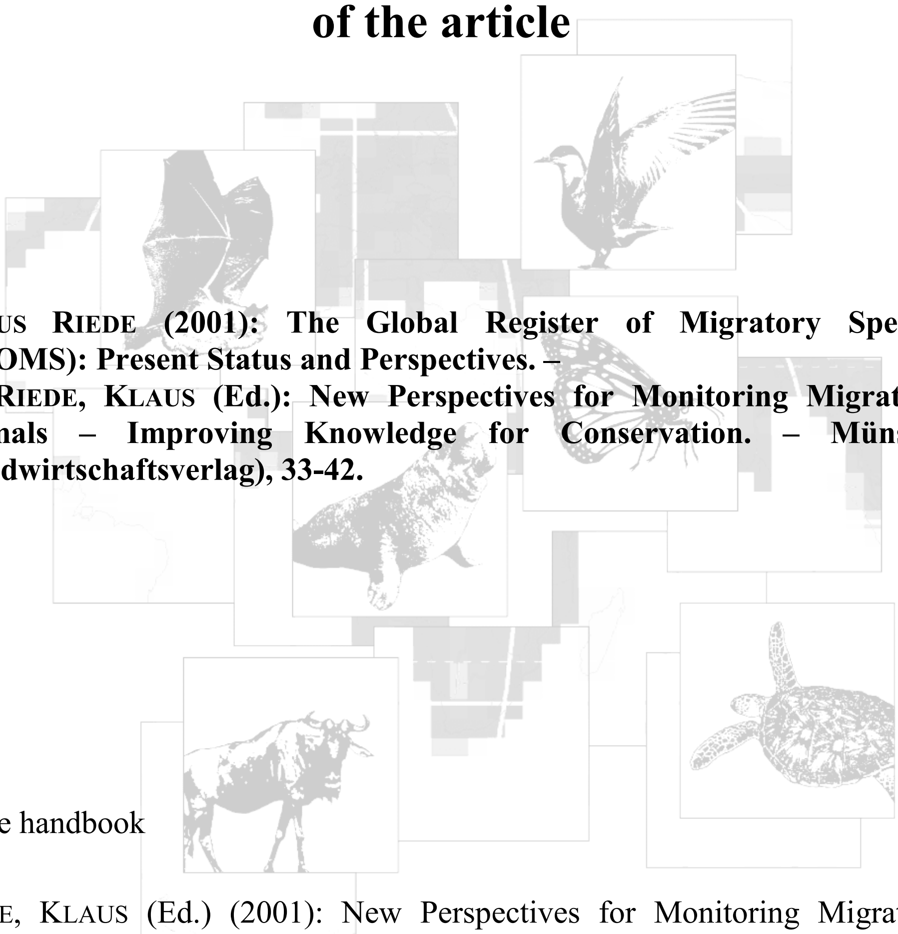
New Perspectives for Monitoring Migratory Animals - Improving Knowledge for Conservation

Klaus Riede (ed.)

This is an electronic reprint of the article



KLAUS RIEDE (2001): The Global Register of Migratory Species (GROMS): Present Status and Perspectives. –
In: RIEDE, KLAUS (Ed.): New Perspectives for Monitoring Migratory Animals – Improving Knowledge for Conservation. – Münster (Landwirtschaftsverlag), 33-42.

The complete handbook

RIEDE, KLAUS (Ed.) (2001): New Perspectives for Monitoring Migratory Animals – Improving Knowledge for Conservation. Proceedings of an International Workshop on behalf of the 20th Anniversary of the Bonn Convention . – Münster (Landwirtschaftsverlag), 166 p.
ISBN 3-7843-3819-4

can be ordered at a price of € 12,00 from
Landwirtschaftsverlag GmbH, 48084 Münster, Germany
on the internet: http://www.lv-h.de/bfn

Monitoring Migratory Animals	2001	33-42	Publ.: Fed. Agency for Nature Conservation (BfN), Bonn

The Global Register of Migratory Species (GROMS): Present Status and Perspectives

KLAUS RIEDE

Abstract

The aim and present status of the Global Register of Migratory Species (GROMS) is summarised in relation to other biodiversity informatics projects. It is a hybrid system, which connects a relational database with a geographical information system (GIS). Complete mapping of migration requires a time axis, which does not form part of routine GIS operations. A geodata model for point observation data with time codes is presented. It is specially suited for managing distribution data of migratory species, but is also applicable to any other biodiversity data set including geographic data. A Java-based graphical user interface for visualization of maps on the World Wide Web is presented. It is compatible with Open GIS specification, which allows connection to a wide variety of other geodata sets.

