North–South cooperation through BIOTA: an interdisciplinary monitoring programme in arid and semi-arid southern Africa

C.B. Krug[a*], K.J. Esler[a], M.T. Hoffman[b], J. Henschel[c], U. Schmiedel[d] and N. Jürgens[d]

Connecting disciplines in a north–South collaboration has many advantages: mutualisms evolve, synergies are created and spin-offs emerge. The BIOTA South (Biodiversity Monitoring Transect Analysis in southern Africa) programme, with its long-term vision to generate knowledge of biodiversity along a north–south transect in southern Africa, is providing opportunities for research, technology transfer and capacity building while focusing on potential solutions for critical challenges that face this environmentally vulnerable part of the subcontinent.

The need for long-term ecological research

A significant proportion of the biodiversity-rich arid and semi-arid regions of western South Africa and eastern Namibia has been transformed over the last 250 years by land-use practices such as mining, cultivation and grazing by large numbers of domestic livestock.[1–6] The likely expansion of these activities in the coming decades, coupled with the predicted effects of climate change, will not only affect the biodiversity of the region[7,8] but also the lives of its inhabitants. The extent, magnitude and direction of change needs close monitoring to ensure ecological and economic sustainability, which is best achieved through long-term, interdisciplinary programmes.[9–11]

A formal, co-ordinated approach to long-term ecological observation is nothing new to international research programmes on global environmental change. Meteorological observation networks, the IGBP programme, GTOS, DIVERSITAS with its bioDISCOVERY programme, ILTER[12] and, recently, GEOSS all address changes in ecosystems over both space and time. Monitoring at fixed sites (to determine spatial variation) over long time periods (decades to centuries) to detect temporal variation assists in the understanding of long-term ecological processes (such as changes in species assemblages over seasons or years), as well as the detection of episodic changes and rare occurrences (for instance, the effect of an uncommon rainfall event in an arid area).[12,13] Comparisons across space and time on local, regional and global scales[12] bring site-based data into spatial context. With greater understanding of ecosystems and their ecological processes, the foundation is laid for the successful management and restoration of threatened ecosystems.[12,14,15]

The need for long-term monitoring in southern Africa is recognized, which is why SAEON (South African Environmental Observation Network) was set up in 2002 within the ILTER (International Long-term Environmental Research) framework. Namibia established a long-term observation programme in 1999 (NaEON, the Namibian Environmental Observation Network), and both South Africa and Namibia are members of ELTOSA (Environmental Long-term Observation network of Southern Africa), which was founded in 2001.[13]

BIOTA in southern Africa

In the 1990s, the German government strongly supported international science programmes on global environmental change (such as the WCRP, IGBP, DIVERSITAS and IHDP). In that spirit, a proposal to develop a global biodiversity observation system in close cooperation with African countries was drawn up.[16–18] Based on recommendations of the National Committee on Global Change Research (www.nkgcf.org), the German Federal Ministry of Education and Research (BMBF) initiated the BIOLOG (Biodiversity and Global Change) programme, funded primarily by the ministry. The primary aim of this programme is to promote research on the sustainable use of biodiversity, with the research focus on Europe (BIOLOG Europe) and Africa (BIOLOG Africa, or BIOTA, for *BIO*diversity Monitoring *T*ransect *A*nalysis in Africa). These continents were selected to investigate the impact of land-use and climate change on biodiversity, as they differ considerably in respect of biodiversity, the availability of skilled people, knowledge and expertise, and face different threats to their respective environments.[19] Within Africa, BIOTA research is conducted in three regions: BIOTA West, covering Ivory Coast, Burkina Faso and Benin; BIOTA East in Kenya and Uganda; and BIOTA South, where research is pursued in Namibia and South Africa. All three BIOTA programmes are interdisciplinary, spanning the natural and social sciences, and involve German and local African researchers and students. Participating institutions are equal partners in the programme, which has an overall budget of €7.5 million (R60 million).[20] However, southern African researchers receive not only monetary support. German partners provide the observatory infrastructure (weather stations, enclosures) as well as logistic and administrative assistance. In exchange, southern African partners bring their expertise and insights to the problems and use local resources, infrastructure and networks on behalf of the programme.

