Grazer Schriften der Geographie und Raumforschung **Band 43/2007** pp. 201 - 208

The Diversity of Nature and How to Manage it with Geo-Spatial-Technologies - Experiences in Sustainability got from Fieldwork in Hohentauern

Josef Gspurning and Wolfgang Sulzer
Institute of Geography and Regional Science, University of Graz, Austria

Abstract

Nowadays the measuring and valuing of the natural environment resides in the centre of interest of geographic researchers. In most of that cases the grade diversity (biodiversity for the biotic or geodiversity for the abiotic branch) can be used to quantify the value of the as-is state of the environment and to describe the relevant elements of the landscape's inventory. With other terms: The focus of sustainability and the goals of sustainable acting are seriously influenced by diversity of nature respectively their indicators.

Furthermore, dealing with diversity and sustainability in general has brought up a need for so called sustainable approaches as well as for an adequate (and of course sustainable) set of toolboxes. This concept can be applied also in more detailed regional scales and particularly in high mountain environments where human and natural sphere typically are influenced by each other in a very intensive way.

Therefore, spatially referenced data material and the knowledge about how to work with it can be seen as fundamentals of diversity acquisition and management; according to this higher education in that field of research first of all has to provide an highly integrated introduction in GIS/RS/Mapping toolboxes and their application during intensive, methodically interlocked field campaigns. On these mandatory field trips the students have to elaborate special thematic packages of their choice, which might work as indicators for diversity and development of a region. In a vertical way of sight all characteristic elements of Geo-Spatial Technologies (acquisition, management, analysis and visualisation of spatially referenced data) have to be employed to perform the most important tasks of diversity research, actual state audit, change detection and conservation.

KEY WORDS: Diversity, geo-spatial technologies, sustainability, GIS, remote sensing, Hohentauern

1. Introduction

The need for conserving the diversity of nature has become an increasingly must during the last decade as rates of habitat and species destruction continue to rise (Nagendra, 2001). At the same time natural environment and its diversity is affected by human activities and (global) climate change. Inventorying the diversity of nature and monitoring the effects of changing have become apparent as important scientific challenges of recent years (Joergensen 1997, Nagendra and Gadgil 1999).

New techniques and data sets now enable GIS and Remote Sensing, in conjunction with ecological models, to shed more light on some of the fundamental questions regarding diversity of nature.

According to Wohlgemuth (1998) it is almost impossible to have a complete (bio-)diversity survey at regional scale of 1-100 square kilometers. Therefore appropriate methods for extrapolations are needed that provide information that is remotely similar to field samples and which would allow to considerably reduce extensive field surveys. Furthermore, GIS and Remote Sensing also may help calculating diversity hotspots to facilitate biodiversity field surveys.

2. Prerequisites

Geo-Spatial Technologies (namely GIS, Remote Sensing and Cartography and not - as often used - the combination of GIS, Remote Sensing and GPS) are tools to investigate and monitor the diversity of nature. In this chapter some remarks about the combination of Geo-Spatial Technologies and diversity will be described as well as the use of the Geo-Spatial Technologies in high mountainous environments.

2.1. Geo-Spatial Technologies and Diversity

"Geo-Spatial Technologies include the computer hardware and software that are commonly used to collect, import, store, manipulate, analyze and display digital geospatial data. These technologies include Global Positioning Systems (GPS), Remote Sensing, and Visualization Systems." (http://www.epa.gov/exchangenetwork/, 2007/09).

At the Institute of Geography and Regional Science (Graz University) all of these components are integrated for educational and research purposes. In first part of the Bachelor studies Geography an integrative geo-spatial approach can be achieved by breaking up the borders between GIS, Remote Sensing and Digital Cartography. During the ongoing studies project based and environmental focused lectures are completing this integrative approach.

