, the Research Agenda for the Carpathians not only needs to identify knowledge gaps and future research priorities but equally has to define and shape an institutional environment that enables the Carpathian research community to move towards the desired direction.



► Participants of the 1st Forum Carpaticum excursion 2010, Poland.



► Surroundings of the Morskie Oko Lake in the Tatra Mts.

2 A COMMON VISION ON THE FUTURE OF CARPATHIAN RESEARCH

The 1st Forum Carpaticum held in Kraków at the Jagiellonian University (15-18 September 2010) was dedicated to the *“Integration of nature and society towards sustainability”*. The conference theme expressed the willingness of the Carpathian science community to move away from disciplinary and fragmented research towards an approach coupling human and environmental systems. The gathered expertise of almost 200 participants from thirteen countries, mostly scientists, but also practitioners and stakeholders, offered a unique opportunity to share the expertise and discuss the current status and future directions of the Carpathian research. The broad representation of disciplines, themes and regions was crucial to the identification of research gaps and the definition of priority research areas for the Carpathian region. Such consent on most eminent needs is in turn a prerequisite for the development of agreed protocols and actions addressing environmental and societal challenges characteristic for this mountain region.

The twelve session topics of the 1st Forum Carpaticum covered a broad range of disciplines in various spatial and time scales, but also inter- and transdisciplinary topics (Ostapowicz 2010; Ostapowicz and Kozak 2010), addressing almost all topics of the GLOCHAMORE Research Strategy (Bjørnsen 2006). To assess the current status of research in the Carpathians, the session chairs summarized the outcomes and identified emerging issues for future research based on the accepted abstracts, oral presentations, discussions and posters related to their session. To complement this information, few experts joined the sessions as ‘observers’ to extract key messages from a different disciplinary angle (Annex I).

2.1 Climate Change



The analyses of the climatological measurement series from the second half of the 20th century from ground and aerological measurements in Slovakia, Poland and Romania showed a statistically significant increase in mean annual air temperature in all studied stations. The rate of the increase varies among regions and altitudes from 0.5 to 0.1 K per decade. Polish studies suggest that the rate decreases with altitude yet, the Slovakian measurements indicate that differences in rates for different altitudes disappear for particular months.

Compared to air temperature, precipitation and snowfall or snow cover changes are much less uniform. In Poland and Slovakia, no significant trends in annual sums of precipitation and

number of days with snow cover were observed. A large inter-annual variability was found instead. In Slovakia, precipitation distribution during the year has changed since 1994. Despite the slight increase of total annual precipitation, the number of days with rainfall decreased while precipitation intensity increased. In the southern part of the Slovakian Carpathians the climatic conditions became more arid, in the northern part more humid. In Romania, the annual sums of precipitation, number of days with snowfall and days with snow cover significantly decreased while a large inter-annual variability was observed. These changes will ultimately have a negative impact on skiing tourism in Romania.

To summarize, the effects of observed climatic changes include: a shift in climate zones and vertical climatic zones; a change in the frequency of extreme meteorological events,

and a change in the fauna structure in the Danubian lowland, e.g. shift of species from the Mediterranean region.

Recommendations for future research. International cooperation in climatological data analysis is urgently needed to (1) identify the magnitude and character of climate change in different parts of the Carpathians, and to (2) characterize its impacts on environment and human activities. Therefore, (3) joint studies using the same time scales and methodology are needed. After assessing climate change at the pan-Carpathian scale, (4) the causes for regional differences need detection.

Observer's Notes. The presented studies had in common that they predict a warmer climate in future (clear trend), depending on the elevation. However, the results of the precipitation studies showed a broad variability. Joint efforts in climate change studies are a crucial requirement, which includes better linkages between individual researchers, more data exchange, and joint protocols (methods, observation periods).

2.2 Chemical environment



Ozone. In the Carpathian mountains high spatial and temporal variability of distribution of ozone (O_3) concentrations was shown, with the highest concentrations in the southern Slovakia (western Carpathians). Typically ozone levels were the highest in mid-summer. On the elevational transect in the Tatra Mountains, O_3 concentrations were increasing with elevation while above 1200 m diurnal changes were lacking. High ozone concentrations in late winter at the highest elevations indicated a stratospheric O_3 intrusion. Ozone monitoring in the Czech Republic showed elevated O_3 concentrations in many areas, including mountain ranges. In the most polluted parts of the Carpathians and mountain ranges of the Czech Republic, O_3 exposures exceeded levels considered safe for sensitive vegetation. From summer surveys near passive ozone samplers in the Tatra National Park in Poland and Slovakia and in Ukraine from 1991–2003, 16 bioindicator plant species for ozone

were identified. Red-fruited elderberry (*Sambucus racemosa*) is the most common and reliable shrub indicator while stone pine (*Pinus cembra*) is the most common conifer indicator. More extensive surveys are needed and a better understanding of the long-term ozone effects on plant growth and reproduction in relation to biodiversity should be obtained.