The main focus of BIOTA Africa is sustainable management of biodiversity in the continent, integrated in a long-term observation system. As with SAEON and NaEON, changes are monitored at fixed sites (biodiversity observatories) over a long period, with initial BIOTA funding for the first nine years. These observatories are arranged along a transect following a land-use, landscape or climate gradient (Fig. 1). In BIOTA West, the transect follows an aridity gradient from the sub-Saharan savanna to coastal rain forest, BIOTA East pursues an altitudinal gradient from the lowlands to the cloud forests; within BIOTA South, the transect tracks a rainfall gradient from the winter rainfall region of the Western Cape province of South Africa to the summer rainfall areas of northern Namibia, crossing the hyper-arid Namib Desert along the way. Along each large-scale ecological gradient, the effect of contrasting land use on biodiversity is investigated, and the impact of the different land-use types on people's

[a]Department of Conservation Ecology and Entomology, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa.
[b]Leslie Hill Institute for Plant Conservation, Botany Department, University of Cape Town, Private Bag, Rondebosch 7701, South Africa.
[c]Gobabeb Training and Research Centre, P.O. Box 953, Walvis Bay, Namibia.
[d]Biozentrum Klein Flottbeck und Botanischer Garten, Universität Hamburg, Ohnhorststrasse 18, D-22609 Hamburg, Germany.
*Author for correspondence. E-mail: ckrug@sun.ac.za

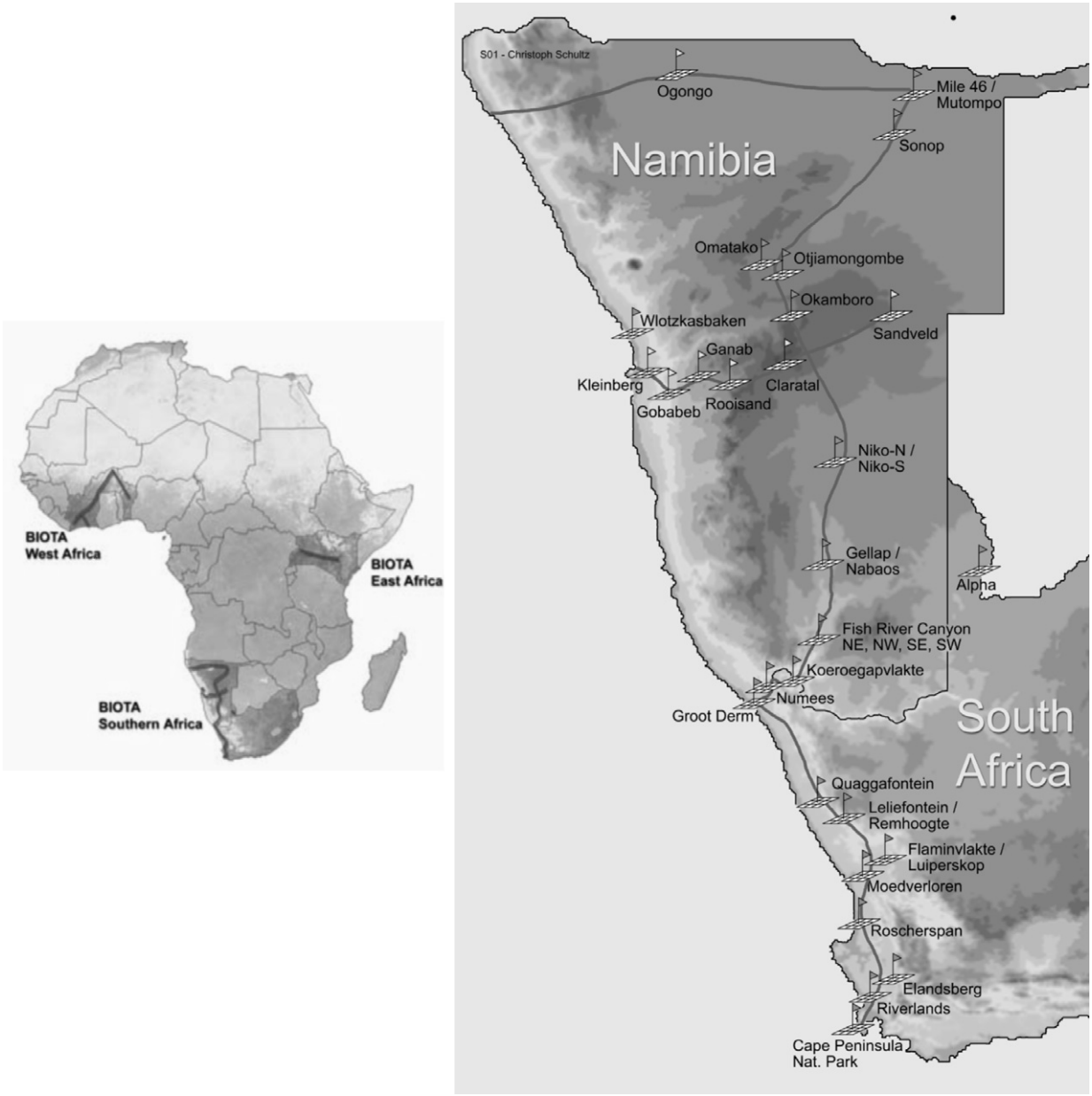

Fig. 1. Position of the BIOTA and BIOTA South transects. In total, 26 observatories along a S–N transect were established in 2001; nine further observatories along a W–E transect in Namibia were added to BIOTA South in 2003.

livelihoods is determined. The main objective in Phase I (2000–03), the pilot phase of BIOTA, was to collect information on abiotic conditions and to record biodiversity on various taxonomic levels along the transect. The patterns, processes and functions of biodiversity were also documented as were the land-based livelihoods of people living in the region. Knowledge gained in this phase provided the research base for subsequent investigations. In Phase II (2004–06), the programme's focus is to understand the drivers and mechanisms of changes in biodiversity and livelihoods. Knowledge about the direction and predictions of change, the interventions needed, and policy- and decision-making proposals will be generated. Their implementation will form the focus of the third and final phase (2007–09).

