BIODIVERSITY AND ENVIRONMENTAL PROTECTION OF SOUTHERN ALTAI

CHLACHULA Jiri

Abstract. The Altai, being a major central Asian mountain system, represents an integral part of the World natural and cultural heritage with diverse ecosystems incorporating specific geographic and topographic zones and hosting rich and unique biotic communities. The broader Altai region has been for several thousand years a traditional and naturally productive habitation area of formerly exclusively pastoral semi-sedentary communities that are being gradually replaced by present-day rural and small urban settlements during the last decades. The present Altai faces an intensifying environmental stress due to global climate warming with accompanying and sometime rather pronounced natural transformations coupled with an increasing socio-economic pressure due to growing material needs of local people as well as the national economies. A modern approach including a multi-level systematic biodiversity monitoring based on inter-linked geo-contextual and biotic studies applied uniformly over the bordering (Russian-Kazakhstan) Altai areas offers an effective documentation, evaluation and control of the on-going biodiversity degradation and ways of its potential conservation. The results from the systematic biodiversity investigations in Gorno Altai (Gorno Altai Republic, Siberia) and Southern Altai (Eastern Kazakhstan) still confirm a pristine natural character and a relative stability of the presently established Altai ecosystems, but also an insufficient level of modern biodiversity protection and environmental management. The present (global) climate change is evident in the topo-geographic structure of the Altai biotopes including an altitudinal shift of vegetation zones as well as expansion of parkland-steppe that implicate new requirements on management of natural resources in balance with the broader Altai biodiversity protection priorities.

Keywords: Altai, biodiversity, environmental management, climate change, ecosystems.

Rezumat. Biodiversitatea şi protecţia mediului în Altaiul de Sud. Altaiul, un sistem muntos principal din Asia Centrală, reprezintă o parte integrantă a patrimoniului mondial ca urmare a diverselor ecosisteme care includ zone geografice şi topografice specifice şi adăpostesc comunităţi biotice unice. Regiunea Altai a fost de câteva mii de ani o zonă de locuire tradiţională şi natural productivă a comunităţilor semi-sedentare exclusiv pastorale, care, în ultimele decenii însă, au fost continuu înlocuite de aşezări rurale şi mici aşezări urbane. Astfel, în prezent, Altaiul se confruntă cu intensificarea presiunii mediului ca urmare a încălzirii globale, care este însoţită de transformări naturale destul de profunde şi de creşterea presiunii socio-economice indusă de nevoile materiale tot mai crescute ale localnicilor şi economiei naţionale. O abordare modernă care să includă monitorizarea sistematică a biodiversităţii bazată pe studii geocontextuale şi biotice realizate uniform în regiunile din jurul Altaiului poate să ofere o documentaţie eficientă, să faciliteze evaluarea şi lupta împotriva degradării biodiversităţii, modul în care se poate realiza o potenţială conservare. Rezultatele investigaţiilor privind biodiversitatea sistemică în regiunea Gorno Altai (Republica Gorno Altai, Siberia) şi în Altaiul de Sud (Kazahstanul de Est) confirmă caracterul natural şi o relativă stabilitate a ecosistemelor prezente în Altai, dar, în acelaşi timp, şi problemele legate de insuficienţa măsurilor de protecţie a biodiversităţii şi de managementul mediului. Schimbările climatice din prezent (globale) sunt evidente în structura topo-geografică a biotopurilor din Altai, inclusiv o modificare altitudinală a zonelor de vegetaţie, precum şi extinderea stepei, ceea ce implică noi cerinţe privind managementul resurselor naturale care să fie în concordanţă cu priorităţile legate de protecţia biodiversităţii din regiunea Altai.

Cuvinte cheie: Altai, biodiversitate, managementul mediului, schimbări climatice, ecosisteme.

INTRODUCTION

This summary paper presents some achievements of the interdisciplinary studies on biodiversity protection and environmental management of southern Altai performed as a part of the Czech-Kazakh Development Cooperation program in the in Gorno Altai (the Kosh-Agach Region) and the adjacent Eastern Kazakhstan (Katon-Karagay and Kurchum Districts) followed by initial preceding studies in Gorno Altai (2002-2005) (e.g. CHLACHULA, 2001, 2003; RICANKOVA et al., 2004). The main objective of field and analytical laboratory studies was mapping of the zonally specific biotic variety in order to support the present biodiversity protection particularly in the Altai mountains in the context of sustainable development of the trans-border Russian-Kazakh region geographically encompassing the adjacent areas of the Katon-Karagay National Park (Fig. 1), the Markakol Lake Nature Reserve, the Plateau Ukok (the present Ukok National Park) and the Katunsky Zapovednik State Nature Reserve (CHLACHULA & GAZALIEV, 2007). The resulting geo-contextual information and taxonomic databases, including some poorly known as well as non-described species of small flora (bryophytes) and fauna (invertebrates), were evaluated by means of corresponding programs and represent a vital source of data for GIS-s of the monitored geographical areas of Gorno Altai and East Kazakhstan. The long-term objectives following this pilot project include a complex evaluation of the main natural and anthropogenic risks to the unique Altai biodiversity, including the most endangered species of flora and fauna, in order to assess, prevent or slow-down the progressing environmental degradation of the pristine mountain ecosystems. The principal goal of current international activities is aimed at establishment of an integrated trans-border concept of effective biodiversity protection strategies and vital conservation rules, balancing a long-term sustainable economic development in the framework of the Altai-Sayan Eco-region. The present and globally-acting environmental pressure on the local biodiversity, reflecting climate change and corresponding natural transformation, is confronted with similar trends observable in Central and Eastern Europe in comparable (mountain and lowland) ecosystems. The present results add to the existing information from the Altai-Sayan Eco-Region. Field documentation (on a regional and local scale)