Sulfurous and nitrogenous air pollution and deposition. In the Carpathians and the Czech mountains, significant reduction of SO_2 concentrations, S deposition and the SO_4/NO_3 deposition ratio has been observed for about 20 years. At the same time acidity of precipitation has been decreasing. Western Carpathians experience one of the highest levels of N deposition in Europe, with an increasing importance of reduced N. Critical levels for nutritional N deposition in the Tatra Mountains have been exceeded both for forests

and meadow ecosystems. Current levels of N deposition inhibit plant growth in acid soils due to a loss of basic cations and increased toxicity of heavy metals in soil. These factors negatively affect Norway spruce stands and contribute to the observed decline of spruce forests in the western Carpathians. Air pollution in the southern Carpathians was generally lower than in the western Carpathians, as indicated by relatively low air pollution levels in the Romanian Bucegi Mountains. However,



even relatively low levels of air pollutants and atmospheric deposition could negatively affect forest health and growth at the increasingly variable climate, especially extreme events, and the intensified effects of pest and pathogens.

Water chemistry. The chemical composition of the Carpathian spring, stream and run-off water shows a great diversity as a result of rich geological structures and water-bearing horizon lithology. In addition, changes in discharge during flood events affect chemical characteristics of water and concentrations of various ions. Recent surface sediments in the high elevation southern Carpathian lakes in Romania showed elevated levels of selected heavy metals, probably affected by an increased atmospheric deposition of particulate matter from the long-range transport of polluted air masses.

Recommendations for future research. (1) Long-term monitoring of air pollution (O_3 , NO_2 , NH_3 and SO_2) and deposition of N, S and heavy metals should be established through the national and international efforts. (2) Efforts for evaluation of critical loads for N and S deposition and acidity as well as critical levels for O_3 exposures should be continued and expanded. (3) Both ecosystem-level research and large-scale studies are needed to understand spatial distribution of N and S pollution and mechanisms of its impact on ecosystems, especially related to Norway spruce dieback. (4) Water chemistry related to natural and anthropogenic processes across the Carpathians should be further investigated. (5) International research and monitoring collaboration between the Carpathian Region and other mountainous regions of Europe and North America should be expanded.

Observer's Notes. The presentations covered mainly air and water pollution issues stretching from the molecular dimension to large atmospheric transport of pollutants. Although sophisticated research has been done on monitoring and process understanding related to ozone, nitrogen and sulfur, the limited availability and access to data hampers system understanding and model development. In future, efforts must be made on the organization of a network of Carpathian field stations (inventory and collaboration) and the development of integrated long-term monitoring systems for the chemical environment (e.g. continued efforts of ICP Forest on forest health), which would also include below ground factors.



2.3 Water resources and management

With the requirement of attaining good ecological state of rivers, formulated in the Water Framework Directive of the European Union, hydroecological research can become a leading scientific theme in all Carpathian countries.

Water quality, fluvial processes and interactions with biotic processes. The quality of Carpathian water resources is affected by factors such as vegetation cover in the supply zone, geology, contaminated precipitation and human activity. A proper vegetation cover can advantageously modify spring water chemistry. Karst areas are especially sensitive for the nutrient anthropogenic input. High rock permeability and fast underground flow deteriorates the quality of subsurface waters and the flora and fauna of the caves.

Human interventions have led in the Carpathians to considerable degradation of the hydromorphological quality of rivers and, consequently, of aquatic and riparian communities. Woody debris in river channels plays a significant role in fluvial processes and in the functioning of river and riparian ecosystems. There are differences between the environmental role of large wood in the narrow, channelized river sections and the wide, multi-thread, unmanaged sections. In the former, scarce wood pieces were deposited outside the low-flow channel and exerted little influence on the river functioning. In the wide sections, large wood was retained in a variety of depositional sites, considerably contributing to the diversity of physical and biotic processes. Woody debris provides habitat structures for aquatic biota in low-flow channels, increases channel sinuosity, divides thalweg to initiate the formation of mid-channel bars, dams narrow side channels and induces the development of pioneer islands from sprouting pieces of willow driftwood. Management of riparian

woodland and stream channels, including channel cleaning practices, reduces the amounts and size of wood recruited to and stored in channels and lessens its environmental role. Human modifications of hydromorphological river conditions such as transversal hydrotechnical structures, channelization, gravel mining-induced channel incision and flow regulation cause impoverishment of invertebrate and fish communities.

Methods. Hydrographic maps (1:50'000) represent a reliable source of the quantity, quality and variability of water resources. They offer, for instance, a comprehensive picture of basic hydrologic features, water circulation patterns and water management and can be used for regional and local water resources management. Hydrographic maps are useful for spatial planning, flood management and environmental protection. They can help to assess water resources, to identify water surplus and deficits and to gain a comprehensive perspective on water circulation conditions with a special focus on the natural environment and current changes. They provide information on mean and extreme precipitation, water levels and river discharge rates at selected hydrometric sites.