The programme currently consists of 12 subprojects, which incorporate more than 20 German, South African and Namibian research institutions spanning ecological, social and economic disciplines, as well as other bodies and government departments (Tables 1 and 2 in online supplement). To promote and maintain a more formal interaction between the partners, the South African BIOTA Steering Committee (SABSC) and the BIOTA Namibia Steering Committee (BIONaSC) have been established, with liaison officers as the main links between the participating institutions (see Table 3 in online supplement). Researchers are encouraged to stimulate trans-disciplinary research. This is achieved by holding regular meetings and workshops, where research results are exchanged, and opportunities for discussion and interaction on all levels are provided.[21]

The first phase of this 'flagship' research programme captured the attention of both German and South African governments and led to reference to the BIOTA project in the joint communiqué of the Fourth Session of the South Africa–Germany Bi-National Commission, which was drawn up at the presidential guesthouse in Pretoria, South Africa, on 30 October 2003. In Namibia, two agreements, concerning technical and cultural cooperation between the governments of Namibia and Germany, have been in place since 1991. To boost the South

African contribution to the project, the Department of Science and Technology committed a further R3 million over a three-year period. The aim of these funds is to contribute to local and regional capacity building by supporting post-graduate and undergraduate students and to strengthen the participation of South African researchers.

A monitoring protocol

Interdisciplinary research within BIOTA South focuses on 26 observatories along a south–north transect, and nine observatories situated on a west–east transect (Fig. 1) and their immediate surroundings. In some cases, observatories are paired to provide a land-use contrast. The observatories are 1-km^2 sites where standardized research methods are adopted (Fig. A in online supplement).[17,22,23] This allows for meaningful comparisons at various scales within and between observatories, the validation of observed patterns and processes along the transect and the long-term monitoring for detecting change. The scale and size of individual research sites within and beyond the borders of the observatories depend on the research question, organisms investigated and the landscape studied.

Within the subprojects, research is conducted in terms of four integrative themes: 1, natural dynamics and processes of biodiversity in space and time;[24–27] 2, human use, values and impact in space and time;[28–34] 3, interventions (tools, techniques, instruments) for sustainable use and management of biodiversity;[35] 4, policy implications at local, national and international levels.[36] For a detailed publications list, see the BIOTA Africa website at www.biota-africa.org.

Research nuggets

At a seminar on the status of BIOLOG held in Würzburg, Germany, in November 2005, team leaders and students were given the opportunity to highlight nuggets of research made possible through the programme. Transdisciplinary links are being forged to understand dynamics, impacts and interventions across scales and taxa. The established system of 26 biodiversity observatories in combination with other archives generates detailed information on the change of biodiversity and underlying dynamics and processes. For example, multi-temporal LANDSAT imagery has allowed researchers working on biological soil crusts to span spatial and temporal scales, resulting in the first analysis of the disturbance, destruction and recovery of lichen communities along the arid Namibian coast.[37,38] Spatially explicit simulation models have allowed integration of processes across disciplines and scales to understand how climatic changes can influence species dynamics and diversity[39–41] and how communal and commercial farming influence large-scale vegetation dynamics[42–44] — the ultimate goal here is to develop economic decision models to aid end users. The large data sets generated over the BIOTA South transect are also proving their worth. For example, insights into how rainwater infiltration is limited by pedodermal soil properties explain why certain landscapes either shed or retain water. This information has practical spin-offs, such as understanding how to activate restoration efforts. Repeated monitoring of sites has already provided a glimpse of the consequences of a changing climate. For instance, temporal monitoring of the life cycles of pollinators and flowering plants at Paulshoek has suggested that synchrony of this reproductive dance is disrupted during years of extreme drought.[45] The spectre of rapidly increasing climatic variability and drying trends might well lead to an unravelling of the threads that tie these communities together.

Capacity development

Skills development on a number of levels is an important aspect of the BIOTA South programme; a capacity building programme has been built into Phase II. Through the financial, logistic, and infrastructural support base, southern African researchers conduct biodiversity research in their own countries. Each of the 12 subprojects provides bursaries for students at undergraduate and postgraduate level, which contributes greatly to skills development in the natural and social sciences, leading to future researchers. Currently, 40 southern African students at B.Sc., M.Sc. and Ph.D. levels are registered at tertiary institutions in the three countries (Table 4 in online supplement), and contribute to research throughout all subprojects (Table 1 in online supplement). Of these, about 40% are women.