was an integral part of biodiversity mapping on the territory of the Altai particularly in relation to geo-botanical studies The applied Quaternary ecology approach is based on the identification of the diagnostic abiotic and biotic factors defining the status of a local biodiversity health, stability and/or rate of environmental change.

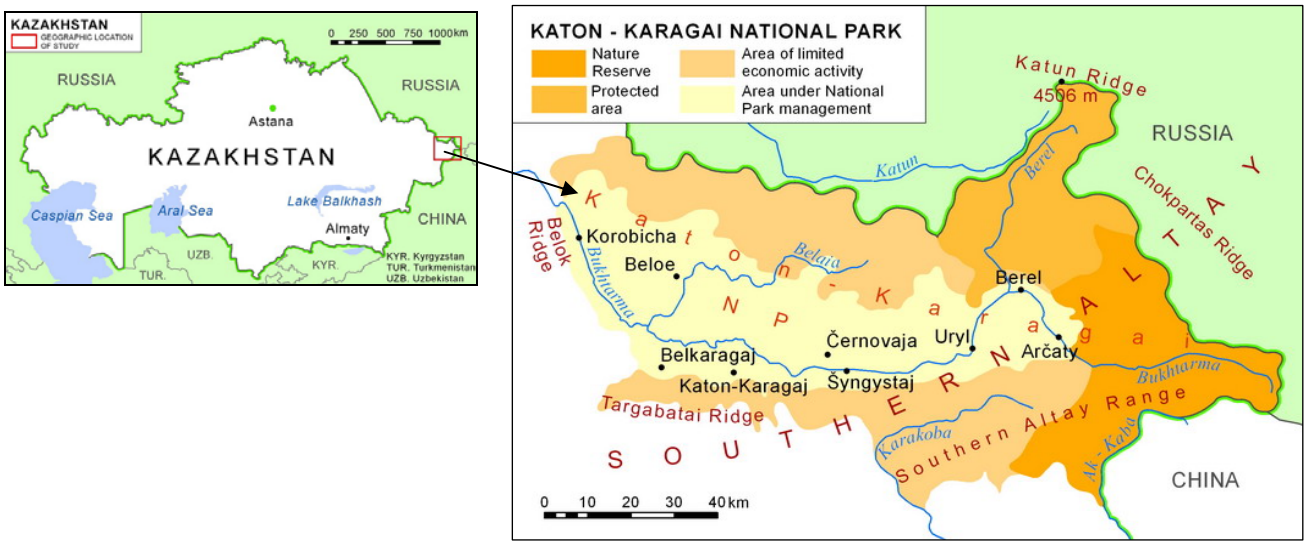

Figure 1. Geographical location of the study areas, Katon-Karagay National Park. / Figura 1. Poziția geografică a zonelor studiate, Parcul Național Katon-Karagay.

MATERIAL AND METHODS

The applied field and laboratory methodology in investigating the southern Altai mountain and parkland-steppe ecosystems was based on a geographically consistent and complex environmental system approach of interdisciplinary geosciences, biosciences, socio-economic and culture-historical studies applied on the territory of Gorno Altai, southern Siberia, in a geographic linkage with the parallel investigations in East Kazakhstan. The main aim was to provide a GIS database for environmental management of natural resources and effective nature protection strategies. Biotic, abiotic and statistical data were systematically collected during particular expeditions and subsequently analytically processed.