1 Introduction

GROMS summarises our knowledge on migratory species in a relational database in combination with a geographical information system (GIS). Basic species information and maps are now available on the World Wide Web (www.groms.de), and a CD-ROM version of the entire database has been published together with an extensive report (RIEDE 2001). The project is funded by the German Federal Environment Ministry (BMU) through the Federal Agency for Nature Conservation since 1998.

Depending on the taxonomic group, knowledge about animal migration[1] is heterogeneous and often insufficient. Migrations of most bird species are comparatively well known, while for mammals, fishes and insects, sufficient information is only available for economically important species. Most of this information is only available in printed format, and – if digitised at all – in different formats.

The database provides basic information for 2880 migratory vertebrate species. It contains scientific names with authority and synonyms, common names (English, French, German and Spanish), threat status according to the international Red List, and protection status by listing under CMS with its agreements and listing in CITES appendices. The GROMS data model differentiates between „populations“ of species, which are defined either taxonomically (subspecies) or geographically. This is necessary because of considerable differences in migration behaviour within a single species. All information

[1] GROMS covers return migrations („true migration“) of more than 100 km distance. For a discussion of different definitions, see Riede 2000.

is fully referenced by a literature module with more than 2500 entries, including a considerable number of full-text digital documents. Additional features include references to web sites and projects, addresses of organizations and experts, and species lists for countries or specific sites.

GROMS liases with or even uses data extracts from several other bioinformatics initiatives, such as the Clearing House Mechanism and the Global Biological Information Facility (GBIF),[2] Species 2000 and in particular „Fishbase“, IUCN/SSC (2000 IUCN Red List of Threatened Species: http://www.redlist.org), the UNEP World Conservation Monitoring Centre (UNEP-WCMC: http://www.unep-wcmc.org), Biodiversity Conservation Information System (see BUSBY 2001, this volume), Wetlands International (see HAANSTRA 2001, this volume) and the African Mammal Database (AMD: http://www.gisbau.uniroma1.it/amd/homepage.html). However, the idiosyncrasies of migratory species made it necessary to design a completely new information system from the ground up.

2 Results

2.1 Designing the geo-database

Maps are important tools for representing movements of migratory species in space and time. GROMS contains GIS maps for 545 species, which can be exported into any other GIS, covering further aspects relevant to conservation (e.g., land use). GROMS contains 3 types of geo-objects:

- Areas (distribution maps),
- Lines (flyways, satellite tracks, river sections),
- Points (observation points or aggregation areas, at present for waterbirds and bats).

However, normal GIS functionality and software does not routinely cover temporal aspects, which are necessary to reflect the tremendous seasonal variation of migrants within certain areas. Therefore, time-codes are administered within the database, together with meta-information about maps. Point coordinates can be stored directly within the database, while more complex geo-objects such as lines or polygons have to be stored outside the database. The present data model integrates both systems, which function as one geo-database. The following section only deals with point data, but the data model works equally for more complex geometries.[3]

2.2 The observation point data model

The following section describes the basic design of the point data model. For basic information on relational database design and the terminology used here, see HARRINGTON 1998. Observation points are simply defined by geographic latitude and longitude, and include any site of relevance for observations on migratory species. These might be aggregation sites for breeding, staging or moulting, turtle nesting beaches, monitoring sites such as bird observatories, or even catastrophes such as oil spills or red tides,

[2] www.gbif.org, with an extensive list of links to the above-mentioned initiatives.
[3] The latest database software is now capable of administering such geo-objects (e.g. Oracle 8 Spatial Cartridge/ 8i SpatialEngine).

