Subproject S01

Remote Sensing and GIS based Monitoring of Vegetation and Biodiversity Dynamics as caused by Natural and Human induced Changes in Southern Africa

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1 List of chief scientific/technological results and other major events

Workpackage 1: Vegetation Monitoring along Transects and assessment of new transect extension

The following tasks have been covered:

- Acquisition and geometric rectification of recent satellite scenes for new transect extensions (Ogongo and Kleinberg-Sandveld transect, Duruchaus & Nareis was already covered by the old transect data).

- Acquisition and geometric rectification of all available aerial photographs for the new observatories Ogongo, Rooisand, Claratal, Ganab, Gobabeb and the Farm Smalstreep (Central-Namibia) which is used by WP S06.6 for vegetation restoration experiments.

- Contribution to Land cover classification, based on remote sensing data and methodology, for the mapping and monitoring of spatio-temporal dynamics of the lichen communities of the Central Namib Desert in the frame of the PhD thesis of C. Schultz. In addition to the monostemal classification for the year 2003, multitemporal classification has been accomplished for the years of 2000, 1999, 1991 utilizing a combined retrospective classification and change detection approach. Based on the results, abiotic factors affecting loss and recovery of lichen communities are identified and discussed. Overall findings lead to the establishment of a monitoring system for the spatio-temporal dynamics of lichen field communities in the Central Namib Desert.

- Based on NOAA-AVHRR 1km time series data and the analysis of phenological NDVI values, existing map-products and literature a vegetation map of South-Western Africa comprising more than 60 classes has been produced. It has been integrated into the BIOTA-South GIS and publication is in progress.
Selection of sites has been done for biomass clipping in Namibia through B. Strohbach (NBRI) at the following observatories: Ogongo 1 & 2, Mile 46 & Mutombo, Sonop, Omatako Ranch, Okamboro, Ovitoto, Duruchaus & Nareis, Sandveld, Claratal, Rooisand, Gobabeb, Nico 1 & 2, Gellap Ost & Nabaos, Kairos (Fish River Canyon Lodge).

At these observatories, local staff has been contracted to clip grass biomass, a procedure started in 4th Quarter of 2004. Therefore, on the basis of recent Landsat-7 ETM+ data, a fixed location has been selected, preferably uniform for at least 1 km in diameter. Following a certain sampling scheme, a total of 40 square meters are thus sampled for each sub site. Sampling is being repeated every 10 days during the vegetation phase and once a month during dry season. Sampling is to be continued until June 2006. For biomass estimation, cut grasses are collected by the responsible technician (Mr V. Mtuleni) and transported to Windhoek for drying and weighing at the NBRI.

During spring 2004, field measurements were done within the biomass study (PhD study) by Pippin Anderson, team of T. Hoffman, IPC, University of Cape Town, in the Namaqualand and Paulshoek region, focusing on the Kamiesberg Mountain range. Volume and wet and dry biomass measurements were performed for some 75 perennial species, which account for 70 – 80% of the cover in the 66 Whittaker plots. By this data, a generation of regression curves is in preparation from which standing perennial biomass are to be estimated for the main vegetation types occurring across the Kamiesberg. In combination with remote sensing data and vegetation index estimation, also the effects of the different grazing regimes on vegetation are to be examined in a later state of the subproject.

Modelling of Structural Diversity indices (Patrick Graz, Polytechnic of Namibia): A simulation model has been constructed using Delphi 7.0 to investigate the behaviour of some of the indexes to be used in the field in a little more detail. The model is a modification / extension of the model used for the investigations published in GRAZ F.P. (2004): The behaviour of the species mingling index Msp in relation to species dominance and dispersal. European Journal of Forest Research 123:87-92.

The model has been completed in late 2004 and an article based on the outcomes of the simulations is in preparation.

Modelling of savanna woodland ecology (Patrick Graz, Polytechnic of Namibia): A detailed literature review has been compiled to look at the spatial structure of the woodlands on a larger scale. The results of the review are available through the Moodle system (http://moodle.polytechnic.edu.na). Notes on the design are under preparation, with the first draft of the introduction almost complete.
Workpackage 2: Maintenance of BIOTA South GIS, support interoperability with climatic databases and capacity building

The following contributions have been done:

- Processing and integration of the SRTM Digital Elevation Model (C-Band) for further completion of the BIOTA-South GIS regarding its relief analysis capabilities. With a spatial resolution of 90 x 90m and a spatial extent of 1600 x 2000 km it covers the complete study area of BIOTA Southern Africa.

