PROCEEDINGS

SAFARI 2000: Southern African Regional Science Initiative Workshop

HELD JULY 26TH TO 30TH 1999
BOTSWANA NATIONAL PRODUCTIVITY CENTRE

Compiled by

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SUMMARY

Background – Aim of SAFARI 2000

The Southern African Regional Science Initiative - SAFARI 2000 - is an international science initiative aimed at developing a better understanding of the southern African earth-atmosphere-human system. The goal of SAFARI 2000 is to identify and understand the relationships between the physical, chemical, biological and anthropogenic processes which underlie the biogeophysical and biogeochemical systems of southern Africa. Particular emphasis is placed upon biogenic, pyrogenic and anthropogenic emissions, their transport and transformations in the atmosphere, their influence on regional climate and meteorology, their eventual deposition, and the effects of this deposition on ecosystems. To accomplish this, SAFARI 2000 participants will:

- integrate remote sensing, computational modeling, airborne sampling and ground-based studies;
- link the biological, physical and chemical components of the regional ecosystems by integrating them within the semi-closed atmospheric gyre persistent over the region;
- combine the expertise and knowledge base of regional and international scientists.

SAFARI 2000 builds upon the success of the Southern African Fire-Atmosphere Research Initiative in 1992 (SAFARI-92). SAFARI-92 showed that a) it is feasible to quantify and validate estimates of regional emissions, and b) critical gaps remain in our understanding of the impacts of the emissions. Programmatically, SAFARI 2000 is an organizational umbrella designed to maximize the overall efficiency and effectiveness of a group of various environmental studies occurring between 1999 to 2001. The studies range from those still in their foundational stage to those which are long-term monitoring efforts.

Objectives of the SAFARI 2000 Regional Workshop

The key objectives of the workshop were to: (i) identify regional activities related to Safari 2000, (ii) identify funding opportunities for regional participants, and (iii) outline aircraft based operations during the campaign. These main objectives were geared towards answering the questions WHO? WHAT? WHEN? WHERE? and HOW? (i.e. who would be involved in what activities, at what time and location, and how would such activities take place).

Given Safari 2000's goal to understand the key linkages between the physical, chemical and biological processes essential to the functioning of the southern African biogeophysical system, discussion took place in the following Discipline-specific Breakout Teams:

- Terrestrial Ecology – Land Processes
- Land Cover – Land Use Change
- Aerosols and Trace Gases
- Clouds and Radiation
- Integrative Modeling
- Socio-Economic and Policy Issues
- Hydrological Issues

The main task of the teams was to determine: (i) researchers intentions, (ii) nature and location of activities to be undertaken, (iii) contribution of projects to Safari 2000 goals and to capacity advancement within the region, and (iv) further opportunities for projects. On the basis of the discipline-specific team discussions the following steps were made possible: (i) areas of overlap and synergy between individual projects were determined, (ii) data management formats, needs and plans were discussed, (iii) proposed collaborative activities were outlined, (iv) regional points of contact were identified, and (v) collaborations and proposals prompted to address gaps in research identified.

Participation at the Regional Workshop

Delegates at the workshop were drawn from a large number of countries including: Botswana, Zambia, Zimbabwe, South Africa, Tanzania, the United States, Namibia, Reunion, Mozambique, Malawi, the United Kingdom and the Netherlands. Researchers from various disciplines, including atmospheric science, terrestrial ecology, hydrology, land cover dynamics, socio-economics and policy issues were in attendance. Such researchers comprised individuals from academic institutions, governmental departments, research institutions, National Parks and consulting companies. The workshop was also attended by a number of policy makers and representatives from various funding agencies, including USAID, the Commonwealth Science Council, and the National Science Federation.

Workshop Proceedings Outline

The Workshop Agenda is provided overleaf. A detailed table of contents is subsequently given for the workshop proceedings. The key science questions identified as part of SAFARI 2000, and forming the basis for the discussions at the workshop, are presented in Appendix A. Activities identified for each core element to be addressed by the SAFARI 2000 campaign are listed in Appendix B. Appendix C comprises lists of the participants in the various core element groups. A comprehensive list of all workshop participants is given in Appendix D.