Capacity development within BIOTA Africa is not restricted to skills development at research institutions. As the overall aim of BIOTA is the sustainable use of biodiversity, the involvement of local stakeholders is critical. This involvement is achieved in two ways: first, through workshops where researchers and students interact with local stakeholders and exchange relevant information with land and conservation managers; second, through a 'para-ecologist' training programme implemented in 2004 at the start of Phase II.

In the latter programme, BIOTA South employs and trains members of local communities as para-ecologists (ecologists who have not received formal, academic training but are trained on the job and via courses in biodiversity research). The aim of the programme is to integrate local communities into the research activities on the BIOTA observatories, to increase participation by empowering the para-ecologists to take over substantial parts of the biodiversity monitoring tasks which were previously carried out by academic scientists, and to promote ownership of the research results by local communities. Eight individuals (3 women, 5 men) have been selected from South African and Namibian communities along the BIOTA South transect by researchers and local institutions (national parks, nature conservation agencies, agricultural research stations), and are employed full-time for the duration of Phase II, with the possibility of further employment in Phase III. Each para-ecologist is mentored and supported by a BIOTA South researcher, and receives training through workshops while conducting field work with the researchers. Table 5 in online supplement outlines aspects of the training programme. The para-ecologists monitor a range of ecological processes (such as the phenology of selected plant species), interview land-users about stock numbers or local knowledge of special organisms, set up and maintain research infrastructure, and function as contact persons and multipliers in the local communities. For the para-ecologists the programme provides a job which goes beyond the learning and applying of methods and also helps to develop self-confidence (Fig. B in online supplement). The vision of BIOTA South is that the availability of experienced, local para-ecologists will continue the monitoring of biodiversity along the transect after the German funding of the project comes to an end, and southern African institutions take over the programme's infrastructure.

BIOTA South — The future

Halfway through Phase II, planning for Phase III is already well under way. Here the main objective is the development of successful interventions and management to conserve the biodiversity of a unique region, while at the same time providing sustainable livelihoods to the local people. This will be achieved by moving the focus from discipline-based subprojects to integrative, question-driven

research themes. Emphasis will be placed on interdisciplinary research projects, synthesis of research results, application of management interventions and decision making. A prerogative of this phase will have to be successful translations of research achievements into applicable tools for land and conservation managers. This requires close involvement of local stakeholders and decision-makers.

Several challenges face BIOTA South. Now that the baselines are largely in place, a synthetic, hypothesis-driven theoretical underpinning is required. This ambitious objective obliges those involved to navigate across cultural, language and disciplinary barriers. Securing a guarantee for sustainability remains key to the BIOTA South long-term vision. Sustainability demands continuation of key activities at selected observatories and a secure but accessible home to realize the full potential of a well-collated data set from this large-scale ecological transect.

We thank Richard Knight, Anthony Mills, Sue Milton and Michael Samways for commenting on the manuscript. The BIOTA project is sponsored by the German Federal Ministry of Education and Research (promotion numbers 01LC0024 and 01LC00024A).