- Continuous maintenance and improvement of existing Landsat database regarding both geometric and radiometric quality while additionally expanding the archives historic dimension for multitemporal analytical purposes and change detection studies.

- Started compilation of modelled climatic raster data sets for further completion of BIOTA-GIS and its analytic capabilities regarding climatically induced influences (Jacob MPI) (see WP S01.3).

- Continued update and maintenance of Meta-Database and Internet-Services at www.biogis.de

Workpackage 3: Regional scale vegetation changes, simulation of future climate and vegetation response

The following contributions have been done:

Climate Change simulation in collaboration with MPI in Hamburg:

- Continued work on the REMO/MM5 climatic dataset. The regional domains for the 0.5° resolution climate simulation, carried out using REMO, have been set by D. Jacob (MPI) and B. Hörsch on the area between 15° N and 39° S and 20°W to 52°E. The necessary data for the drivers, extracted of the 40 year analysis of EZMW for the 0.5° simulation, have been prepared. The simulation has run for 1958 to 2001.

- First validation results show an error in the prepared driver data around 1960. This has been corrected and a new simulation for about 5 month was conducted. Preparations for climate simulation on a 1/6° grid were taken. Further validation of the 0.5° simulation was conducted and will be continued in the future.

- The REMO precipitation over the BIOTA-South transect seems to be slightly overestimated compared to the long term mean (1901-1985) documented in Atlas of African Rainfall and its Inter-annual Variability, Florida State University, Tallahassee, Florida, US. Along the transect, in general no significant long term trend (less than ±1 mm/year) was simulated from 1958-2001, although the decade 1961-1970 seems to be somewhat drier than the following 3 decades. The general no-trend result is in good
agreement with the CRU version 2 precipitation dataset (CRU2). A more detailed regional interpretation has still to be done.

- For the BIOTA-transect covering the South African Succulent Karoo, B. Hewitson (UCT) was able to identify August and September as the months of maximum Photosynthetic Activity on the base of NOAA AVHRR NDVI data from 1985-1999 and rainfall surfaces.

- The Sheffield Dynamic Global Vegetation Model (SDGVM) has been used by B. Hewitson (UCT) to simulate a potential natural vegetation distribution for southern Africa. To investigate how this land-surface change has impacted on the climate of the region, a number of MM5 simulations were done. Since the SDGVM vegetation map does not include agricultural land use types and the USGS distribution does, the difference between the two maps represents a plausible approximation of the effects of human activities on southern Africa's natural vegetation. The simulation results indicate a significant atmospheric response to the altered land-surface map.

- An empirical downscaling of future climate change projections from three general circulation models (GCMs) completed by B. Hewitson (UCT) was initiated. Regional climate model (RCM) based downscaling is continuing. The results show a marked agreement in the projected climate change, reflecting a commonality between the GCMs as to future changes in synoptic scale atmospheric forcing. The projections generally agree on a wetter climate for the eastern parts of the region coupled with an increased number of rain-days, and drier conditions for the south-western Cape and West Coast associated with fewer rain-days.

Studies on regional scale vegetation changes:

- Compilation of NOAA-AVHRR time series and homogenisation with the BIOTA South GIS by Ralf Hanatschek for analysing the formation of Namib fog to be used in the analysis of fog precipitation for small and large scale patterns of vegetation.

- In the frame of a separate study in collaboration with Prof. M.T. Hoffmann and Dr. N. Allsop (ARC), S01 has supported a field campaign for the analysis of the Namaqualand ecotone by PhD Ndafuda Shiponeni under supervision of Prof. MT Hoffman and Dr. N Allsopp (ARC). The results of this campaign will be analysed jointly in October/November 2005 during an invited sojourn of Ms. Shiponeni in Würzburg.