In most of that cases diversity as a grade can be used to quantify the value of the as-is state of the environment and to describe the relevant elements of the landscape's inventory. In this concept biodiversity covers the biotic branch, while the term geodiversity includes the wide variety of abiotic natural features on earth, primarily represented by rocks, minerals or landforms and the processes which have formed these features; because of their exceptional occurrences these elements of geodiversity contribute to our quality of life in direct and non-direct ways:

- **Appreciation:** The features are attractive for many people causing large numbers of visitors/tourists attracted to some sites.
- **Knowledge:** Studying the genesis of these features contributes to the understanding of our planet's evolution and history.
- **Commercial use:** Extraction of sand, stone and minerals for the concrete industry; in a smaller scale collecting of fossils and minerals brings enjoyment to individuals.
- **Natural Processes:** The functioning of natural systems provide a number of essential services, such as water supply and electricity production and natural flood defense.

Economists, planners and politicians use to take into account these four points on a legal and a commercial level; each of them is forcing diversity related activities.

In contrast to these aspects biodiversity is most often characterized by three different biotic "action" - levels. Genetic diversity (the variety of genetic information), species diversity which describes the variety of living species and - from the geographer's point of view the most interesting one – the ecosystem diversity.

Although (bio-) diversity can mean different things to different stakeholders, there is no doubt about the significant cultural and social value for human beings. Therefore the environment is depending heavily on biological systems and processes for its sustenance, health, well being and enjoyment of life. Biodiversity is the fundament of numerous services and resources, the ecosystem is providing to mankind and which is influencing the social network of people and their lifestyle in different ways.

Furthermore, biodiversity is multi-dimensional in character, involving multiple species and ecological processes that interact and proceed at multiple scales (Noss, 1998). According to hierarchy theory, temporal and spatial scales cover; longer processes tend to occur over larger spaces. Sampling diversity at more than one spatial scale allows a more complete understanding of simultaneously existing processes that operate on different time scales. In this context, the magnitude of the study (area and time) and the degree of detail collected can be adjusted purposefully to capture the level of biodiversity sought (Dickson et al.).

Taking into account the benefits mentioned above it's becoming obviously, that firstly, the value of our knowledge about diversity and its interdependences will increase dramatically; vice versa the still existing lack of information and the gaps between the crystallization seeds of knowledge as well as at the nature – technology interfaces are getting more and more important. These facts get increasing complicated through the rapidly ongoing loss of diversity. So at the moment conserving the status quo and stopping reduction of diversity seem to be the most important tasks for the next decennium. This special scenery of sustainability induces a set of conservation and protection – focused applications, which can be summarized to four essential tasks: evaluation of the actual state, documentation, research and education.

As already published in 2007 (Gspurning and Sulzer) the conservation and protection of natural and cultural heritage typically sets up a network of legal conditions and, in most cases, concurring interests. Figure 1 sketches the most important factors forming the Styrian conservation network scenery and shows clearly the most prominent instances of such a concept:

It is also evident that the entire multilevel legal framework per se produces demands on the conservation system. The fulfillment of the intention of the electors, the transformation of international conventions and EU Directives into provincial law as well as the execution of their tenor requires a specialized set of spatial data and, of course, an appropriate methodology. In the case of nature conservation there are basically three compelling steps on the way to put the conservation process into action.

a) **Compilation of an inventory:** Usually for the legislative instance there is a strong need to create databases (data acquisition, compiling catalogues and indexing) covering relevant spatially referenced features. Doing so brings up new fields to consider: Referring to local, regional, national and international needs, issues of scale, accuracy, precision and semantics have to be discussed even if in the case of a newly created database; things might get rather complicated, if already existing databases should be integrated or homogenized and different data formats, data types or different methods are used during the acquisition phase. To avoid upcoming standardization problems most of the basic datasets (e.g. administrative boundaries, roads or railway networks…) were provided by local, regional or European authorities.

b) **Monitoring:** As a matter of course doing conservation/protection work automatically includes the need for controlling the results and evaluation of the measures taken. From the GIS and Remote Sensing specialists point of view monitoring brings in one more dimension – time. But the implementation of time series data used to describe and analyze static snapshots at different stages or dynamic chances means that all arguments mentioned under a) are still valid. Furthermore, handling of time series data require specific tools for management and information retrieval. And at last acquisition, management, analysis and presentation of time series data usually raise the costs to a significant level so that the public available supply of appropriate data decreases rapidly.