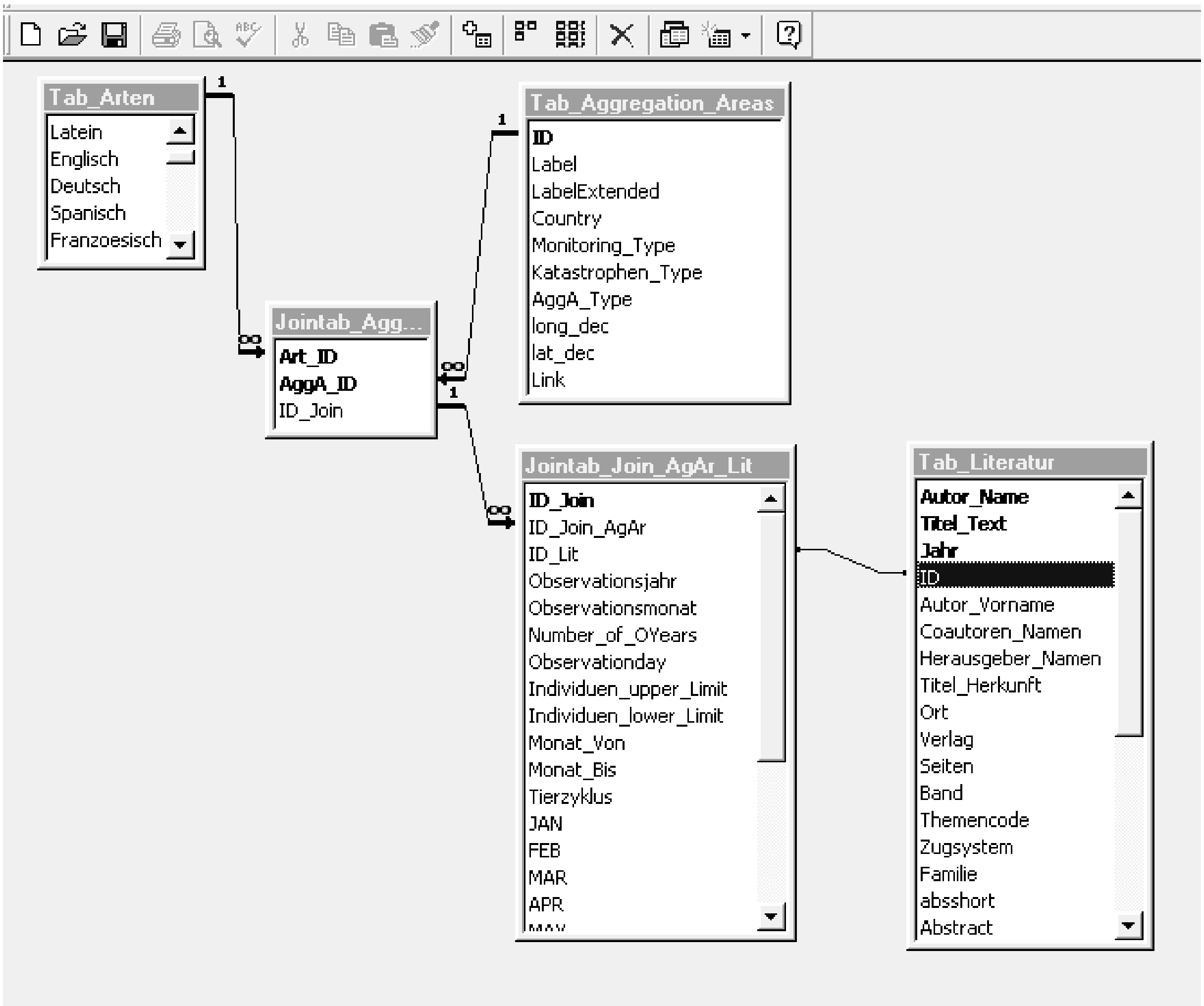


Fig. 1: Data model for the connection of point data with species information and time code. The species table (Tab_Arten) is connected with point data (Tab_Aggregation_Areas) as an m:n relation via a Jointab. Point coordinates are stored in decimal degrees (lat_dec, long_dec). An additional Jointab (Jointab_join_AgAr_Lit) connects references (Tab_Literatur) with the observation data reported therein, in particular date of presence (e.g. year of observation, month: JAN, FEB) and animal cycle (Tierzyklus). Primary keys are marked up. For further details see text.

affecting certain species. Sites have to be linked with the species table as a many-to-many relation (m:n), because several species can occur at a specific site, or one species can occur at different sites. Relational database design requires this relation to be converted into two one-to-many relationships, connected by an additional „join“ table. The latter forms an additional „composite entity“, representing one species at a given aggregation area (Fig. 1: Jointab_AggA). Any data referring to this species/site combination make up an additional composite entity, linked to the reference table (Fig. 1: JoinTab_JoinAgAr_Lit). This stores the time-code, either as months of presence, an observation date and/or a qualitative description of the animal’s biological cycle, such as wintering, feeding, breeding or spawning. Additional observations such as sightings, population numbers or localised threats can be stored, and the model is scalable for any higher temporal and spatial resolution appropriate to administer supplementary information. The respective reference, together with any other additional information, is stored as a many-to-many relation with the reference table (Tab_Literatur). Two major data sets have been entered as a test for functionality and retrieval tools:

- Important staging areas for Eurasian ducks and geese (from the „Atlas of Anatidae populations in Africa and western Eurasia“, SCOTT & ROSE 1996, Annex II),
- Bat cave communities from various sources (see Fig. 3).