**Workpackage 4: Multi-scale remote sensing detection and analysis of human induced changes in land surface and vegetation characteristics over space and time**

The following tasks have been covered:

- Acquisition of historic Landsat TM scenes for the whole transect completed, ongoing integration into the Biota-South GIS.
Successful development and implementation of change detection techniques on Landsat (E)TM-data for the classification and mapping of natural and human induced vegetation changes in the region of the BIOTA observatories Omatako Ranch, Ovitoto and Erichsfelde in central Namibia within the PhD work of Melanie Vogel, University Würzburg. This bi-temporal change detection approach is based upon image differencing, selective Principle Component Analysis (sPCA), and image segmentation techniques. It allows the classification of characteristic land cover change processes in savanna systems like gradual vegetation decrease and increase like effects of actual grazing impact, bush dieback disease or bush encroachment. The method allows the detection of total vegetation loss over time (desertification) or recover of formerly unvegetated areas. Due to its non-parametric approach, the technique possesses high potential for application on study sites in other biomes. A validation will be performed in the dry wood forests of the Kavango (Mile 46/Mutompo region) and for the dwarf shrub savanna of Gellap Ost/Nabaos in March 2005.

Namaqualand-Ecotone mapping started by N. Allsopp, N. Shiponeni (ARC), and T. Hoffman (UCT). Ndafuda Shiponeni has developed a project proposal for PhD studies on this project, registered at the University of Cape Town under supervision of Prof Timm Hoffman with Dr. N. Allsopp as non-university supervisor.

Grassy patches for intensive field work have been identified along an approximately 90 km N-S transect. Grassy patches are located on: private farms, recently acquired communal land, and land protected from grazing for at least 20 years. Permission has been granted from farmers and land managers to conduct research on their land. Vegetation composition, vegetation cover, extent of patches and edaphic features have been determined for seven patches. Size class distribution of the most common grass and shrub species at each site have been measured in order to determine population dynamics. Nearest neighbour analysis for the most common grass and shrub species has been undertaken at these patches to determine the nature of inter- and intraspecific interactions. Rainfall data for ten to 20+ years has been obtained for seven sites along the ecotone. Aerial photos in digital format have been purchased for the ecotone for 1960, 1962, 1967, 1976, 1989 and 2004.

At the Kamiesberg range (Region of Paulshoek observatory, RSA), T. Hoffman and P. Anderson (UCT) completed their data collection for the diversity study, exploring grazing impacts across fencelines, in Namaqualand. Two papers, one on a gradient analysis across the Kamiesberg and the other addressing the impacts of grazing on the flora of the region, are currently being worked on, with anticipation of their completion in early 2005. An experiment has been set up to explore the growth of succulent species at different altitudes in the Kamiesberg. This will form part of the greater gradient analysis component of Pippin Anderson’s PhD, in looking at what drives the shifts between the vegetation
types across the Kamiesberg. In particular this experiment is aimed at addressing the question of whether succulents are excluded from higher altitudes on the Kamiesberg due to altitudinal-related environmental parameters, or whether they are fire-excluded. Two hundred seedlings of three species were planted out at three different altitudes, in two soil types. This experiment will be monitored over the next three years.

- In his current investigations, R. Main (Team of R. Knight, UWC) has been focusing on the Koeroegab Vlakte inside the Richtersveld National Park. For small scale ecologic and land use analyses, a Digital Elevation Model of 30 m by 30 m resolution based on topographic maps has been generated. Several vegetation indices have been tested for description of this particular environment.

  Preliminary results, from two dates of imagery, show that many of the stockposts (buffered at 1km) within the Koeroegab Vlakte exhibit higher vegetation indices (NDVI and SAVI) than the surrounding areas. From the current results it is indicated that the herders and their livestock do not have a significant impact on the area. First approaches of image differencing between one mid winter and one beginning of spring scene have been done showing stronger changes concerning NDVI and SAVI vegetation indices than the surrounding area.

  Preparations have been done concerning ground investigation of vegetation composition (e.g. investigation of optimal digital sample plot sizes) in order to set up digital transects across the Vlakte.