c) **Densification of knowledge:** Unlike most of the approaches mentioned under a) and b) researcher's work can be described best as intensification/ densification of knowledge. This often implicates the need for data that is completely unavailable until now, still not

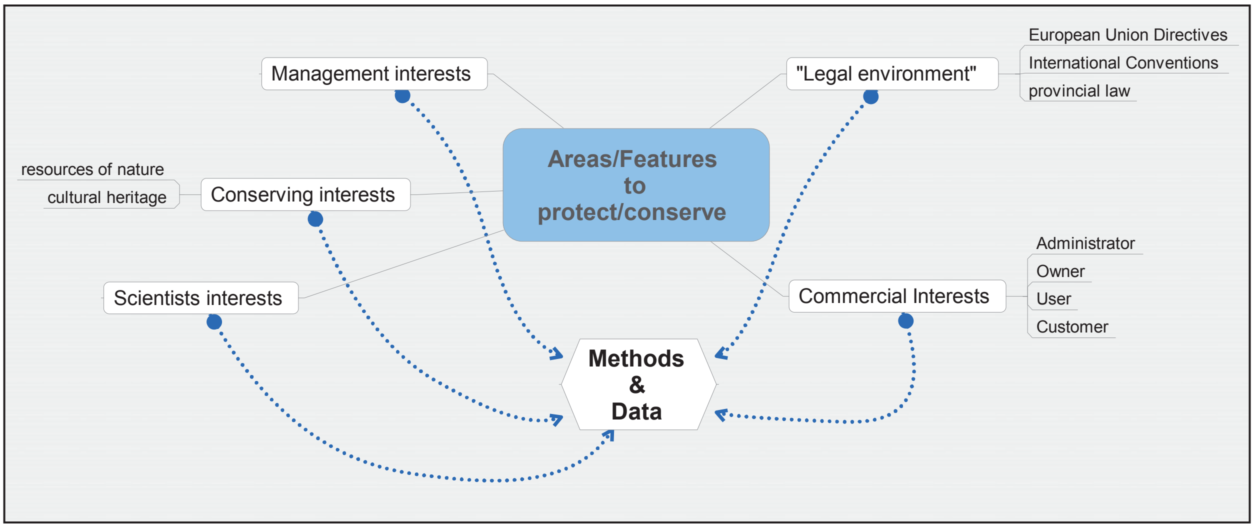

Figure 1: The network of nature conservation (Gspurning and Sulzer, 2007)

available for the topics needed, still not available at a favored scale level (spatially and thematically), or data generated by the means of newly developed tools or sensors.

2.2. High Mountain Environment - A Challenge for Geo-Spatial-Technologies

Remote High Mountain Areas often suffer from appropriate geodata. No or only few very roughly produced data bases are available. Remote Sensing therefore means a valuable tool for providing a basic (GIS-) database for a cartographic product of those mountain regions.

High Mountain Areas are regions, which are especially suitable for providing surface information by means of Remote Sensing (Buchroithner, 1995). Remoteness, inaccessibleness and high relief engender limits for terrestrial methods. Remote Sensing techniques provide useful tools for spatial and especially for height related interpolation of local – field based acquired information. Due to their contactless and spatial extent, aerial photographs and satellite images get an increasing importance for many mountain related topics (LULUC, change detection, hazards, monitoring, etc.). The knowledge of the possibilities and limitations of remote sensing and the careful evaluation of remotely sensed image data are inevitable for the meaningful, effective and financially feasible application of these techniques.

Typical data acquisition focused problems in High Mountain areas are (Gspurning et al. 2004, Sulzer and Kostka, 2006:):

- "Insufficient" analogue topographic maps (mainly low accuracy, less actuality, ...).
- Generally a lack of project - adequate geodata.
- None documented analogue and digital datasets, which means bad or missing metadata. The biggest advantage of Geo-Spatial Technologies results from the integrated use of data layers which has the compatibility of data as an indispensable precondition. In many cases digital or analogue data sources don't even have essential information (about the projection parameters for example) attached.
- Only few themes covered paired with low spatial coverage (because many of the alpine related geodata emanate from highly specialized studies undertaken for a distinct short term purpose and not to implement information/monitoring system).
- Lack of actuality (because for the most cases it is nearly impossible to keep the databases actual for the whole investigation area).
- Proper resolution of datasets (alpine areas are composed of small distinguishable landform units usually also characterized by a high value of relief energy; therefore modelling of alpine processes requires high resolution datasets (i.e. 1m - DTM's) which are seldom available).