RESULTS AND DISCUSSIONS

1. Contextual Quaternary Environmental Studies and GIS

Interdisciplinary Quaternary (geology, geomorphology, geography, pedology and GIS) studies represent the contextual part of the Altai biodiversity mapping. The investigations are aimed at elucidating the natural processes, their dynamic and relative/absolute chronology in terms of reconstruction of past climate evolution and (palaeo)environments since the Last Glacial until present, i.e., during the last ca. 100 000 years (CHLACHULA, 2001, 2005, 2009; EVANS et al., 2003). The Quaternary paleoenvironmental research carried out in the pristine Altai mountain and steppe areas displays a gradual and patterned climatic evolution leading to the establishment of the present-day climate and regional environments. Geomorphic mapping, included in GIS of the Katon-Karagay Nature Park, have focused on glacial landforms in the Bukhtarma valley, with the series up to 300 m-high glacio-fluvial terraces analogous to the geomorphic forms in the Katun, Argut and Koksu basins of Gorno Altai that provide evidence of cataclysmic floods at the end of the last glaciation and depict the history of subsequent fluvial processes leading to the formation of the present Altai drainage system. Intact profiles of aeolian deposits (loess) with horizons of buried fossil paleosols in Eastern Kazakhstan indicate a pronounced intensity of processes and marked climatic fluctuations of increased aridity during the Late Pleistocene and Holocene (CHLACHULA, 2010). The present climate changes are to be viewed as a natural part of this long historical process (CHLACHULA & SUKHOVA, 2011). Pedological studies were a part of the geobotanical mapping in the framework of GIS in respect to the distribution of specific biotopes and plant species. Quaternary studies also assess the current erosion due to on-going environmental transformations and anthropogenic activity. The geographical location of particular rocks correlates with the distribution of specific floristic communities preferring either basic or acid bedrock environment. The present soil cover, including primarily regosolic, podzolic, brunisolic and chernozemic soil groups, reflects the geological and pedogenic context and dominant soil forming processes.

A methodological basis of the contextual geo-data evaluation of biodiversity field mapping in the central and southern Altai area is represented by the geographic information system (GIS) and remote sensing control (RSC). The combination of the two methods allows complex and detailed analyses in terms of landscape ecology by synthesis of geological, geomorphological, petrological, pedological, geobotanical, floristic, zoological (macro- and micro-

biological), demographic, economic, social, culture-historical, archaeological and other databases. The generated geo-/bio-maps can be used for modelling of past and present topography, for reconstruction of the Quaternary climate history and dynamics of the region, as well as for monitoring of the acting natural processes, including potential geomorphic threads and hazards such as critical inundation areas, landslides and erosions (KUDA & MACUR, 2007; CHLACHULA, 2009). Computer simulations deliver various scenarios of possible natural rates of extinction of some most endangered taxa that are confronted with empiric terrain observations. The generated GIS-s have been further successfully used for calibration of satellite images in the framework of geo-botanical studies for definition of the principal vegetation types and biotopes in the trans-border Russian-Kazakh Altai study area (HOVORKOVA & CHLACHULA, 2010). The resulting information may eventually be used as a main tool for a future environmental management and development planning in the socio-economic sector on the territory of the Katon Karagay National Park (East Kazakhstan) that covers most of the formerly investigated area but also the adjacent Ukok NP and the Katun' Nature Reserve.

2. Biodiversity Studies

Geo-botanical studies determined 9 main vegetation formations comprising 25 specific vegetation types that were recognized in the Southern Altai and Gorno Altai (KOUTNY et al., 2003). The main defined GIS components of the landscape include taiga, alpine grasslands and shrubs, steppes, and secondary mesophilous meadows. The specific species composition of these communities consists of native species; very few introduced species (except for those directly planted by people) were found and no spreading of invasive species was recorded. The controlling environmental factors that influence the vegetation cover are altitude, topography (especially inclination and orientation of slopes) and intensity of human activity. In comparison with Gorno Altai, the adjacent Altai of East Kazakhstan exhibits in places a more humid climate, which results in a wider distribution of wet plant communities and a more reduced distribution of xerophilous flora. The southern Altai within the Bukhtarma valley is also much densely inhabited than the neighbouring Kosh-Agach region; therefore the structure of landscape and vegetation is more anthropogenically influenced. An adequate (not-exceeding a moderate) level of human activity exposed to the pristine landscape is crucial for the maintenance of a high local biodiversity. Overall, the research results clearly demonstrate the high biological value of the studied areas of both the Gorno and Southern Altai, which are worth being protected (HRADILEK & CHLACHULA, 2010).

Systematic biology studies were also carried out on the micro-vegetation biodiversity in marginally explored mountain and forest-steppe areas of southern Altai. Several taxa of cyanobacteria and algae were identified in the principal biotopes (rivers and streams, backwaters, irrigation channels, lakes, high-tundra periglacial and barren land settings, snow fields, and pedogenic /soil cover/ environments) of a territorial topographic range of ca. 400-3 900 m asl. on the basis of morphological phenotypes and ecological demands, displaying a remarkable taxonomic variability, including several non-described endemic species of algae adapted to locally specific geo-environmental conditions. A primary research of aquatic micro-flora was linked to both the assessment of the state of water purity as well as mapping of a taxonomical variety of lower plants and algae in the broader Altai region. The focus of field studies was aimed at evaluating a potential negative human influence on local pristine environments in all topographic zones and geographic areas. The investigated trans-border Gorno Altai – East Kazakhstan region, although sparsely populated, may experience a locally significant effect of anthropogenic pollution in the vicinity of settlements harming the local ecosystems. The assembled database derived from the main biotopes / habitats of the principal ecosystems (aquatic, terrestrial, air-related and snow-cover related) is used for assessing the quality of the main water drainages, particularly the Bukhtarma River with its tributaries, and for the species variability of cyanobacteria and algae that in general represent a very good proxy indicator of water quality.