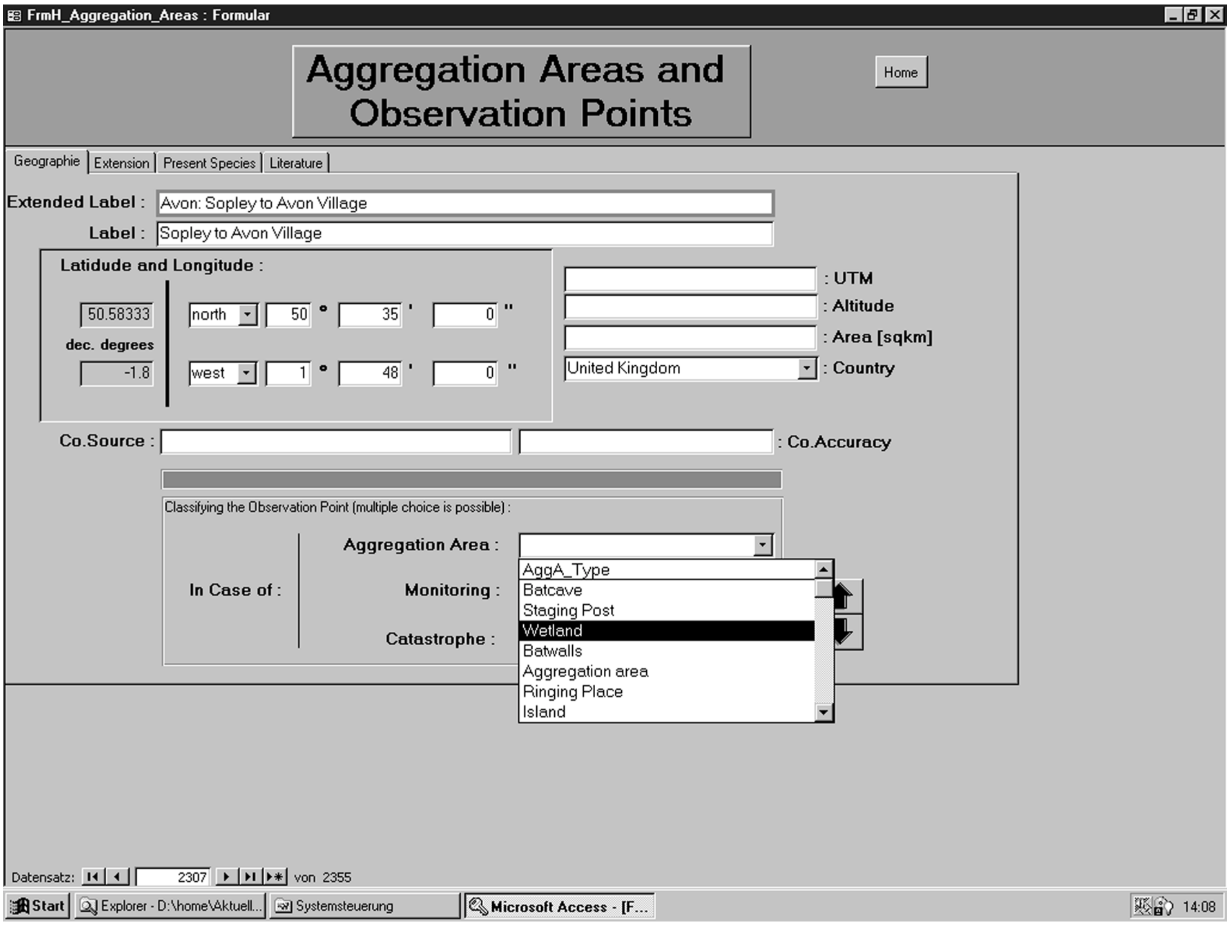


Fig. 2: Data entry form for observation points. Geographic coordinates are converted automatically to decimal degrees upon data entry. Species presence and literature references can be entered via the register card; dropdown menus facilitate data entry.

2.3 Tools for data entry and visualisation of geo-data

A data model needs to be complemented by efficient forms for user-friendly data entry, which should minimise mistakes. Fig. 2 shows the entry form, which is based on the data model shown in Fig. 1. Species names and literature can be selected by dropdown menus, thereby minimising spelling errors. Major systematic errors can arise from double entries within the species or literature authority files, due to mis-spelled authors or undetected species synonymy. Correction of such mistakes is time-consuming within a relational data model, due to the number of tables involved. For birds in particular, one has to check carefully which taxonomy or checklist has been used by the respective publication.