Furthermore the applicability of geodata in high mountain environment has system immanent limits; the requirements for analyzing, mapping and monitoring purposes are listed below:

- Availability of high resolution spatial and temporal data
- GIS and Remote Sensing toolboxes (which have to be adopted or newly created)
- Suitable data basis for processing (rectification, image/GIS analyses and presentation; e.g. (digital) topographic maps, DEM, fieldwork, ...)
- Suitable weather condition and season ("nice" weather - RADAR!, less snow, ...),
- Suitable sensors (geometric/spectral/radiometric/temporal –resolution),
- Skilled user for geodata processing – analyses – presentation (image processing/GIS, knowledge about natural and cultural environment, cartographic skills ...).

3. Aims of a project like "Hohentauern" and its key tasks in biodiversity research

As already addressed in this paper one of the major shortcomings prohibiting researcher's work and the implementation of adequate counteractive measures is the lack of understanding the integrative role the elements are playing in the ecosystem. Additionally it is hard to assess or quantify influences of human caused interferences (like landscape fragmentation, changes of the landcover, soil degradation ...) into the geo-/biosphere. From that perspective Hohentauern, an alpine village seemed to be an ideal test site for diversity research and teaching. Located along a pass road with partly heavy traffic load, the winter tourism (skiing) causes serious consequences for the sensible equilibrium of nature in the high mountain area. On the other side there are only few alternative sources of income, so most of the people have to commute to higher ranking centres like Judenburg, Knittelfeld (southwards), Trieben, Rottenmann or Liezen (north-wards). Against the background of shifting climatic trends it can be assumed, that disadvantageous effects will cause deeper impacts in the natural landscape which are clearly recognizable; so investigations and monitoring will produce more obvious results in shorter time spans.

Apart from these aspects the project "Hohentauern" has been designed also as a diversified approach for figuring out the possible contributions a team of university teachers and their students were able to make within a non-profit-venture. So from the beginning the project has to cover a wide spread range of topics and intended services:

- **Support for researchers:** Development, testing and application of integrated toolboxes derived from the enhanced field of Geo-Spatial-Technologies (Digital Cartography, GIS, GPS, and Remote Sensing).
- **Support for teachers:** As a spin off, higher education teachers should be able to use the data, the methods and findings of the project within their lessons, practises or excursions.
- **Compiling databases:** Acquisition of multi thematic data providing kick – off information for different human- and physical-geographic topics; it is also intended to enrich these datasets with linkable information from other research branches.
- **Development of partnerships:** First partnerships (mainly with the representatives of the communities) were already established during the field campaigns and in the phase of data acquisition; networking with NGO's, other researchers and different user groups has to be set up according to the presentation of the results to a larger audience.
- **Publishing information and findings:** Because of its low level priority at the moment this part of the work package is done only in a more traditional way (i.e. as posters, publication in scientific magazines, oral presentations ...).

4. Educational aspects

Embedded in that environment, diversity research and documentation by the means of Geo-Spatial-Technologies works as the glue for an integrated education in GIS, GPS, Remote Sensing and Digital Visualization education at the IGR; to meet the needs the schedule and syllabus have to be broken into three interdisciplinary packages. The **first block** (taking place in the lesson theatre or in the computer lab) focuses on the topics "becoming acquainted" with the investigation area, bibliographic work followed by the definition of potential problems and the search, preparation and homogenization of currently available analogue and digital data. This part of the course schedule also includes more or less theoretical sessions to make the students familiar with selected topics of Geo-Spatial-Technologies, for example:

a) GIS, GPS

- Repetition of ArcGIS
- Creation of appropriate data models (resolution, scale, common data types, accuracy, precision, vector, raster, DEM´s, preparation of analogue maps).
- Attribute definition (preparation of analogue sources like texts, tables, ...)
- Data Input Generating coverages with ARC/INFO, import, export, data exchange and formats.
- Digitizing and Creating Topology Tablet and onscreen digitizing techniques
- Introduction to Global Positioning Systems (GPS) Collection, downloading data, and differential correction

b) Remote Sensing

- Introduction to Remote Sensing EM spectrum, reflectance, resolution, types of imagery, display and use of image processing system using ERDAS Imagine
- Image Classification Compilation of a landcover/landuse classification. Elaboration of the differences between supervised, unsupervised, knowledge based and object based classification.

The **second block** consists of an intensive 2 days lasting field campaign mixed with a plenary session where the teams had to present the state of their work and to discuss the results elaborated so far. During the field work the students had to pay special attention to problems of accuracy assessment (using GPS and land cover map in the assessment procedure, compiling data dictionaries, checking satellite availability and PDOP, employing postprocessing steps), comparing different sampling techniques, habitat modeling with GIS and attribute data acquisition.

The **third work package** (held in the lesson theatre or the PC Lab) deals with the finalization of the individual projects; after a concluding presentation/discussion the teams had to re-work their documents (maps, papers and posters) and compile a "Presentation-CD". Table 1 lists the key issues and the topics the students had to elaborate within the project.

5. Conclusions

The role of data integration and effective realization of nature conservation are strictly bound to an operational management and analysis system and useful spatial data. Because of the possible problems and the trans-national importance of the subject, the extensive knowledge about GIS (especially the more precise vector based version) as a valuable toolbox is indispensable. As geographical scope the Natura 2000 area of Hohentauern in Styria was defined, because of the fact that the preconditions make the investigation area very suitable for "Bio-GIS" training and research purposes. Although "Hohentauern" is conceived as a long time project, in the first phase the emphasis of

Key Issues	Topics
Avalanches	modelling of potential avalanche hazard areas
Natura 2000 area Bösenstein	RS-based mapping of the Natura 2000 area
Recent changes of high mountain landscape	Visual interpretation of historic aerial photographs , data integration and generation of orthophotos
Geological issues	Visualization of the geological landscape genesis
Soil erosion	Mapping of real erosive structures and modelling of erosive potential
Vegetation changes	Analysis of vegetation structure and its changes
Digital terrain modeling	Production of an ASTER-based DTM and comparison with the official Austrian DTM
Glacier retreat	Simulation and visualization of the retreat of the Bösenstein-Glacier; construction of a virtual world of the late glacial
Valuing of landscape	Development of a standardized tourism assessment scheme for mountainous landscapes
Geomorphological mapping	GIS based (semi-) automatic morphological classification
Geo-ecological structuring of the investigation area	(Semi-) Automatic construction of a geo-ecological map
Hydro-electric power plant SUNK	Simulation of the consequences of a hydro-electric power plant
308 KV high voltage power line	Feasibility-/visibility study for a high voltage power line
Habitat modelling	Habitat analyses for golden eagle, brown bear and lynx
Roman roadway	Finding the route of an ancient roman road
Ski centre Hohentauern	Feasibility study for a ski centre “Hohentauern”

Table 1: Key issues and topics covered by the “Hohentauern”- Project.

the work lays on acquisition, standardization and integration of spatial data for (nature) conservation relevant research. The Remote Sensing projects were affiliated to GIS topics. There cannot be drawn and distinct line between GIS and Remote Sensing application. All techniques employed have to be merged together in hybrid approaches. During the work the following points of weakness have been identified by the “diversity community” as most valuable GIS/RS features: Need for national (and higher) level linkages, high(er) accuracy of data, measurements and classifications, the coordination of scientific and conservation monitoring communities, the continuity and actuality of data sources, an increasing technology and knowledge transfer and well defined datasets designed to support the reporting requirements of various environmental treaties and agreements.