The results show a limited impact of direct and indirect human activity to local environments (water sources) and minor ecological risks by present (traditional) exploitation of natural resources. All documented algal species are indifferent to water pollution and are common in clean water. Only a minor part of the algae taxa were identified as typical for polluted waters. Administrative regulations and systematic monitoring may contribute to the improvement of the polluted localities, particularly in places where economic activity is linked to mining. The pilot and very contributive results of the initial micro-botanical studies (CAISOVA et al., 2009) may serve as a background for a subsequent hydro-environmental work.

Fauna investigations have encompassed all levels of study from bacteria to large mammals. The studies of invertebrates in the East Kazakhstan Region (the Southern Altai Mountains) have been particularly productive. The zoological material included terrestrial arthropods, bristletails, earwigs, beetles, centipedes, millipedes, woodlice, spiders, harvestmen and diurnal butterflies evaluated within the principal model groups in diverse biotopes related to an arid semi-desert, (parkland-) steppe, taiga-forest, meadows (or pastures), alpine meadow and mountain tundra, following an altitude gradient. Several so far non-described species of centipedes found in the Katon-Karagay NP provide witness of a persisting potential for empiric biodiversity studies (TUFF, 2007). From the ecological point of view, affinities of some species in terms of typical biotopes or altitudes were found. Communities of the highest and the lowest topographic localities were relatively poor; the highest documented invertebrate diversities are between 1 000-1 400 m a.s.l. Monitoring of insects by the RFIT (Radio Frequency Identification Technology) may be in the local biodiversity context a highly productive source of quality information on a regional multi-level (macro- and micro-) biodiversity composition. Study of the environmental requirements and niches of the most sensitive taxa to

environmental changes in biotopes may significantly enrich knowledge of their ecology and contribute to the improvement of their protection in other countries. The entomological studies in southern Altai confirm the necessity of preserving the pristine heterogeneity of landscape for retaining the genofund variety of the area, with a differential degree of successive locality development that reflects ways of land exploitation. The new results enriched present knowledge of diversity of invertebrates of east Kazakhstan.

Systematic ornithological studies represented an integral part of complex GIS biodiversity investigations in the Altai and delivered new information particularly from marginally studied geographical areas. A particular attention was paid to the localities on the territory of the Katon-Karagay National Nature Park (the most protected sector- "zapovednik") as well as in the neighbouring parts of Gorno Altai (Katunskiy Zapovednik) with mosaic habitats of mountain as well as river-valley habitats (Fig. 2). The Distribution of specific bird taxa is influenced by the composition and structure of particular biotopes that in turn reflect macro-climatic, topographic as well as long-term anthropogenic factors. The present data of the ornithological research within the Kazakh-Russian border area indicates a unique character of the mountain regions with the inclusion of the Eurasian, Siberian and Central Asian elements of bird fauna, and with the occurrence of relict, rare and protected species (BUFKA, 2007). The completed ornithological distribution databases can then be used in respect to their quantitative and qualitative value, for monitoring changes of the Altai birds' biotopes and their protection in terms of primary biodiversity centres, as well as protection and management of secondary locations that are of main importance for local ornithocoenoses.

A key part of the zoological research was the documentation of endemic biodiversity particularly of environmentally very sensitive small mammals, such as rodents, and small faunal taxa living in rich geographically "transgressive" biotopes (SEDLACEK et al, 2007). Except for mapping an overall representation of an ecosystems biodiversity, a recording of new and original data on occurrences and frequencies of mammal species in poorly known areas may be of particular importance (RICANKOVA et al., 2006). The investigated localities of the Altai biotopes included arid steppe, parkland-steppe, taiga-forest, alpine meadow and mountain tundra. The RFIT monitoring has proven to be a useful and accurate tool for in-site documentation of spatial behaviour of small animals (vertebrate and invertebrate) that also provides a major potential in the frame of preservation of endangered ecosystems of the Altai-Sayan Eco-region (MATYAS & CHLACHULA, 2010). A DNA analysis of the selected faunal samples facilitates taxonomic determination of individual species. The summary data eventually contribute to the monitoring of natural processes and transformations of the interest area as well as to environmental management of protected and pristine nature regions of both Eastern Kazakhstan and Gorno Altai. The comparative analytical results coherently provide evidence of some increased rates of species recession than during the preceding decades. These shifts in ecosystems evidently reflect the present global climate change (warming and increased aridization) and related restructuring of mountain as well as parkland-steppe environments that are clearly observable in the Altai. Anthropogenic factors may play a minor role in this process.