1. Todd S.W. and Hoffman M.T. (1999). A fence-line contrast reveals effects of heavy grazing on plant diversity and community composition in Namaqualand, South Africa. *Plant Ecol.* **142**, 169–178.
2. Riginos C. and Hoffman M.T. (2003). Changes in population biology of two succulent shrubs along a grazing gradient. *J. Appl. Ecol.* **40**, 615–625.
3. Hendricks H.H., Bond W.J., Midgley J. and Novellie P.A. (2005). Plant species richness and composition a long livestock grazing intensity gradients in a Namaqualand (South Africa) protected area. *Plant Ecol.* **176**, 19–33.
4. Allsopp N. (1999). Effects of grazing and cultivation on soil patterns and processes in the Paulshoek area of Namaqualand. *Plant Ecol.* **142**, 179–187.
5. Seymour C.L. and Dean W.R.J. (1999). Effects of heavy grazing on invertebrate assemblages in the Succulent Karoo, South Africa. *J. Arid Environ.* **43**, 267–286.
6. Joubert D.F. and Ryan P.G. (1999). Differences in mammal and bird assemblages between communal and commercial rangelands in the Succulent Karoo, South Africa. *J. Arid Environ.* **43**, 287–299.
7. Midgley G.F., Hannah L., Millar D., Rutherford M.C., and Powrie L.W. (2002). Assessing the vulnerability of species richness to anthropogenic climate change in a biodiversity hotspot. *Global Ecol. Biogeogr.* **11**, 445–451.
8. Midgley G.F., Hannah L., Millar D., Thuiller W. and Booth A. (2003). Developing regional and species-level assessments of climate change impacts on biodiversity in the Cape Floristic Region. *Biol. Conserv.* **112**, 87–97.
9. Mascia M.B., Brosius J.P., Dobson T.A., Forbes B.C., Horowitz L., McKean M.A. and Turner N.J. (2003). Conservation and the social sciences. *Conserv. Biol.* **17**, 649–650.
10. Campbell L.M. (2005). Overcoming obstacles to interdisciplinary research. *Conserv. Biol.* **19**, 574–577.
11. Scoones I. (1999). New ecology and the social sciences: What prospects for a fruitful engagement? *Ann. Rev. Anthropol.* **28**, 479–507.
12. Hobbie J.E., Carpenter S.R., Grimm N.B., Gosz J.R. and Seastedt T.R. (2003). The US Long Term Ecological Research Program. *BioScience* **53**, 21–32.
13. Henschel J., Pauw J., Banyikwa F., Brito R., Chabwela H., Palmer T., Ringrose S., Santos L., Sitoe A., and van Jaarsveld A. (2003). Developing the Environmental Long-Term Observatories Network of Southern Africa (ELTOSA). *S. Afr. J. Sci.* **99**, 100–108.
14. Hobbie J.E. (2003). Scientific accomplishments of the Long Term Ecological Research Program: an introduction. *BioScience* **53**, 17–20.
15. Gosz J.R. (1996). International long-term ecological research: Priorities and opportunities. *Trends Ecol. Evol.* **11**, 444–444.
16. Jürgens N. (1998). Aspects of botanical biodiversity in southern African arid regions – An outline of concepts and results. In *Biodiversity — A Challenge for Development Research and Policy,* eds W. Barthlott and M. Winiger, pp. 53–70. Springer, Berlin.
17. Jürgens N. (1998). Biodiversity monitoring transect analysis. In *Biodiversitätsforschung in Deutschland. Potentiale und Perspektiven,* eds W. Barthlott and M. Gutmann, pp. 1–73. Graue Reihe, Europäische Akademie, Bad Neuenahr-Ahrweiler.
18. Jürgens N. (2001). *Biodiversity — The Living Resource: Challenges and Research Strategies. A science plan for the German research on the global change of biodiversity,* pp. 23–45. German National Committee on Global Change Research, Bonn.
19. Roth S. and Nunny V. (2003). *Biological Diversity: research for the future. The BMBF research programme BIOLOG-biodiversity and global change.* Bundesministerium für Bildung und Forschung, Bonn.
20. Bundesministerium für Bildung und Forschung (2005). Förderkatalog des BMBF/BMWA. Online: http://oas2.ip.kp.dle.de/foekat
21. Akhtar-Schuster M. 2004. Starting a dialogue for strengthening the effectiveness and performance of inter-disciplinarity in BIOTA AFRICA.
22. Schmiedel U. and Jürgens N. (2005). Biodiversity observatories. A new standardised monitoring tool for biodiversity studies. *Basic Appl. Dryland Res.* **1**, 87–91.
23. Jürgens N. (in press). Recent change of flora and vegetation in Namibia — a brief review of dynamics, drivers and scientific approaches. In *The Changing Culture and Nature of Namibia: Case Studies,* ed. H. Leser. Publishing House Basler Afrika Bibliographien, Basel, Windhoek.