Hydrologic models can determine water balance compounds in different mesoscale basins. In spite of some uncertainties, they can be considered as a practical tool for hydrologic simulations and thus, a useful basis for further ecological applications. Various types of GIS software help to visualize the modelling results, which should be supported and validated by experimental data obtained directly on-site (e.g. soil moisture, leaf area index, meteorological parameters, hydro-physical properties of soils etc.) before drawing conclusions.

Recommendations for future research. (1) Crucial means for a proper water management in the region would be the initiation of a 'Water-environmental information and monitoring system' (Carpathian river network; experimental, representative and semi-natural basins). (2) Future hydrological change in runoff, flood formation, low flow and droughts, groundwater recharge, evaporation and erosion as a hydrological response to the climate changes should be quantified in Carpathian river catchments. (3) An international effort to publish a 'Hydrological Atlas of the Carpathian Mountains' is needed. (4) International research is required on the adaptation of water conservation and water resources management strategies in trans-boundary river basins. (5) The efforts that should lead to future attainment of good ecological state of watercourses require a renewed increase of their morphological diversity and re-establishing of the longitudinal continuity of their ecosystems.

Observer's Notes. The session gathered actors in water management from different regions discussing the influence of land cover (e.g. forest stands and forest type) on spring water quality, land use impact on karst lakes, management impact on river ecology and river restoration. It was highlighted that the hydrographic map database available for Poland could be a promising approach to harmonize data over the whole Carpathian area. An integrated methodology and approach would be desirable for the entire Carpathian range.

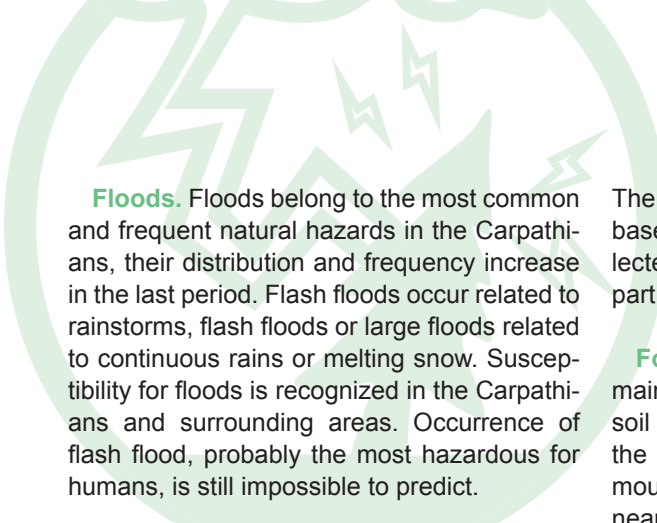
2.4 Natural hazards and risks



The session covered a large variety of topics including geomorphic and hydrologic hazards (landslides, snow avalanches, floods, soil erosion), climate hazards (convective rainstorms) and forest fires in a wide geographical area of the Carpathian mountains. Recent transformation of relief in the Polish Carpathians was shown based on quantitative data with the emphasis on the role of extreme hydrometeorological events. The main techniques in use were based on GIS and remote sensing, representing a significant step forward in the evaluation and mapping of the susceptibility, vulnerability and risk. Yet, as most of contributions presented results of local or regional case studies, the information of natural hazards in the Carpathians is far from being complete. The results of some significant projects (e.g. SOPO or avalanche surveys in the Tatras or the Fagaras), as well as some important issues (e.g., debris flows) were missing.

Landslides. Landslide hazards occur especially in flysch mountains, but differs much in particular parts of the Carpathians mountains. Using GIS and remote sensing, susceptibility, vulnerability and risk are evaluated for some regions, especially in the Romanian Carpathians. The landslide registration system was developed for the Polish Carpathians in the SOPO project.

Avalanches. Recognition of snow avalanche hazard is still a challenge in the Carpathians. Avalanche mapping using satellite navigation systems and assessment of avalanche hazards using modeling, geophysics and geodetic techniques is currently carried out for the Tatra Mountains, besides Tatras, the avalanches are surveyed also in the Fagaras Mountains (Romania).



Floods. Floods belong to the most common and frequent natural hazards in the Carpathians, their distribution and frequency increase in the last period. Flash floods occur related to rainstorms, flash floods or large floods related to continuous rains or melting snow. Susceptibility for floods is recognized in the Carpathians and surrounding areas. Occurrence of flash flood, probably the most hazardous for humans, is still impossible to predict.

Soil erosion. Risk of soil erosion is highest in the Carpathian Foreland or in large basins where agriculture is still a dominant activity.

The assessment of soil erosion risk can be based on existing long-term data series collected at research stations located in different part of the Carpathians or on modeling results.