- A suite of sensors and platforms has been assessed regarding their potential to derive useful information at required accuracies for tasks of land use / land cover assessment and biodiversity management. A sensor list has been generated and is available for planning of further activities and studies. Remote Sensing will be used to assess the possibility of finding and deducing proxies to quantify diversity or to lead towards quicker assessments of diversity in the field.

- Further tasks are being addressed in the following months.

Other major events

- In May 2004 Dr. Bianca Hörsch left the team and was substituted by Dr. Michael Schmidt as new subproject leader.

- In November 2004 Ralf Hanatschek, whose PhD thesis should have been dealing with modelling of fog in the Namib Desert, has left the team.
• Due to DLR-internal organisational reasons the project team (PhD-student Christoph Schultz, PhD-student Melanie Vogel) moved from the DLR Campus in Cologne to the “HGF-Nachwuchsforchungsgruppe” at the Remote Sensing Unit of the University of Würzburg in December 2004.

• At the turn of the year 2004 / 2005, Manfred Keil added to the BIOTA-S team at DLR in Oberpfaffenhofen.

2 Comparison of project status with original work and time planning (or with planning amended with the consent of UHH, respectively German R&D partner institution)

Work package 1: Vegetation Monitoring along Transects and assessment of new transect extension

a) Original work
The project is sticking to the original objectives.

b) Time planning
Most work was fulfilled within the time frame. Exceptions are as follows:

• Vegetation mapping of the new transect extensions could not be done, because field sampling data by the S06 project was not yet available.

• Destructive biomass sampling in Namibia started delayed at the beginning of the rainy season 2004/2005, due to the delayed conclusion of contracts with the Namibian botanists.

• The field work on structural diversity of forests (P. Graz, Polytechnic of Namibia) has not taken place in 2004 as there has not been a sufficiently long period of time available to travel. The field work must be done in one sitting as the money budgeted for transport does not allow for more than one trip. In addition, due to the cut in the budget and increased transport cost, one or possibly two of the sites to be visited may have to be omitted.

• T. Hoffman (UCT): While the observatory Paulshoek was proposed to be used as a pilot study for biomass assessment, it is felt that the amount of work necessary to assess the greater Kamiesberg transect is such that two years will be required and as a result these two components will be run concurrently, with the greater Kamiesberg assessment spanning two years.

Work package 2: Maintenance of BIOTA South GIS, support interoperability with climatic databases and capacity building
a) Original work
The project is sticking to the original objectives.

b) Time planning
Due to the personnel changes within the team no capacity building activities (e.g. training of N. Shiponeni) took place in 2004.

Work package 3: Regional scale vegetation changes, simulation of future climate and vegetation response

a) Original work
The project is sticking to the original objectives.

Due to the loss of scientific capacity for climate tasks with the designation of Ralf Hanatschek, the tasks concerning fog data compilation may have to be given up.

b) Time planning
Most work was fulfilled within the original time frame. Exceptions are as follows:

- D. Jacob (MPI) was able to reconstruct the REMO/MM5 model for 43 years from 1958 – 2001 instead of the originally planned 20 years.
- The analysis of climate-vegetation interactions did not take place yet.

Work package 4: Multi-scale remote sensing detection and analysis of human induced changes in land surface and vegetation characteristics over space and time

a) Original work
The project is sticking to the original objectives.

b) Time planning
Work was fulfilled within the planned time frame.


a) Original work
The project is sticking to the original objectives.

b) Time planning
Work was fulfilled within the time frame.
3 Have the prospects of reaching the project targets within the stated cost period changed compared with the original proposal (reasons)?

No.

4 Have any third parties announced R&D results of relevance for implementation of the project?

No.

5 Are any changes to the targets necessary or will any become necessary?

No.

6 Have licenses or patents been issued?

None.

7 Is there any economic use of the outcome (even after project end). If yes, when will it occur?

Not yet foreseeable.

8 What might be the potential success (scientific / technical) after project end, how can results be used (for public issues, data bases, networks)? Please consider co-operation with third parties (institutions, companies, networks, research facilities).

- The in situ data gathered in the field plots and the linked and geo-referenced information derived from satellite data will be prepared and delivered to adjoined scientists and land managers. Thus, facilitating the spread and employment of earth observation products and methodologies. A common interface, sampling scheme and data sharing protocol will enable all partners to feed and employ the generated comprehensive system to the effective management and the better understanding of land surface processes in the target areas and beyond.