3. Landscape Ecology and Environmental Management

The multi-facetted biodiversity studies carried out in the broader Altai during the last 10 years have provided new insights on the present Altai biodiversity composition, its status, mechanism and conservation priorities. The biotic and abiotic summary information assembled in the framework of GIS is crucially relevant for recommendations of environmental management and a future biodiversity monitoring on the territory of the Katon-Karagay National Park (6435 km^2) as well as the neighbouring naturally protected areas of Gorno Altai. The unique mountain ecosystems of the Southern and Central Altai with mosaic mountain habitats are regionally disproportionally influenced by people (Fig. 3). A biodiversity monitoring and a modern administrative concept, including systematic observation of fundamental model phenomena and documentation of key mammal species, are the main preconditions for a long-term and effective environmental protection of the threatened Altai nature. These species have primary relevance in terms of impact on the Altai ecosystems, the changing landscape structure and the main faunal food-chains. Taxonomy and diversity of single faunal species are still insufficiently documented. A large-scale registration and a systematic monitoring of the key species, including application of genetic methods and GIS (Fig. 4), is the conceptual basis. A very important role in the systematic monitoring of biodiversity plays a mutual symbiosis of individual species of flora and fauna at all taxonomic levels, pointing to the fragility of this natural biotic co-existence. Extinction of one species of plants usually means the disappearance of at least five insect species dependent on the particular floral taxon and a co-linked extinction of other species particularly of micro-fauna (e.g. endemic parasites). Among the most important aspects of the modern biodiversity loss is considered a termination and shift in the distribution of particularly unique mosaic but also most fragile alpine natural habitats that require most attention for their conservation. Equally important is a close international cooperation on protection of the Altai unique natural and cultural heritage.

4. Environmental Risks and Hazards

Environmental risks and hazards include both natural and anthropogenic factors-potential pollutants. Soil pollution was tested by the initial (paleo)microbiology investigations in Gorno Altai (Kosh-Agach District) concentrated on both the present pedogenic cover compared to some deeply buried fossil (Pleistocene-Holocene) palaeosol horizons intercalated in fine silty (loessic) deposits in the Altai (Katun' and Bukhtarma) valleys opening into the northern and western plains, respectively. The objective was to isolate and characterize the bacterial strains present in the local substrates to compare with those used for biodegradation of modern industrial xenobiotics. The pilot studies focused on diverse vegetation zones located in different altitudes characterized by specific ecosystems from both sporadically settled areas as well as the pristine Altai wilderness. The laboratory testing included preparation of

microbacterial solutions in phenol, naphthalene, toluene, xylene, ethylbenzene and benzene agars (KOUTNY et al., 2003). The study samples originated from differentially developed soils, ranging from an organic-rich, humid brown forest soil and a dark brown forest-steppe chernozem to a poorly developed regosolic high-mountain rocky semi-desert soil. The concentration of the detected bacteria strains in the complete KING-FU agar greatly varied, with the highest proportion of bacteria (up to 10^6 CFU/g) in the samples from more humid mixed southern taiga forest locations with mixed arboreal communities of larch (*Larix sibirica*), pine (*Pinus sibirica*) and birch (*Betula* sp.). The recorded phenol-degrading strains prove the presence of phenol in the pristine Altai environments *a priori* unexposed to modern industrial pollution. No other bacterial strains characteristic of industrial contamination were found. The final results support the assumption that some key enzymes used for the biodegradation of modern xenobiotics did apparently not develop in the reaction to the modern industrialization and the related anthropogenic pollution, but may occur in their natural forms promoting degradation of various chemical compounds derived from decomposing organic matter (plant tissue, etc.) (CHLACHULA et al., 2002).

Figure 2. The Jazovoye Ozero Lake setting, representing a unique pristine Altai ecosystems, Katon-Karagay National Park, East Kazakhstan. / Figura 2. Aşezarea Lacului Jazovoye Ozero, reprezentând un ecosistem unic şi nepoluat din Altai, Parcul Național Katon-Karagay, Kazahstanul de Est.

Figure 3. The Bukhtarma Valley, Southern Altai, East Kazahstan. / Figura 3. Valea Bukhtarma, sudul Altaiului, Kazakhstanul de est.