Forest fire and forest decay. Both are main types of hazards related to forest and to soil erosion. Forest fires are relatively rare in the Carpathians when comparing with other mountain regions of Europe (e.g. Mediterranean area), but their risk increased recently in connection to climate change, especially due to more frequent drought events.

Recommendations for future research. (1) International standards are needed for the evaluation of the main hazards; in particular, (2) an interdisciplinary assessment approach to evaluate the relation between natural hazards, human pressure on the environment and climate change is required, including the interaction with land use and changing landscape patterns. (3) Dynamics of mountain system should be addressed in the framework of catchment areas as basic areal units of the mountain landscape; monitoring and assessment of complex natural hazards should also take into account spatial and temporal scales and catchment hierarchy level. (4) Monitoring of extreme events of various types of natural hazards is needed.

Observer's Notes. Hazards are a strong concern to both public authorities (e.g. spatial planners) and academics, which would both benefit from closer cooperation. Research could allow informed decision-making, including intervention to amend the law, e.g. in terms of measures to increase protection against landslide risk. A key question is the weight attributed to different parameters, e.g. when assessing risks, what quantitative or qualitative methods have to be used, and if the new methods could be introduced to predict areas of potential landslides.

2.5 Land use and land cover change



Land Use and Land Cover Change (LULCC) is identified as a cross-cutting topic covering different research domains such as forestry, agriculture, hydrology or climatology. From a systemic point-of-view, LULCC research is closely connected to the evaluation of changes in ecosystem services and biodiversity. It is apparent that results from LULCC analyses will fuel research focusing on carbon cycling, biodiversity

and – specifically when analyzing drivers of change – on the socio-economic context.

Methodologically, LULCC research is closely connected with remote sensing data analyses. Implicitly, questions of scale, proper analysis schemes, and the appropriate thematic depth of results are of great importance. Accordingly,

LULCC research based on remote sensing analysis needs to be integrated with informa-

tion from statistical surveys, field based information and appropriate geospatial datasets.

Recommendations for future research. Strategically, LULCC research opens up opportunities to further (1) integrate research across the whole Carpathian mountain range, including its foreland. While a lot of excellent research results are available across all scientific domains in all Carpathian countries, we often lack basic knowledge about the pan-Carpathian ecological, social and economic background. Next, (2) broad-scaled pan-Carpathian studies as well as meta-studies combining research from different sites is urgently needed. Ultimately, (3) the provision of homogeneous information on past and future LULCC and its drivers for the whole Carpathian region is an important goal.

Observer's Notes. The session focused mainly on forests but also addressed questions related to agriculture. It identified a strong need for homogenized datasets on LULCC that is better than CORINE Land Cover and spans both EU and non-EU countries (in particular Ukraine). The session showed that continued monitoring of Carpathian ecosystems is important, as highlighted by the rapid land changes instigated by the EU accession of some countries or the forest restitution in Romania. While lots of effort targets on the mapping of land use and land cover in the Carpathians, studies on future land use are missing.

2.6 Forests, their management and resources

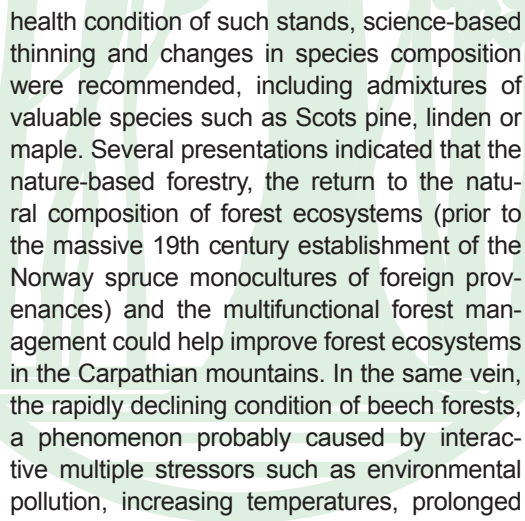
Forests are an integral component of the Carpathian Mountains fulfilling many important functions for the entire region. They are crucial for soil formation, slope stability, water retention and supply, preservation of biodiversity, carbon sequestration, conservation of endangered habitats, supply of corridors for migration of rare and endangered wildlife species, recreational use, and for timber production.

The two forestry sessions covered various topics, such as forest environment, water cycling and quality, biodiversity, preservation of natural resources, silviculture, forest management practices, stakeholders perception of ecosystem services, and new innovative techniques used in forestry science.