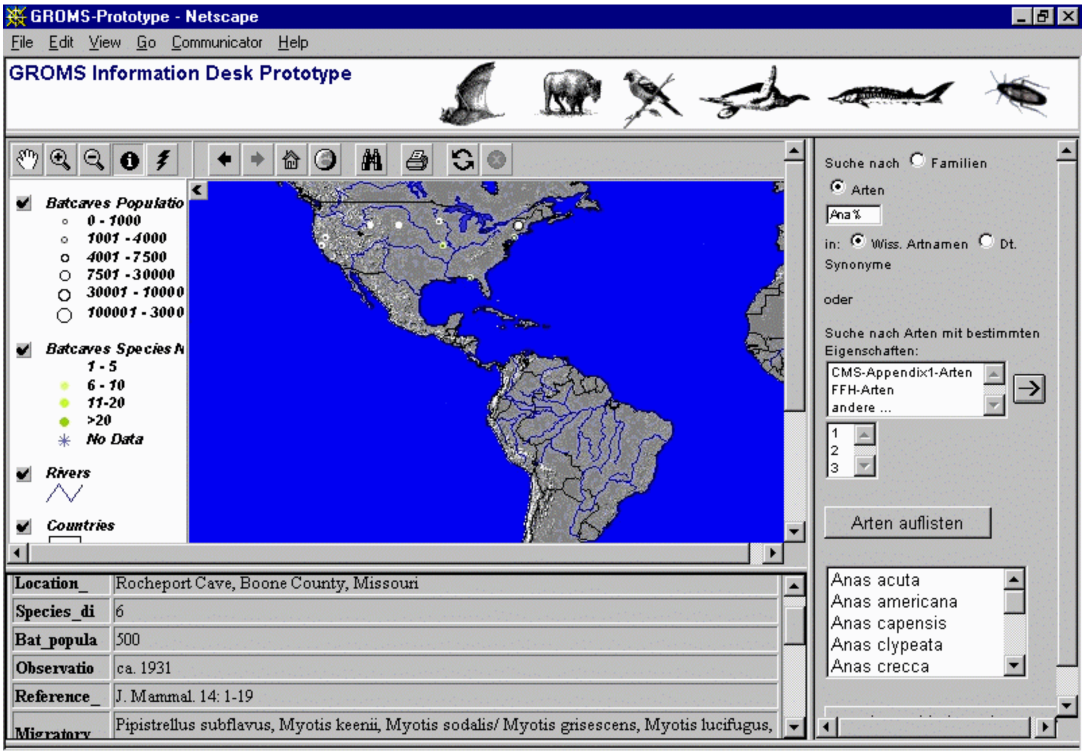


Fig. 3: Representation of bat cave localities on the WWW with Arcview Interactive Map Server. Species diversity and abundance is coded by colour and dot size, respectively, and details can be retrieved interactively. A selection panel allows species search. Information has been gathered from scattered publications, including older literature (ABEELE 1946).