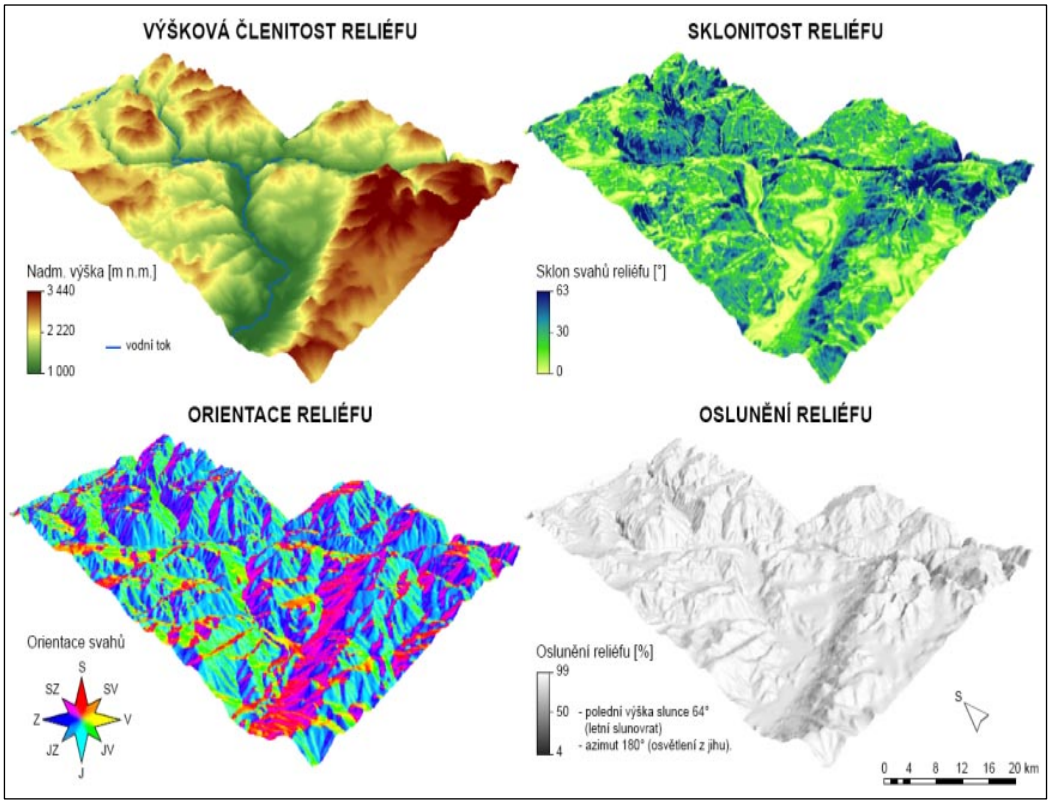

Figure 4. 3D-visualisation of relief (GIS) based on altitude, slope orientation, slope gradient and solar insolation (Uryl district, East Kazakhstan) (by M. Hovorkova). / Figura 4. Reprezentarea 3D a reliefului (GIS) realizată pe baza altitudinii, orientării versanților, pantelor şi insolației (districtul Uryl, Kazahstanul de Est) (de M. Hovorkova).

Other complex environmental studies focused on the present natural (geo-hazard) as well as on industrial ecology risk assessment with the following conclusions:

1. The present environmental risks and natural hazards in the broader area of Southern Altai should be regularly monitored and/or to some degree directly effectively regulated in the context of environmental management and socio-economic development.

2. The main natural risks (geo-hazards) linked to present global warming include desertification, increased fragility of vegetation cover, progressive salinization of seasonally water-saturated semi-arid areas, progressing soil erosion due to mechanical stress, disturbed slope / bedrock balance, seasonal storm floods and pedogenic degradation

3. The main anthropogenic risks that can be controlled represent forest fires, overgrazing by domestic animals, over-exploitation of forest resources, unregulated tourism, surface and ground water contamination by industrial toxic and radioactive waste.

4. Geological and palaeoenvironmental records (loess sections and biotic databases) may be used as highly climatically susceptible multi-proxy tools for the reconstruction of past and present climate change as well as for climate prognosis on the regional / global scale.

5. Focus on exploitation of renewable natural resources in accordance with modern ecological management represents a vital alternative of effective socio-economic development in both the steppe and mountain areas of the Altai-Sayan Eco-Region.

6. Conclusions of the present pilot Altai studies can be extrapolated into other areas of the continental Eurasia with most fragile ecosystems and transitional economies.

5. Natural Resource Exploitation and Sustainable Socio-economic Development

The fundamental aims and goals of the biodiversity research are oriented to the practical evaluation of the current state of agriculture and the related socio-economic situation, including its feedback on the Altai biotic diversity and its long-term perspectives in the trans-border Gorno Altai – East Kazakhstan region. Although the main source of information is provided by field research, contact with representatives of local communities is equally important. Principal information on the land exploitation and sustainable development plans, programs and priorities can be delivered by the official national administrations and ecological interest groups. The summary information on the particular geographic areas includes data on the present settlement and administrative structure, land use and the current agricultural production (such as crop production, animal husbandry and forestry). Comparison of selected agricultural criteria in the monitored areas is provided in respect to the overall economic development in East Kazakhstan and the Gorno Altai Republic. The main priorities of the present economic development of the region are linked with the support of the private rural economic sector, including production of roe deer (maral) and regulated eco-tourism in particular in congruence with the environmental management plans of the principal protected natural areas of southern Altai (NP Ukok, Katon-Karagay NP, Katunskiy NP-Zapovednik, Late Markakol Nature Reserve).

The main aim of the pilot field studies in the Altai was also to characterize and evaluate the current recreation use on the territory of the present Ukok Nature Park and the Katon-Karagay National Park, respectively, in view to the existing nature conservation and landscape protection regulations, and to make recommendations for promotion of sustainable tourism development in particular areas. The fundamental method of primary investigations was a multi-proxy field research in terms of characterization of the current recreation use of the protected area of KKNP and definition of its main features and future priorities. Terrain evaluations were completed by personal contacts and interviews with local participants (stakeholders) - managers of protected areas, rangers, local people, as well as tourism operators providing visitor services. The objective was to define specific aspects concerning the present offer of services for park visitors, receive a feedback from local people about their ideas, priorities and perspectives of socio-economic development of the protected areas, and about the future direction and preferences of recreation use in both Gorno Altai and East Kazakhstan. Main opportunities (strengths) and threats (weak points) for the sustainable tourism development in this border region were defined for each area separately and are up-dated. Especially the Kosh-Agach region is presently experiencing a dramatic and steady increase influx of both organized and individual tourists in the formerly closed and now accessible border zone, particularly (but not exclusively) responding to the establishment of the Ukok Nature Park in 2007. Identification of the basic long-term principles of a modern and sustainable tourism-development strategy and decisive indicators for conservation of the original pristine natural habitats of the Altai, their geographical range as well as overall quality is of major relevance to keep up with the increasing pressure due to the expanding and uncontrolled mass tourism. On the other hand, the local communities should profit from the influx of visitors directly (financial income) and indirectly (access road construction and improvement of infrastructure supported by the central government economic development programs where tourism plays the key role). Except for commercial tourism, the unique Altai nature offers unique possibilities for ecology educational courses and programs at all levels of the public and state sector, including university and joint international educational initiatives.