Functioning of forest ecosystems is affected by changing chemical environment and climate. This includes changes in nutrient cycling, eco-

physiological processes, regeneration and growth of trees and other species, as well as water availability and resources. Extreme climatic events such as the 2003 drought had pronounced effects on ecophysiology of sessile oak in Hungary while climate change observed in the 20th century significantly affected timberline dynamics in the Carpathian range. Forest functioning and health depend on the effects of multiple interactive stressors, such as air pollution, climate change, outbreaks of pests and diseases, and improper management practices. Important changes are observed in forest biodiversity and species composition, including lichens, herbaceous plants and trees, as described for different parts of the Carpathians. Decline of the Norway spruce monocultures has been extensively occurring in the western Carpathians, and reported in Poland, Slovakia and the Czech Republic. To improve the





health condition of such stands, science-based thinning and changes in species composition were recommended, including admixtures of valuable species such as Scots pine, linden or maple. Several presentations indicated that the nature-based forestry, the return to the natural composition of forest ecosystems (prior to the massive 19th century establishment of the Norway spruce monocultures of foreign provenances) and the multifunctional forest management could help improve forest ecosystems in the Carpathian mountains. In the same vein, the rapidly declining condition of beech forests, a phenomenon probably caused by interactive multiple stressors such as environmental pollution, increasing temperatures, prolonged drought and unfavorable management practices, should be considered as a research priority.

Examples of new scientific tools and techniques to advance forestry research were presented. Computer tomography, for instance, is a promising technique that has been used for an assessment of wood decay in the Sil-

ver fir stands in the Polish Carpathian forests. Integrating LiDAR with GIS has facilitated the preparation of databases and mapping of trees, while the airborne laser scanning has helped characterizing selected forest inventory parameters in the Tatra National Park, Poland. To quantify above-ground biomass of spruce forests in the western Carpathians a modeling approach combining field observations and remotely obtained data was presented.

The necessity of international forest research collaboration to address complex issues of Carpathian forests was emphasized, giving the example of the EU FP7 Project BACCARA, which focuses on forest biodiversity and gives guidelines for forest managers and policy makers dealing with risks to biodiversity caused by pests and pathogens under the currently occurring climate change. FORZA, the Swiss-Ukrainian collaborative program that aimed at developing the science-based strategies for forests of the Transcarpathian Region was taken as a second example.

Recommendations for future research. (1) The understanding of long-term climatic and chemical environmental changes needs to be improved. In a second step, (2) the interactive effects of multiple stressors on ecophysiology of key forest tree species should be investigated. (3) Biodiversity changes, especially from a perspective of rare and endangered species and invasive plants should be evaluated. (4) The present and future effects of environmental pollution, climate change and management practices on water resources should be investigated. (5) The effects of forest management practices in various countries on the sustainability of Carpathian forest ecosystems should be studied. (6) New techniques for improved inventories of below- and above-ground biomass and carbon pools should be developed and tested. (7) Ecosystem services and their risks caused by multiple interactive stressors should be evaluated together with (8) the public perception of the importance of forests and ecosystem services for the Carpathian mountains.

Observer's Notes. As vegetation responds to a warming climate, the forest session clearly overlapped with the issues discussed in the Climate Change session. The whole session could be summarized with two words: spruce dieback. Spruce dieback is a common and most pressing concern for the entire region and has already stirred a number of joint activities. Many monitoring activities with traditional and new techniques are ongoing and numerous adaptation measures have been taken in response.



2.7 Conservation and sustainable use of biodiversity

Population genetics. Several studies showed that despite fragmented distribution in Carpathians or even in one mountain range, species like *Pinus cembra*, *P. sylvestris*, *Dianthus callizonus* are able to maintain viable populations, and for species survival other factors than genetic structure are critical (e.g. habitat availability or disturbances). Despite their small size, Carpathian populations of *Pinus cembra* were able to maintain high haplotypic variation, even higher than Alpine populations, which indicates that currently fragmented and isolated populations represent remnants of former continuous distributions. Genetic analyses represent valuable tools for historical analysis of species distribution, for analysis of genetic diversity and population viability.

Species. The high species richness of the Carpathians is still not sufficiently known. As knowledge gaps exist of endemic and rare species for which the Carpathian countries have high responsibility, research on endemic taxa should be fostered. The studies of closely related species, species complexes and aggregates are highly needed; recent modern methods can be applied for them. Several presentations highlighted the importance of remnant refugees for some fungi, plant and animal species. The depopulation of rural areas can have negative consequences for biodiversity of cultural landscape. On the other hand, it offers also new opportunities for conservation of forest species and mammals with large area requirements, such as the European bison. However, most local populations of this species remain relatively small and isolated despite suitable habitats. The potential for growth of European bison population is especially high in Ukraine and Romania, whereas north-south running major highways, the isolation of existing European bison herds and poaching are limiting factors.

Habitat. The old-growth forests in protected areas serve as natural reference about biodiversity, including species, stand structure and ecological processes of forest ecosystems. The obtained knowledge can be used for developing management guidelines for biodiversity conservation in managed forests. Further, the Carpathians are rich on natural and semi-natural grassland types that contribute significantly to the biodiversity of Carpathians landscapes. However, they are strongly influenced by land use change, intensification of agriculture and land abandonment and currently belong to the most threatened habitat types.