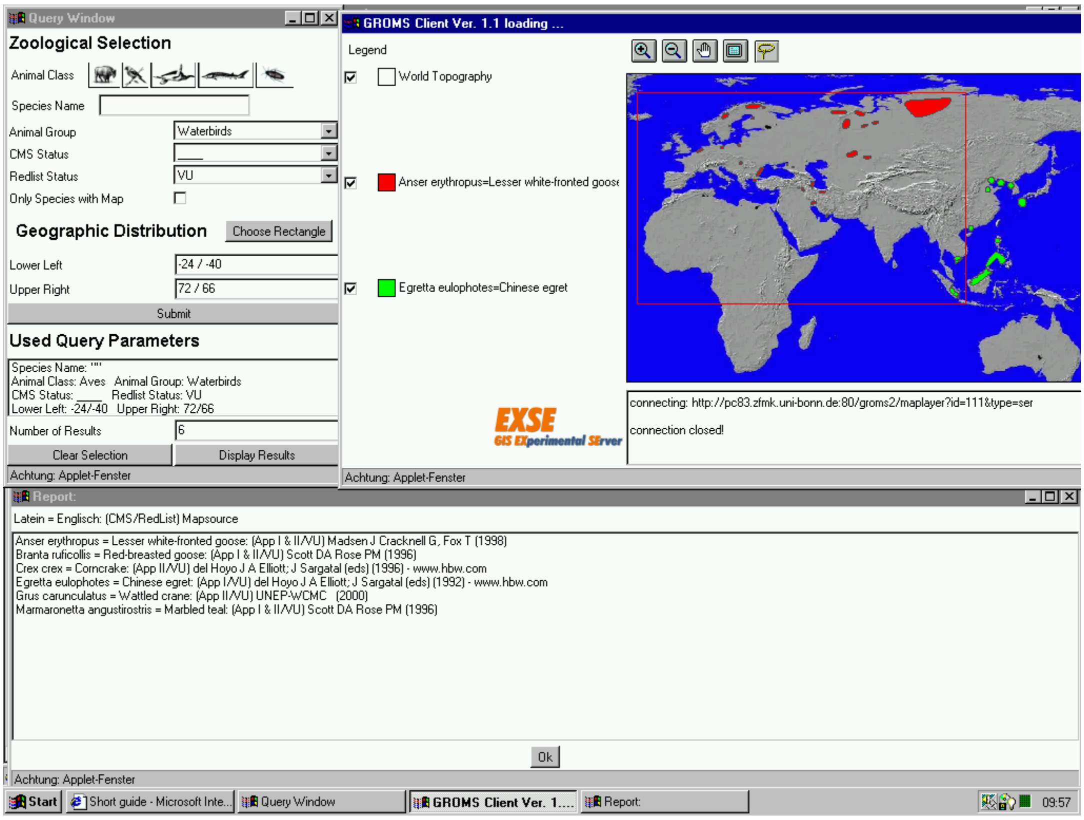


Fig. 4: Graphical User Interface for web-based retrieval of maps. A Java-based interface (see Fig. 5) connects the GIS maps with the GROMS database and allows searching for species within an area, or generation of species reports. Simple dropdown menus for information retrieval are specially adapted to the needs of conservationists and policy makers.

Retrieval and visualisation of data are two different tasks. The latter addresses a great variety of users, who are often unfamiliar with the arcana of GIS or database design, but want rapid answers to their inquiries for species and their distribution.

A GIS-server (Arcview-Internet Map Server) was used to publish and visualise pilot data sets of bat caves on the WWW as interactive maps, in cooperation with the Geographic Institute of Bonn University (Fig. 3). This allows direct publication of GIS data on the Web. Appropriate user interfaces can be programmed, and there are some good examples of visualisation of biodiversity data such as the „Marine turtle nesting database" (UNEP-WCMC 2000).

However, this system was expensive and still too complicated for most users. In addition, it was found cumbersome to implement several basic information retrieval features, especially if data sets for many species have to be managed. For example, it is not possible to answer the seemingly simple, but frequently asked query for a list of species occurring within a certain region. Therefore, a completely new Graphical User Interface (GUI) was designed from scratch. This interface allows visualisation of maps, together with simple species reports (Figs. 4, 5).[4]