CONCLUSIONS

The present research results show a major potential for future systematic ecology studies as a part of complex natural monitoring and management strategy of protected areas of Eastern Kazakhstan, but also a limited impact of modern human activity on the quality of local water sources with only minor ecological risks resulting from the

traditional lifestyles of pastoralist communities. The Southern Altai is bio-geographically unique and belongs in respect to its peripheral geographic location to the least biotically investigated parts of central Asia. Application of modern technologies (satellite images, aerial vegetation mapping, GIS, or specific biological monitoring approaches, such as RFIT) shows new innovative ways of collecting and processing of biotic and contextual abiotic data related to environmental monitoring and complex ecosystem studies. Except for documenting taxonomically described species, the new techniques can provide a major assistance in the study of poorly known and/or so far non-described taxa of (lower) plants and small animals in the context of the local flora and fauna composition as well as the on-going environmental transformations. Fusion of the regionally assembled biodiversity databases can contributed to a better understanding of the main aspects of the Altai trans-border ecosystem functioning, including a year-around migration of particular species within single geographic sites in terms of the overall biotic community composition, its food-procurement hierarchies, mobility range, etc., in reflection to the pronounced seasonality and present global climate change. Necessity for protection of particular localities hosting the most endangered species is a strong argument for discussions about anthropogenic use of the corresponding biotopes.

The focus of future ecology activities based on the present experience should include:

- systematic documentation of the southern Altai ecosystems with a terrain reconnaissance of the principal study areas; revision and completion of the present biodiversity databases;
- evaluation of the current environmental management, particularly on the territory of Katon-Karagay NP, definition of new approaches for improvement of nature protection strategies, implementing modern technologies and methods;
- application of innovative techniques (e.g., RFIT) can be systematically implemented in biodiversity investigations in the Altai area and may entail various geographical locations and specific topographic zones with the widest range of particular (and selected) faunal species;
- advanced technical and personal support in the frame of the structural development of the state institutions, including transfer of methodical know-how and GIS databases;
- establishment of eco-bases for research, training and educational purposes;
- support of international cooperation (the multi-proxy Quaternary ecology, biodiversity and social studies), conservation of the Altai natural heritage in view of sustainable development.

Implications of multidisciplinary (geo-/bio-/eco-) field investigations, monitoring the present landscape transformations in respect to climate change, should add to an adjustment of the national environmental protection policies, management of the local sustainable development and state regulations in the economic exploitation of natural resources. A systematic geo-contextual approach in biodiversity investigations based on detailed geology/ geography and climatic studies in association with biological and socio-economic environmental aspects and priorities can be ultimately used for the improvement of the existing concept of biodiversity protection and conservation of the most fragile ecosystem in the broader Altai area. An exact and systematic monitoring of a seasonal as well as an annual spatial distribution and a particular floral and faunal species variety in its pristine natural environment is one of the key issues of the modern and multidisciplinary-oriented biodiversity-preservation strategy that can significantly contribute to a long-term Altai biodiversity protection and local environmental risk management. Modelled analyses of the regional / national park GIS databases can further redound to creation and a subsequent implementation of a uniform trans-border Altai biodiversity protection strategy based on an effective assessment of the specific mountain and parkland-steppe ecosystems as well as an optimal planning of the socio-economic progress.

ACKNOWLEDGEMENT

Field investigations in the Altai (2005-2007) were supported by the Czech Development Program and the Government of Gorno Altai Republic, the Russian Federation, and coordinated by IRBIS, Czech Republic.

REFERENCES

BUFKA L. 2007. *Diversity of Birds of Southern Altai (Study Results of 2006-2007).* In: Biodiversity Protection of Southern Altai in the Context of Contemporary Socio-Economic Development (J. Chlachula, Ed.). Final Report 2007. Altai: 83-103.

CAISOVA L., BAŠTA T., CHLACHULA J., KOMAREK J., HUSAK S. 2009. *Taxonomic investigations of the crynobacterial and algal microflora from the Katon-Karagay National Park (Southern Altay, East Kazakhstan).* Biodiversity Research. Edited by B. J. Ackowiak. **15**: 45-54.

CHLACHULA J. 2001. *Pleistocene climates, natural environments and palaeolithic occupation of the Altai area, west Central Siberia.* In: Lake Baikal and Surrounding Regions (S. Prokopenko, N. Catto and J. Chlachula, Guest Eds.), Quaternary International. Washinton. **80-81**: 131-167.