24. Dean W.R.J., Anderson M.D., Milton S.J. and Anderson T.A. (2002). Avian assemblages in native Acacia and alien *Prosopis* drainage line woodland in the Kalahari, South Africa. *J. Arid Environ.* **51**, 1–19.
25. Suhling F., Sahlen G., Kasperski J. and Gaedecke D. (2005). Behavioural and life history traits in temporary and perennial waters: comparisons among three pairs of sibling dragonfly species. *Oikos* **108**, 609–617.
26. Uhlmann E., Gorke C., Petersen A. and Oberwinkler F. (2004). Arbuscular mycorrhizae from semiarid regions of Namibia. *Can. J. Bot.* **82**, 645–653.
27. Eccard J.A., Meyer J. and Sundell J. (2004). Space use, circadian activity pattern, and mating system of the nocturnal tree rat *Thallomys nigricauda. J. Mammal.* **85**, 440–445.
28. Tews J., Schurr F. and Jeltsch F. (2004). Seed dispersal by cattle may cause shrub encroachment of *Grewia* lava on southern Kalahari rangelands. *Appl. Veg. Sci.* **7**, 89–102.
29. Wichmann M.C., Jeltsch F., Dean W.R.J., Moloney K.A. and Wissel C. (2003). Implication of climate change for the persistence of raptors in arid savanna. *Oikos* **102**, 186–202.
30. Tews J., Moloney K. and Jeltsch F. (2004). Modeling seed dispersal in a variable environment: a case study of the fleshy-fruited savanna shrub *Grewia flava. Ecol. Model.* **175**, 65–76.
31. Musil C.F., Schmiedel U. and Midgley G.F. (2005). Lethal effects of experimental warming approximating a future climate scenario on southern African quartz-field succulents: a pilot study. *New Phytol.* **165**, 539–547.
32. Bolus C., Hoffman T., Todd S., Powell E., Hendricks H. and Clark B. (2004). The distribution and population structure of *Aloe pillansii* in South Africa in relation to climate and elevation *Trans. R. Soc. S. Afr.* **59**(2), 134–140.
33. Jürgens N. (2001). Remarkable differences in desertification processes in the northern and southern Richtersveld (Northern Namaqualand, Republic of South Africa). In *Sustainable Land-Use in Deserts,* eds S-W. Breckle, M. Veste and W. Wucherer, pp. 177–188. Springer-Verlag, Heidelberg.
34. Mayer C. (2004). Pollination services under different grazing intensities. *Int. J. Trop. Insect Sci.* **24**(1), 95–103.
35. Anderson P., Hoffman M.T. and Holmes P. (2004). The potential of *Cephalophyllum inequale* for the restoration of degraded arid landscapes in Namaqualand, South Africa. *Restoration Ecol.* **12**(3), 343–351.
36. Nuppenau E.A. (2002). Towards a genuine exchange value of nature: interactions between humans and nature in a principal-agent-framework. *Ecol. Econ.* **43**, 33–47.
37. Schultz C. and Weber B. (2005). Multi-scale remote sensing techniques for long-term monitoring of biological soil crusts (BSCs). In *BMBF: Biodiversity and Global Change — Status Report 2005.* PT-DLR Environmental Research and Technology, Würzburg.
38. Weber B., Deutschewitz K., Schultz C., Dojani S. and Büdel B. (2005). Development and implementation of remote sensing techniques for long-term monitoring of biological soil crusts (BSCs). In *Proc. 3rd CHRIS-Proba Workshop,* ed. B. Hörsch. ESRIN, Frascati, Italy.
39. Wichmann M.C., Dean W.R.J. and Jeltsch F. (2004). Global change challenges the Tawny eagle (*Aquila rapax*): modelling extinction risk with respect to predicted climate and land use changes. *Ostrich* **75**(4), 204–210.
40. Wichmann M.C, Groeneveld J., Jeltsch F. and Grimm V. (2005). Mitigation of climate change impacts on raptors by behavioural adaptation: ecological buffering mechanisms. *Global Planet. Change* **47**(2-4), 273–281.
41. Wichmann M. Jeltsch F., Dean W.R.J., Moloney K. A. and Wissel C. (2003). Implications of climate change for the persistence of raptors in arid savannah. *Oikos* **102**, 186–202.
42. Tews J., Blaum N. and Jeltsch F. (2004). Structural and animal species diversity in arid and semi-arid savannas of the southern Kalahari. *Ann. Arid Zone* **43**, 413–425.
43. Tews J. and Jeltsch F. (2004). Climate change impacts woody plant population dynamics in arid savanna. *BMC Ecol.* **4**, 17.
44. Tews J., Milton S.J., Esther A. and Jeltsch F. (in press). Linking a population model with a landscape model: assessing the impact of land use and climate change on savanna shrub cover dynamics. *Ecological Modeling.*
45. Mayer C. and Kuhlmann M. (2004). Synchrony of pollinators and plants in the winter rainfall area of South Africa — observations from a drought year. *Trans. R. Soc. S. Afr.: Proc. Colloquium on Adaptations in Desert Fauna and Flora*: Special Issue, **59**(2): 55–57.