Landscape. In contrast with most other regions of Europe, the Carpathians host steep gradients in land use intensity among regions. This provides opportunity to study relationships between land use and biodiversity among contrasting landscapes. Implementation of policies about conservation and restoration of aquatic ecosystems requires rapid biodiversity assessment methods that will be applied in multi-disciplinary framework. The indicator taxa approach can be useful for this purpose, and indicators that reflect biodiversity values can be applied in spatial planning and support of policies implementation, e.g. EU Water Framework Directive. The ecological networks like Pan-European Ecological Network (PEEN) and National Econet of Ukraine have high importance for conservation of biodiversity in Carpathians. Activities in this field should be followed by adequate measures for maintaining and improving connectivity between areas important for biodiversity.

Recommendations for future research. (1) To initiate and foster comparative and retrospective biodiversity studies with pan-Carpathian coverage. (2) To initiate special program for the study of endemic Carpathian species paying attention to factors that jeopardize these species and to measures that will eliminate the influence of these factors. (3) To study in detail native forests in strict forest reserves and to use those results as reference for managed forests. (4) To look for suitable biodiversity indicators that are easy measurable and can be used for policy implementation at local and regional levels in cultural landscapes, forests and aquatic systems.

Observer's Notes. The session was incredible diverse, covering a wide range of taxa, scales, and ecosystems. One recurring topic was the importance of grasslands, which are currently lost rapidly. Grasslands are threatened by the abandonment of traditional grazing systems, but also because grasslands cannot be managed within strictly protected areas. This raised the question what conservation approaches would be more suitable for the Carpathians, one focusing on strict protection or one promoting low-intensity land use in a larger area.

2.8 Ecosystem services and human well-being



Ecosystem services (ESS) is an emerging concept linking various facets of the environmental dynamics with its value for society. Part of the presentations at the 1st Forum Carpaticum dealt with problems and methods of ESS identification and valuation, dealing, for instance, with carbon sequestration, wild-

life habitat provisioning and recreation. Other studies focused more on stakeholders' perceptions of ESS in the studied areas with some reflections of local economy perspectives. Research was often carried out in protected mountain regions with prevalent forests.

Recommendations for future research. (1) A clearer understanding of the concept of multiple ESS and of approaches for their evaluation should be developed. (2) Especially novel non-market methods to evaluate regulating and supporting ESS should be developed further requiring an even closer cooperation between ecologists, socio-economists, political and other specialists. (3) Importance should be attributed to the institutional analysis and to the analysis of new forms of governance with more active public engagement in the decision-making process on issues that concern sustainable provision, management and use of ESS. (4) Climate change and biodiversity are cross-cutting themes that merit more attention from the side of social and political scientists. (5) To improve human well-being, local knowledge should be better assessed and comprehended through the consultation with relevant stakeholders and the public on sustainable use and management of ESS.

Observer's Notes. This session had a wealth of technical information, economical formulas and discussions on the valuation of ESS. Ongoing habitat degradation and exploitation of wildlife stirred the question of how carbon credits and payments for ecosystem services could generate funding for natural resource management and protection of biodiversity. Several presentations focused on Ukraine (e.g. stakeholder surveys) with reflections on forest policy and illegal logging.

2.9 Integrated land resource management and regional development policy



Presentations in the framework of this session focused on problems related to sustainable governance and management of forested and traditional agricultural landscapes, emphasizing preservation of biodiversity and ecological connectivity. The presentations touched issues of trans-boundary cooperation in the Carpathians, management of protected areas and historical landscapes, impact of tourism on cultural landscapes, bio-energy, and networking between science and practice.

Various approaches to the integrated land resource management and regional development were presented: geo-spatial (geographical), ecological, and socio-economic / political, typically combined in a variety of ways. Several studies were based on new data gained via field observations and measurements, remote

sensing, and GIS analysis. Some studies relied on integrated information from other sources.

The lively discussions among the participants dealt with ecological networks and connectivity, sustainable forest management, carbon sequestration, preservation of historical landscapes and conservation of rural biodiversity (especially in grassland habitats) threatened by changes in agricultural areas. Much attention was devoted to the concept of the Carpathian Ecoregion, considered as a large biological entity. Studies on comprehensive (cross-sectoral) physical (spatial) planning based on the landscape-ecological approach and on participatory governance were clearly underrepresented.

Recommendations for future research. (1) To pay more attention to the issues of sustainable cross-sectoral planning on local and regional levels. (2) To study the possibilities of the unification of data and methods for studies on integrated land management in the different parts of the Carpathians. (3) To consider a wider use of remotely sensed data available for the whole Carpathian Ecoregion.

Observer's Notes. The session focused on topics such as ecological networks, boundaries, connectivity across borders (e.g. Carpathian Ecoregion as a large biological entity), cooperation, sustainable forest management, old-growth management, carbon sequestration, biodiversity resources, historical landscapes, and other changes in agricultural areas. A lot of biodiversity studies are conducted on grassland, as this habitat is most threatened due to the loss of cultural and historical landscapes.