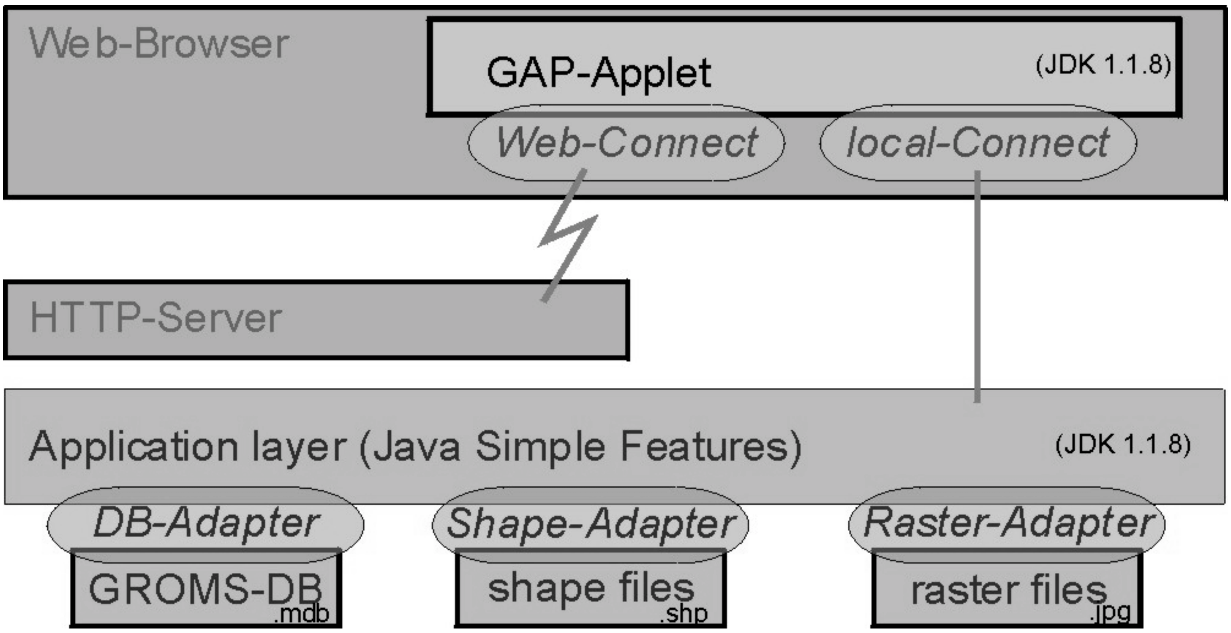


Fig. 5: Architecture of the Java-based Graphical User Interface (GUI). Further explanation see text.

The GUI has been designed for an inexpensive, user-friendly visualisation of interactive maps on the World Wide Web (GAP – Groms Auskunftsplatz/Groms information desk). The Java applet works within a Web-Browser, either via the Web (WebConnect) or on a local machine (local-Connect). The application layer accesses the GROMS database and GIS data (shape or raster files) by specially designed adapter programs. This open-source software can easily be modified, and complies with the

4 Note that only basic information is accessible on the WWW. The full functionality of the GROMS database is available on CD-ROM (Riede 2001).

Open-GIS standard. The Geography Department of Bonn University developed GROMS; the latest English version of this Java-based map server is accessible at http://www.groms.de.

The system is compatible with the OpenGIS Simple features specification (FITZKE et al. 2000, see also http://www.opengis.org/info/gisworld/SignificanceofSimpleFeatures.htm), which describes the common denominator of geodata formats and supports integration of vector data on diverse servers. There is a huge variety of ecological data, but these are not readily available. The potential of user-friendly visualisation and retrieval of ecological data for the analysis of biodiversity data is plain, but will not be possible without such common data standards.

2.4 First results and experiences from data integration

Though the first phase of the GROMS project had to concentrate on the development and functionality of the geo-database, thus far several preliminary results have emerged.

2.4.1 Efficient conservation requires animal distribution data in GIS format

In spite of the great potential, GIS analysis of species ranges is still in its infancy. Most distribution maps are still published in analogue format, thereby wasting opportunities for future analysis. Among the few examples of major GIS data sets are African mammals.[5] These data were integrated into GROMS without difficulty. For all other species, maps on a global scale were geo-referenced by GROMS. These allow a variety of analyses when intersected with other GIS data sets. For example, an intersection with political borders produces species lists for each country or even province, which can be queried by the database. This facilitates maintenance of range state lists, and allows comparison of different data sources. In case of contradictory results, clear research questions can be asked. There are numerous additional applications for biodiversity maps in GIS-format, among them:

- Comparison of maps from different sources and different projections,
- Calculation of diversity hotspots,
- Intersection with other GIS-layers such as ecoregions, land use, population pressure or climate change predictions, to name just a few.

One interesting result of a calculation of migratory birds and mammals for each administrative unit revealed a high species number in temperate regions (see RIEDE 2000, Fig. 1). This simple analysis, based on available information, suggests that a great deal of responsibility for conserving migratory species lies within the range of industrialised and transition economy countries. One major implication of this analysis is that the present concentration of biodiversity conservation plans on tropical „hotspot areas" will be completely insufficient to conserve most intercontinental migrants.

[5] AMD: http://www.gisbau.uniroma1.it/amd/homepage.html, and Arctic birds and turtles by UNEP-WCMC (http://www.unep-wcmc.org).

2.4.2 Huge data sets exist but digital access and analysis is difficult

Huge species data sets exist, but digital access is limited. This is exemplified by bird and bat ringing data, or museum specimens, which could provide high-quality point data to improve maps. Bird lists for certain sites such as wetlands or Important Bird Areas (IBAs) are maintained by various agencies. This wealth of information could be integrated easily within a common GIS database. Satellite tracking data are published in many formats, but there is no agency for organised storage of these valuable data sets. Data holders should rapidly agree on common protocols if they are disposed to share their data, and digital data publication should be a pre-requisite for public funding (with the exception of sensitive data).

2.4.3 Considerable knowledge gaps with respect to migratory behaviour have been identified

A lack of information has been identified for bats, Asian antelopes, small whales, tropical migratory fishes and insects. There is an urgent need to compile information about tropical fish migrations, because severe threats to many freshwater migrants must be expected from the high number of river dam projects in tropical and subtropical rivers, thereby repeating mistakes made in highly developed nations, the former USSR and China (MCCULLY 1998).