Supplementary material to:

Krug C.B., Esler K.J., Hoffman M.T., Henschel J., Schmiedel U. and Jürgens N. (2006). North–South cooperation through BIOTA: an interdisciplinary monitoring programme in arid and semi-arid southern Africa. *S. Afr. J. Sci.* **102**, 187–190.

Table 1. List of subprojects within BIOTA South, with number of workpackages (individual projects or tasks), German, South African and Namibian institutions involved, and number of researchers (including post-doctoral researchers) and students (Ph.D./M.Sc./B.Sc./B.Tech.) working in each subproject (some researchers are involved in more than one subproject).

Sub-project no.	Subproject title	Institutions involved	Work packages	Researchers/ principal investigators	Students
S01	Remote sensing and GIS-based survey of spatial and temporal biodiversity dynamics and analysis of biodiversity and geodiversity interrelationships	German Aerospace Centre Max Planck Institute for Meteorology Universität Würzburg ARC-Range and Forage Institute South African National Biodiversity Institute University of Cape Town University of the Western Cape National Botanical Research Institute, Namibia Polytechnic of Namibia	5	8	7
S02	Edaphical diversity and biodiversity in mutual dependence	Universität Hamburg Stellenbosch University	5	5	5
S03a	Mycocoenoses of the soil, their species diversity and functions	Eberhard-Karls-Universität Tübingen	4	3	0
S03b	Biodiversity of rust fungi in southwestern Africa: Species monitoring, database and data analysis	Eberhard-Karls-Universität Tübingen	3	1	1
S04	Development of a storage and retrieval system for lichenological biodiversity data	Staatliches Museum für Naturkunde, Karlsruhe Universität Bayreuth National Herbarium, Pretoria Polytechnic of Namibia	2	2	0
S05	Biological soil crusts (BSCs): biodiversity, functional diversity, their environmental determinants and role in the ecosystem	Universität Hohenheim Universität Kaiserslautern Universität Leipzig Staatliches Museum für Naturkunde, Karlsruhe University of Limpopo	7	5	9
S06	Towards sustainable use of phyto-diversity: analysis of the mechanisms which control the changes caused by human land use and climate change	Universität Hamburg South African National Biodiversity Institute Stellenbosch University University of Cape Town University of Pretoria University of the Western Cape Western Cape Department of Agriculture National Botanical Research Institute, Namibia Polytechnic of Namibia	6	13	22
S08	Effects of anthropogenic changes on the diversity of Namibian Odonata: modelling on differentgeographical scales	Pädagogische Hochschule Karlsruhe Tierärztliche Hochschule Hannover Technische Universität Braunschweig National Museum of Namibia	5	6	4
S09	Structural, functional and species diversity in semiarid savannas of southern Africa: scaling-up and modelling-based integration	Philips-Universität Marburg Universität Potsdam Universität Regensburg Universität Tübingen University of Cape Town University of Pretoria	5	10	13
S10	Arthropods as ecosystem engineers: the impact of ants, termites and tenebrionids on soil properties and vegetation	Universität Würzburg Desert Research Foundation of Namibia Gobabeb Training and Research Centre	2	2	3
S11	Socio-economics of biodiversity management: Policy, institutions and land use concepts	Justus-Liebig-Universität Giessen Philipps-Universität Marburg Universität Hamburg University of Cape Town University of Zululand Desert Research Foundation of Namibia University of Namibia	6	7	14
S12	Zoological diversity in transformed landscape of the Western Cape, South Africa	Stellenbosch University	4	4	3
Total			54	66	81

Table 2. Disciplines represented within BIOTA South, and number of German, Namibian and South African researchers working within the different disciplines. Researchers are listed only once, according to their main discipline.

Discipline	German	Namibian	South African	Total
Economics & Social Sciences	4	3	0	7
Earth & Atmospheric Sciences	5	0	5	10
Biological & Life Sciences	17	2	12	31
Applied Sciences	0	1	2	3
Total	26	6	19	51

Table 3. Contact details for the German BIOTA South head office, and the Namibian and South African steering committee chairs and liaison officers.

Head Office BIOTA South	BIONASC	SABSC
Norbert Juergens Biocentre Klein Flottbek and Botanical Garden University of Hamburg Ohnhorststr. 18 22609 Hamburg Germany	BIOTA Namibia Steering Committee Ibo Zimmermann (Chair) Patrick Graz (Co-Chair) Agriculture Department Polytechnic of Namibia Private Bag 13388 Windhoek Namibia	South African BIOTA Steering Committee Nicky Allsopp (Chair) ARC-Range and Forage Institute c/o University of the Western Cape Private Bag X17 Bellville 7535 South Africa
Coordinator: Ingo Homburg Tel: +49 (0)40 428 16409 E-mail: ihomburg@botanik.uni-hamburg.de	**Liaison Officer**: Bertchen Kohrs Tel: +264 (0)61 227 913 E-mail: bertchenk@iway.na	**Liaison Officer**: Tessa Oliver Tel: +27 (0)21 959 3381 E-mail: toliver@uwc.ac.za