2.10 Urban and rural development

The session reported findings on the role of large enterprises for the development of rural communities in the Polish Carpathians. A large variation in the presence of such enterprises with general decline from the west to the east was found. This observation corresponded with the pattern of declining spatial accessibility. Larger enterprises have a rather limited impact on local development, as they are located in areas where development is anyway rapid and driven by multiple factors. These findings go along with the reported regularities in the development of cities in the Polish Carpathians over last 20 years. They have confirmed stronger position of cities in the western part.

Accessibility is of crucial importance for the development of rural areas and well-being of their inhabitants. It was shown that the accessibility in rural areas of the Western Carpathians in Poland, Slovakia and the Czech Republic was comparable to accessibility in the Swiss Alps (Kanton Uri), although there were

large internal variations depending on the location and size of the villages. Poor or very poor accessibility was reported for the Eastern Carpathians in Poland and Slovakia.

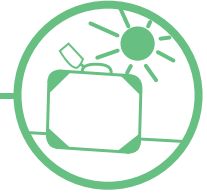
The concept of functional urban areas could be a promising approach not only for research but also for planning if applied instead of administrative units. Improving the methodology of delimitation of Functional Urban Areas in Romania using GIS could contribute to better spatial planning.

More advocacy is needed for an integrated approach of practitioners, planners, scientist, politicians and local people for achieving the best results with regard to sustainable rural development. Landscape could be used as a concept and tool for knowledge production and social learning, hence the name “landscape laboratory” was coined.

Recommendations for future research. (1) The need for further research on the socio-economic context of the overall development and sustainability in the Carpathians. (2) Integration and cooperation between scientists towards valuable pan-Carpathian research needs to be fostered, while the S4C initiative was found to be the best platform to achieve this goal.

Observer's Notes. The session was highly diverse with each paper covering a completely different topic. Spatial patterns of economic activities and history of urban and rural areas were main issues. Both influence local development and have a high impact also on economic and social performance. Another issue was the identification of functional urban areas, e.g. through assessments of commuter flows.

2.11 Tourism and sustainability



Presenting contemporary models, directions and development strategies of tourism in the Carpathian countries, the tourism session clarified the complexity and the diversity of tourism development processes in the region and showed how deeply tourism development is determined by the socio-economic transition in individual countries. There seems to be a general consent on the crucial role the concept of sustainability plays in the contemporary planning of tourist development and the shaping of the tourist function in the rural and protected areas in the Western Carpathians. However, the environmental impact of tourism depends also largely on the models of tourist development in the socialist past, such as mass second homes construction and the

social holidays. Furthermore, ecotourism and geotourism could play a role as alternative forms of tourism and options for sustainable development in Romanian rural communities. The concept for a trans-Carpathians hiking trail was proposed as a tool for integrating nature and cultural values for tourism along the Carpathian mountain range. In stark contrast to the strong emphasis on the importance of tourism for local and regional development, related problems and unwanted side-effects were not discussed (e.g. spa tourism, ski investments, agrotourism, cultural tourism, international and regional competitiveness, environmental impact of intensive forms of tourism development).

Recommendations for future research. (1) To initiate and foster comparative studies in the adjacent and trans-border tourist regions; (2) to study in detail the features and the changing trends in tourism demand with special focus on trans-border contexts; (3) to identify the barriers of social involvement and activity in tourist sector with the special reference to rural communities; (4) to initiate special programs for creating good practices in sustainable tourism development and spreading them among local authorities and entrepreneurs.

Observer's Notes. On the background of the late socialist period and the time of market transition, Carpathian mountain tourism developed in a very specific way. Current challenges include finding the balance of sustainable tourism development regarding both the economic development and environmental protection. Topics that were touched in the discussion included secondary housing in the Carpathians, tourism activities and development opportunities in the Polish Protected Areas and Biosphere Reserves. The session provided insights on potential development paths in special geological and geomorphological sites (e.g. geoparks) or long-distance hiking trails. It addressed opportunities but also challenges related to global employment risks and employment in local communities. The development of management tools for sustainable tourism development in the Carpathians is a main future task.

2.12 Traditional knowledge



This session presented a wide range of studies with focus on local knowledge of people living close to the natural landscape. The field is highly interdisciplinary: botanists, anthropologists, psychologists, sociologists, land-use planners, linguists and historians work together to understand traditional knowledge and not only require a sound knowledge of the landscape, but should also master the local language.

As an information source for nature conservation, the study on the perception of vegetation and landscape by Csángó people (Eastern Carpathians) could be used. Another study approached the subject investigat-

ing the discourse of space and memory of a minority (Lemkos) living in Poland and Ukraine. As shown in a further study, traditional village systems can play a vital role also for sustainable management of forest landscapes in Ukrainian Carpathians. Finally, the history of pasturing in the Carpathian-Balkan space was analyzed based on Romanian names for shepherds.