References

BUCHROITHNER, M.F., 1995: Problems of mountain hazard mapping using spaceborne remote sensing techniques. In: Adv.Space Res., Vol. 10, No 11., 57-66.

BUCHROITHNER, M.F., PRECHTEL, N. and CHR. HESSING, 1996: High Mountain game habitat assessment using Remote Sensing. Proceedings of the 4th International Symposium on High Mountain Remote Sensing Cartography, Karlstad - Kiruna - Tromsø, August 19-29, 1996, 61-69.

DICKSON, E.E., FRANKLIN, S.E., and L.M. MOSKAL, N.Y.: Monitoring of Forest Biodiversity Using Remote Sensing, Forest Stand (High Spatial Resolution) Protocol and Examples. Alberta Biodiversity Moonitpring Institute, http://abmi.biology.ualberta.ca/ReportsDocuments/Protocols.htm (2007/09).

GSPURNING, J., KOSTKA, R. and SULZER, W., 2004: Applicability of available Geodata in high mountain environmental research – examples from the Khumbu Himal Area (NEPAL). Proceedings of the 19th European & Scandinavian Conference for ESRi Users, Copenhagen, 2004. http://www.euc2004.dk/papers/papers_web/ID016_Josef_Gspurning_copenhagen_v2.pdf

GSPURNING, J. and SULZER, W., 2004: GIS and Remote Sensing Education – The application in mountain environment of High Tatry Mountains (Slovakia). In: A Message from the Tatra - Geographic Information Systems and Remote Sensing in Mountain Environmental Research. (W. Widacki, A. Bytnerowicz, A. Riebau (editors), 2004. Jagiellonian University Press, Krakow, Poland, 77-95.

GSPURNING, J. and Sulzer, W., 2007: The demand of geospatial data integration. In: M. Vysodil, B. Lampič and W. Sulzer (ed.): Sustainable Environmental Research – Promoting international cooperation and mutual assistance in natural parks. Palacký University, Olomouc, Czech Republic, 77-79.

JOERGENSEN, S.E., 1997: Ecological modeling by “ecological modeling”. Ecol. Model. 100: 5-10.

NAGENDRA, H., 2001: Using remote sensing to assess biodiversity. Int. J. Rem. Sens. 22: 2377-2400.

NAGENDRA, H. and GADGIL, M., 1999: Satellite imagery as a tool for monitoring species diversity: an assessment. Journal of Applied Ecology 36: 388-397.

NOSS, R.F. 1998: At what scale should we manage biodiversity? In Policy and Practices for Biodiversity in Managed Forests: The Living Dance. F. L. Bunnell and J. F. Johnson, editors. UBC Press, Vancouver, BC.

SULZER, W. and KOSTKA, R., 2006: Mt. Aconcagua – A challenge for Remote Sensing mapping activities in the Andes. In: D. Pertovič (Ed.), Proceedings of the 5th Mountain Cartography Workshop (International Cartographic Association – ICA, Commission of Mountain Cartography) in Bohinj (30th March – 1st April 2006), Slovenia, Ljubljana, 229-235.

WASER, L.T., KUECHLER, M., SCHWARZ, M, STOFER, S., SCHEIDEGGER, CH., IVITS, E. and KOCH, B., 2004: Prediction of Biodiversity – Correlation of Remote Sensing data with Lichen field samples. Proceeding sof the XXth ISPRS Congress, 12-23 July 2004 Istanbul, Turkey, Commission 7.

WOHLGEMUTH, T., 1998: Modeling floristic species richness on a regional scale: a case study in Switzerland. Biodiversity and Conservation 7: 159-177.

STRAND, H., N.Y.: NASA-NGO Biodiversity Working Group and World Wildlife Fund. Convention on Biological Diversity, http://biodiv.org/doc/publications/cbd-ts-32.pdf (2007/9).

Correspondence to:

JOSEF GSPURNING

WOLFGANG SULZER

Institute of Geography and Regional Science

Karl-Franzens University Graz

Heinrichstrasse 36

A-8010 Graz, Austria

e-mail: josef.gspurning@uni-graz.at

e-mail: wolfgang.sulzer@uni-graz.at