CHLACHULA J. 2003. *Recent Advancements in climate and ecology studies of the Altai region. Materials of the Second International Scientific Practical Conference* „Actual Problems of Ecology". Karaganda State University. **4-5**(1). **12**: 27-30.

CHLACHULA J. 2005. *Past global climate change: a high-resolution record from SW Siberia*. Lithosfere 3 (2005). Urals Branch RAS, Institute of Geology, Ekaterinburg: 148-153.

CHLACHULA J. 2009. *Contextual Quaternary ecology studies in southwestern Siberia. Conference proceedings,* Solution problems of Exceptional Risks Events and Regional Crisis Situations. Uherské Hradiště, 3-4 September 2009, IBT - T. Bata University. 7 pp.

CHLACHULA J. 2010. *Pleistocene climate change, natural environments and Palaeolithic peopling of East Kazakhstan*. In: Eurasian Perspectives of Environmental Archaeology (J. Chlachula and N. Catto, Editors). Quaternary International. Washinton. **220**: 64-87.

CHLACHULA J. & GAZALIEV A. M. 2007. *Modern Approaches to Biodiversity Protection in the Context of Steady Development.* Achievement of the Republic of Kazakhstan Proceedings of International Conference (July 18-19, 2007, Ust-Kamenogorsk). 139 pp.

CHLACHULA J., KOUTNY M., RUZICKA J. 2002. *Climate evolution and pristine environments of southern Siberia.* Biodegradation. Univerzita T. Bati ve Zlíně. **82**: 1-4.

CHLACHULA J. & SUKHOVA M. G. 2011. *Regional manifestations of present climate change in the Altai, Siberia.* Proceedings. ICEEA (19-21 August, 2011). Shanghai (in press).

EVANS M. E., RUTTER N. W., CATTO N. R., CHLACHULA J., NYVLT. D. 2003. *Magnetoclimatology: teleconnection between the Siberian loess record and North Atlantic Heinrich events.* Geology. Arizona. USA. **31**(6): 537-540.

HRADILEK Z. & CHLACHULA J. 2010. *New bryophytes records from Kazakhstan.* Nova Hedwigia. 14 pp. (under review).

HOVORKOVA M. & CHLACHULA J. 2010. *Methods and Visualisation of Geographic Information System in Southern Altai.* In: Climate change and sustainable conservation of biodiversity in the Altai-Sayan Eco-region. International Conference Gorno Altaisk, Gorno Altaisk - Ust-Koksa, 23-27 July, 2010. Poster.

KOUTNY M, RUZICKA J., CHLACHULA J. 2003. *Screening for phenol-degrading bacteria in the pristine soils of south Siberia.* Applied Soil Ecology. Elsevier. **23**: 79-83.

KUDA F. & MACUR L. 2007. *Geohazards and Geomorphological Mapping by GPS, Southern Altai, East Kazakhstan*. In: Biodiversity Protection of Southern Altai in the Context of Contemporary Socio-Economic Development (J. Chlachula, Ed.). Final Report 2007. Altai: 25-36.

MATYAS J. & CHLACHULA J. 2010. RFIT – *A new tool for small fauna spatial distribution monitoring and biodiversity preservation of southern Altai, East Kazakhstan*. International Conference Ecology: a multi-aspect interaction – a factor of sustainable development), East Kazakhstan University, Ust-Kamenogorsk (21-22 October, 2010). Poster.

RICANKOVA V., FRIC Z., FALTYNKOVA A., CHLACHULA J. 2004. *Habitat Use of the Long-Tailed Ground Squirrel, Spermophilus undulatus, in the Altai Mountains Biology in Asia.* International Conference 7-10 December 2004, Singapore. Conference Book of Abstracts: 5 pp.

RICANKOVA V., FRIC Z., CHLACHULA J., STASTNA P., FALTYNKOVA A., ZEMEK F. 2006. *Habitat requirements of the long-tailed ground squirrel (Spermophylus undulatus) in the southern Altai*. Journal of Zoology. Published of the Zoological Society of London. **270**(1): 1-8.

SEDLACEK F., RICANKOVA V., BUFKA L., ROBOVSKY J. 2007. *Species Diversity of Small Mammals of Southern Altai.* Biodiversity Protection of Southern Altai in the Context of Contemporary Socio-Economic Development (J. Chlachula, Ed.): 104-111.

TUFF I. 2007. *Diversity of Selected Taxa of Invertebrates of the East Kazakhstan.* In: Biodiversity Protection of Southern Altai in the Context of Contemporary Socio-Economic Development (J. Chlachula, Ed.). Final Report 2007. Altai: 71-82.

Chlachula Jiri
Laboratory of Palaeoecology, Tomas Bata University in Zlin;
nam.T.G.Masaryka. 5555, 760 01 Zlin, Czech Republic
Institute of Geoecology and Geoinformation. Adam Mickiewicz University
Dziegielowa 27, 61 -680, Poznań, Poland
E-mail: altay@seznam.cz

Received: April 2, 2011
Accepted: July 8, 2011