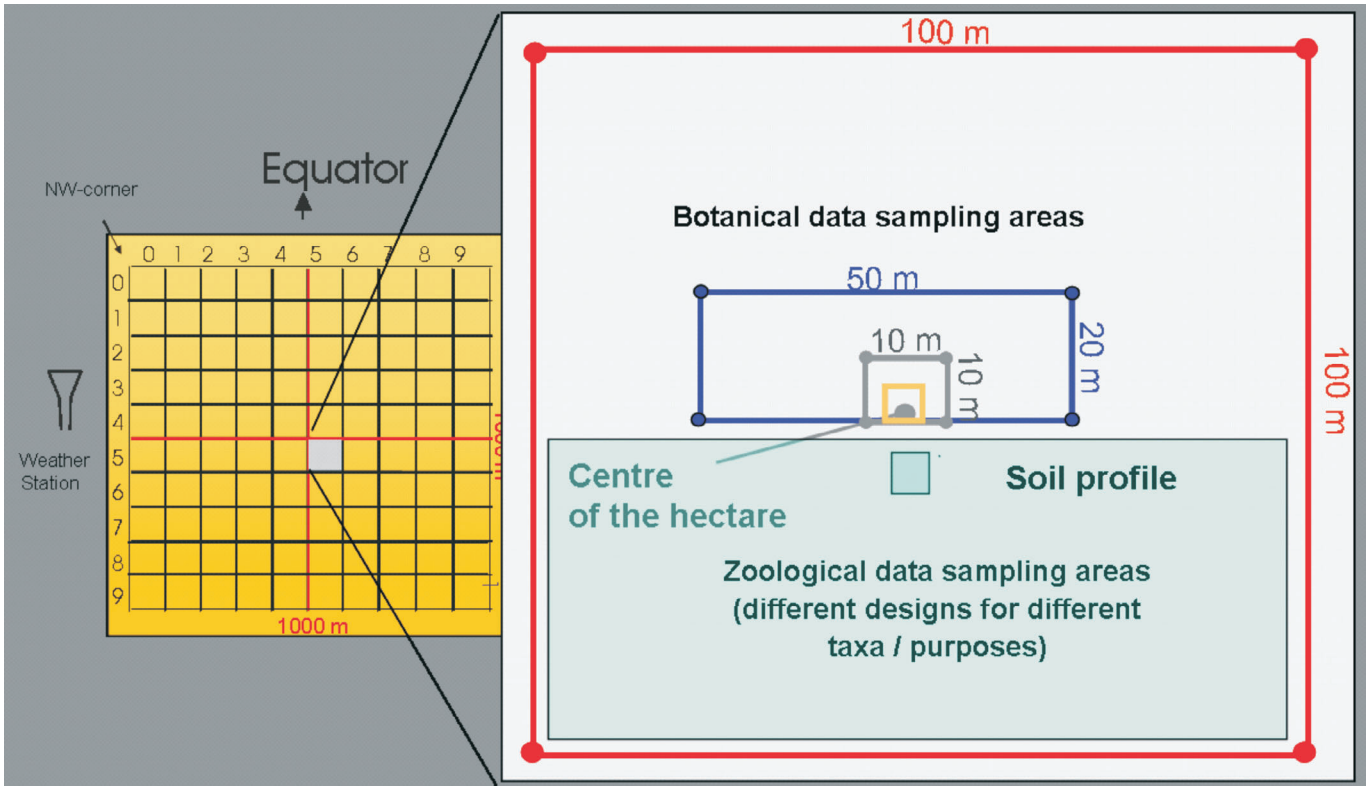

Fig. A. Design of the 1-km^2 observatories. Biodiversity research focuses on a number of randomly selected hectares within the observatory; the number of hectare plots investigated differs between subprojects. Soil, lichenological and botanical sampling plots are set on predefined, fixed points whereas other disciplines work outside of these within each hectare sampled.

Table 4. Total number of southern African students at B.Sc., M.Sc. and Ph.D. level supported by BIOTA South at South African, Namibian and German tertiary education institutions.

Institution	Degree	Female		Male	
		Total	PDI*	Total	PDI
University of Cape Town	B.Sc.(Hons)	2		2	
	M.Sc.			3	1
	Ph.D.	3(1)	1(1)†	1	
University of the Free State	Ph.D.			1(1)	
University of Pretoria	B.Sc.(Hons)	1(1)			
	M.Sc.	1		1	
	Ph.D.	(1)			
University of Stellenbosch	B.Sc.(Hon)			1	
	M.Sc.	2			
	Ph.D.			2	
University of the Western Cape	B.Sc.(Hons)			1	
	M.Sc.			1	
	Ph.D.			1	
Polytechnic of Namibia	BTech	2	2	2	2
University of Namibia	LLB	2	2	5	5
	M.A.			1	1
Universität Göttingen	Ph.D.			(1)	(1)
Universität Hamburg	Ph.D.			(1)	
	Total	16	6	24	10

*Previously disadvantaged students, i.e. as understood in contemporary South Africa (meaning black or mixed-race students, and women). Only 10% of the South African students are drawn from these groups compared to 80% of the Namibian students.
†Brackets denote number of Namibians studying at South African or German institutions.

Table 5. Aspects of on-the-job training of the BIOTA South para-ecologist programme.

The courses and on-the-job training comprise the following:

a) general skills (e.g. to facilitate workshops, to conduct interviews, to share research activities and objectives with local communities, to promote environmental awareness in the community, to develop self-help);
b) the use of technical equipment (e.g. GPS, maps, cameras, computers);
c) collection and identification of plants and animals;
d) assessment and documentation of monitoring data on flora, fauna and soils;
e) assessment of socio-economic information;
f) the ecology of and threats to the respective ecosystems they work and live in.

Fig. B. Para-ecologists proudly displaying their certificates after successfully completing the training course held at Gobabeb, Namibia, in October 2004.