- Prof Dr. Timm Hoffman & Mrs. Pippin Anderson, IPC: The findings of this project will give insight to the impacts of variable veld management practices on the different vegetation types found across the Kamiesberg. During the course of the project to date,
there has been interaction with the Kamiesberg Municipality, the SKEP network, Mazda Wildlife, and numerous communal and commercial farmers in the region.

- Patrick Graz, Polytechnic of Namibia: The results may also be used to support the interpretation / classification of satellite images of the area.

- Dr. N. Allsopp, ARC-Range & Forage Institute, South Africa: The database of results will be maintained in the BIOTA database which will allow future time series of remotely sensed data to be compared to this study. The results will be of importance to decision makers at local and higher government levels around land-use management and planning in an environment of climatic change.

9 Potential scientific or economic follow-up capability for a next project phase, and/or any next innovative steps for successful implementation of the R&D results.

**Scientific:**

- For the monitoring scheme, biomass assessment of the second phase will be enlarged and deepened during the third phase, with the combined field and remote sensing concept for biomass monitoring calibrated and refined. Final goal is the successful transfer of the results towards a prognostic biomass monitoring concept to aid farm and conservation management at local as well as regional scale.

- Biomass assessment in Namibia and South Africa can further be used for ground thruthing of MODIS-derived LAI (Leaf Area Index) data. The validation of these remote sensing derived data will be performed in accordance with the European VALERI Initiative (http://www.avignon.inra.fr/valeri/).

- With the already established link to the continental biodiversity group W03 of Biota-West, the coherent long-term concept of the analyses of climate forcing, vegetation and biodiversity response shall be enlarged and up-scaled to a sub-continental and potentially a continental scale.

- For the climatic scheme, the study of fog from the second phase which generated crucial insight into e.g. the importance of precipitable water for vegetation growth could be implemented into a pre-operational fog monitoring scheme run e.g. at the DRFN, potentially providing important information for fog parameterization for regional climate models which shall be developed during the third phase as well.

- Further work on human induced land cover changes and their subsequent biodiversity changes in high temporal detail will be continued. In the BIOTA-South transect starting from the six detailed study regions along the whole transect conclusions will be drawn for the regional scale to finally derive detailed degradation maps in five year intervals.
Beginning in the 1960s, the detailed maps and prognostic models to evaluate the future development of vegetation and biodiversity are to be derived and developed.

*Prof. Dr. Timm Hoffman & Mrs. Anderson, Institute of Plant Conservation - Botany Department; University of Cape Town:*

- As this project assesses the impacts of land use on a range of vegetation types across the Kamiesberg, an interesting follow-up phase might establish a vegetation-monitoring strategy to assess vegetation recovery in those areas immediately adjacent to Soebatsfontein recently included in the Namaqualand National Park. This would draw on the findings of the current study, as well as a study carried out in the pilot phase, which explored the restoration potential of the rangelands around Soebatsfontein.

- In light of current climate change predications which place emphasis on the need for an expanded understanding of the implications of climate change on different growth forms, there is also potential to continue the monitoring of the experiment exploring growth of succulents at different altitudes.

*Patrick Graz, Polytechnic of Namibia:*

- Thus far, no Namibian growth data is available for Namibian woodland species, although some was generated in neighbouring countries. However, due to differences in climatic conditions, it is not feasible to transfer such information directly to Namibia.

- Changes in spatial structure have also not, to our knowledge, been assessed in the region. The information collected here would therefore present an important baseline for monitoring of such change.

*Dr N Allsopp, ARC-Range & Forage Institute, South Africa:*

- The study will determine the main climatic and land use influences on the ecotone. As such it may become a potential tool for predicting and monitoring the effects of climate change and resolving such change from change induced by land use or shorter term climatic variability.

*Economic:*

- We focus on providing for an operational Remote Sensing system to monitor vegetation permanently along the BIOTA transect employing an homogenised GIS, database and methodology which is to be implemented at respective institutions and used by African authorities for ecological monitoring, analyses and land management planning.
• Capacity building is to accompany this initiative actively.