2.4.4 Harmonised terminologies were needed to produce GROMS and are needed for other biodiversity initiatives

To guarantee the future compatibility of GROMS with the biodiversity initiatives mentioned above, harmonised terminologies are needed. In particular for birds, major nomenclature differences between different species lists in use complicated cooperation between different database projects, as they require management of parallel taxonomies. To ensure future compatibility of digital data sets it is very important to agree on generally accepted taxonomic authority files.

3 Perspectives and restrictions

At present, GROMS contains basic data sets such as taxonomic authority files and distribution maps on a global scale, together with several high-resolution data sets. It is evident that GROMS cannot cover all available information, simply because of limitations of personnel for data entry and data integration. In addition, there are several database initiatives already providing such data for certain animal groups, some of which have been cited above. However, modern technologies such as CORBA make it possible to connect distributed databases, and frameworks such as the Biodiversity Conservation Information System (BCIS) could provide the rules for data custodianship and management of intellectual property rights. The concepts outlined above would also work between such distributed databases, which hopefully will grow together in the near future.

The next step for the management of spatio-temporal data should be the modelling and visualisation of the temporal sequence of localities. An example for such an animation of flyways is presented on the GROMS website (www.groms.de – click on Java animation tool) and discussed in this volume (MAY 2001, Fig. 4). The generalised data model would require a transition matrix of time-coded geo-objects, including different levels of temporal resolution, a problem which will be tackled within the next GROMS project phase.

Finally let me mention some *caveats*. A database has a rigid structure, which is not always compatible with the information gathered by biologists. Certain methodological constraints or subtle additional information provided by scientists in the text of a study get lost by simply entering numbers or standardised keywords into a database. Facts might be generated from hypotheses and conjectures, important hints might get lost. It is therefore necessary to create a complementary text-based information retrieval system, based on Extensible Markup Language (XML) techniques, to handle semi-structured documents. This, in combination with GROMS, could provide the powerful information system necessary to handle the challenges of the third millennium.

Acknowledgements

GROMS is a Research and Development project financed by a grant to the University of Bonn, Center for Development Research, from the German Federal Environment Ministry (BMU) through the Federal Agency for Nature Conservation (BfN). Thanks are due to the Alexander Koenig Zoological Research Institute and Museum for cooperation in this project, and in particular to Dr. Gustav Peters for help with literature on bats. I am indebted to the EXSE team of the Geography Department, Bonn, for hosting the Java GUI and the GROMS data on their web server, and to Markus Müller, Bonn, for providing Fig. 5. Special thanks go to Dr. Horst Gruttke, Federal Agency for Nature Conservation, for stimulating discussions and critically reading the manuscript.

References

VAN DEN ABEELE, M. (1946): Contribution to Congolese speleology. The caves of the Homas Mountains, Bull. – *Séances Inst. Royal Colonial Belge*, Brussels, 17, 358-363.

BIRDLIFE INTERNATIONAL (2001): Slender-billed curlew database.

BRISEÑO-DUEÑAS, R.; ABREU-GROBOIS F.A. (1999): Databases, Research and management techniques for the conservation of sea turtles. – In: ECKERT, K.L.; BJORNDAL, K.A.; ABREU-GROBOIS, F.A.; DONNELLY, M. [Eds.]: Research and Management Techniques for the Conservation of Sea Turtles. – IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 1999, Sine pp., http://www.tortugas.unam.mx/mtsg/Tech_manual/0000%20Table%20of%20Contents.htm.

FITZKE, J.; GREVE, K.; MÜLLER, M. (2000): Experiences with a Java-based Simple Features implementation. – In: Proceedings of EOGEO 2000, http://webtech.ceos.org/eogeo2000/.

HARRINGTON, J.L. (1998): Relational Database Design – Clearly Explained – London, 286 p.

MCCULLY, P. (1998): Silenced Rivers – The Ecology and Policy of Large Dams. 2nd edition – London, 350 p.

RIEDE, K. (2000): Conservation and modern information technologies: The Global Register of Migratory Species (GROMS). – *Journal of International Wildlife Law and Policy* 3(2), 152-165.

RIEDE, K. (2001): Global Register of Migratory Species, Münster. (book and CD).

SCOTT, D.A.; ROSE, P.M. (1996): Atlas of Anatidae populations in Africa and Western Eurasia. – Wageningen (Wetlands International), 336 p.

Contact:

Center for Development Research
Walter-Flex-Straße 3
53113 Bonn, Germany

and

Zoologisches Forschungsinstitut und Museum Alexander Koenig (ZFMK)
Adenauerallee 160
53113 Bonn, Germany
email: k.riede.zfmk@uni-bonn.de