All examples underlined the fact that local traditional knowledge is vital to the understanding of local societal and landscape changes, and to the planning of development or nature conservation in rural areas.

Recommendations for future research. (1) To increase understanding of local community attitudes towards landscape change, and nature conservation. (2) To document traditional knowledge in selected landscapes along the Carpathian chain. (3) To promote efficient use of local knowledge in planning agricultural and nature management of the Carpathians.

Observer's Notes. The question how the disappearance of traditional cultural landscapes with the entailed traditional knowledge systems can be mitigated or prevented was at the core of this session. Two scenarios might apply to the development of traditional rural areas: the first with the introduction of tourism, the second where existing cultural landscapes are maintained. It is unclear which development path would and should be preferred.



► S4C Workshop 2008, Institute of Geography and Spatial Management, Jagiellonian University, Kraków, Poland.

3 IMPLEMENTING THE RESEARCH AGENDA

With its broad goals, S4C activities, including the 1st Forum Carpaticum, not only offered a conducive environment for the integration of science and practice towards sustainability, but also facilitated and promoted the coherence between national research activities, which has been suggested by the Interim Secretariat for the Carpathian Convention. The vivid discussions among the members of the mountain research community at the 1st Forum Carpaticum were continued by S4C members in the preparatory phase to the next Forum Carpaticum in 2012. They allowed to identify the most important topics for future research in various fields, and also to formulate the key issues to organize and foster science in the Carpathian region.

1. From agenda to action

In due consideration of global trends and guided by policies implemented at the European level, the preliminary priority topics listed in the present document, in various fields ranging from climate change and water management, through biodiversity conservation to regional development and preservation of traditional knowledge should be refined in consultation with experts from research and practice, promoted and implemented through the S4C network.

2. Advocacy for the Carpathian Research Area

Enhancing the visibility and accountability of the Carpathian mountain research community is crucial both at the European and global levels. International research partnerships will increase the research capacity in the region, which will in turn open access to international funding schemes (e.g. Framework Programs of the European Union). In the same vein, advocacy for a 'Carpathian Space Program', similar to the 'Alpine Space Program' for the Alpine Bow, should be high up in the political agenda of the Carpathian countries to allow the expansion of international research collaboration.

3. Funding for research coordination and networking

The coordination of scattered activities towards integrated, trans- and multi-disciplinary approaches is urgently needed to counter the current fragmentation of the Carpathian research efforts. This includes also the development of common protocols for data acquisition, research methods and indicators leading to pan-Carpathian information systems. The S4C initiative is so far hosted by the MRI-Europe Program, Institute for Mountain Research: Man and Environment of the Austrian Academy of Sciences and relies to a great extent on volunteer work of devoted scientists and experts from various countries. A minimum pre-requisite for a sustainable functioning of the S4C initiative is a regional S4C office with a long-term financial and institutional support from the benefiting nations.

4. Promote coordination and collaboration between national research programs

Institutions working in the field of mountain research and education should seek better information exchange and concerted actions at the national and international level, both in policy and implementation. Pan-Carpathian studies across the national boundaries are needed, similarly as meta-studies merging the results of small-scale case studies carried out in various countries of the region, breaking the language barriers and the nationally-centered research tradition of the past.

5. Data: availability, quality and access

A pervading theme in a majority of discussions reels around data: the need of getting better access to existing data, better knowledge of data quality and the generation of new data in a manner that allows data sharing among researchers. Provided that data is available, pan-Carpathian or meta-studies compiling and synthesizing the results from different parts of the region are imperative. The DIAMONT project (<http://www.uibk.ac.at/diamont>) is an example of an Alpine effort to compile and share data on a joint platform. The issue of data integration and harmonization fits also very well to the actions of the European Commission under the INSPIRE Directive (<http://inspire.jrc.ec.europa.eu>).

6. Strengthening national research capacities

National research will need appropriate and reliable resources with long time frames, which are a prerequisite not only for the generation of meaningful data series but also for the ability to generate integrated and visionary solutions addressing future challenges.

7. Foster dialogue between research and practice

Today's science system fosters disciplinary and highly competitive research largely preventing researchers from entering a dialogue with other disciplines or investing time in knowledge dissemination to potential user groups. The S4C initiative views it as a societal responsibility to deliver scientific knowledge in a form useful to potential beneficiaries, contributing ultimately to the sustainable development of the Carpathian region.

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ANNEX I

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Natural Hazards and Risks

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ANNEX II

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ANNEX III

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More information on the 1st Forum Carpaticum:
www.forumcarpaticum.org
<http://mri.scnatweb.ch/networks/mri-europe/carpathians/>

S4C – Research Agenda for the Carpathians 2010 - 2015

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