AGENDA

SAFARI 2000 WORKSHOP – JULY 26TH – 30TH 1999
BOTSWANA NATIONAL PRODUCTIVITY CENTRE

DAY 1 MONDAY JULY 26th, 1999

Opening Ceremonies

07h30 onwards	Registration in Main Foyer
08h30	Assembly of Dignitaries
09h00	Entrance of dignitaries stand for Botswana National Anthem Master of Ceremonies – Professor Issac Mazonde, Chairman, Botswana Global Change Committee
09h10	Welcome of Dignitaries and Delegates by Professor Sharon Siverts, Vice Chancellor, University of Botswana
09h15	Official Opening: His Excellency Ambassador Robert Krueger , US Special Representative of the Secretary of State to the Southern African Development Community
09h30	Keynote Address: The Honourable Dr Margaret Nasha, Minister of Minerals, Energy and Water Affairs
09h45	Vote of Thanks by Dr. Brian Mokopakgosi, Deputy Vice Chancellor, Academic Affairs, University of Botswana.
10h00	Brief outline of the SAFARI 2000 Project, Dr Bob Swap International Co-ordinator, Global Environmental Change Program, University of Virginia, USA.
10h15	SAFARI 2000 Botswana Perspective, Professor Sesei Mpuchane, Dean of Science, University of Botswana.
10h30	Closing of Opening Ceremonies - Professor Issac Mazonde, Chairman, Botswana Global Change Committee and Directorate of Research and Development, University of Botswana.
10h30 – 11h00	TEA/COFFEE

Plenary Session 1: Objectives of Meeting – Safari 2000 Science Plan
Chair: Dr Raban Chanda (UB)

11h00 – 11h30	Objectives of meeting – Overview of Safari2000 project Prof Harold Annegarn, University of Witwatersrand
11h30 – 12h30	Presentation of the Science Plan, Dr Bob Swap, University of Virginia and discussion
12h30 – 12h45	Outline of Meeting Schedule, Dr Bob Swap, University of Virginia and Prof Sue Ringrose, University of Botswana
12h45 – 14h00	L U N C H

Plenary Session 2: Ongoing and Anticipated Regional Science Projects (Angola and Botswana)
Chair: Dr Luanne Otter (CSIR)

(14h00 – 15h00 : 5 Min per Speaker)

1. OKACOM (Mr Muzila/Angola)
2. Subsistence rangelands project (Drs Chanda/Moleele)
3. Miombo project – (Dr Desanker?)
4. Remote Sensing projects – (Prof Ringrose/Dr Ferraz)
5. Kalahari Transect (Dr Dowty)
6. Maun Tower etc. (Dr Veenendaal)
7. ADAS masts (Mr Carlsson)
8. Aerosol measurements (Dr Verma)
9. Pan aerosols (Dr Eckardt)
10. Socio-economic/policy implications (Dr Kgathi)

15h00 – 15h30 TEA/COFFEE

Plenary Session 3.1: Ongoing and Anticipated Regional Science Projects (Malawi, Namibia, South Africa, Tanzania)
Chair: Dr Frank Eckardt (UB)

15h30 – 16h45

Plenary Session 3.2: Presentations by the International Aid /Funding Agencies based in Southern Africa

16h45 – 17h30:

(1) USAID
(2) Commonwealth Science Council
(3) National Science Federation
(4) Anglo American/Debswana
(5) EU or DFID?

EVENING RECEPTION – HOSTED BY UNIVERSITY OF BOTSWANA 7:00 PM AT BOTALA RESTAURANT BNPC

DAY 2 TUESDAY JULY 27th, 1999

Plenary Session 4.1: Ongoing and Anticipated Regional Science Projects (Mozambique, Zambia, Zimbabwe)
Chair: Dr Anne Thompson, Ozone Project

09h00 – 10h30:

(1) Miombo Project
(2) Forestry Commission
(3) FEWS

10h30 – 11h00 TEA/COFFEE

Plenary Session 4.2: Presentations by Botswana Government Departments on databases:
Chair: Mr Chipeta, Zambia Meteorological Services

11h00 – 11h45:

(1) Department of Meteorological Services (Mr Lesolle)
(2) Department of Mines (Mr Matale)
(3) Ministry of Agriculture (Mr Mandeuv)
(4) Department of Water Affairs (Mr Muzila)
(5) National Conservation Strategy (Mr Monna)

Plenary Session 5: Presentation by D Tim Suttles on Results of the NASA EOS SAFARI Boulder Workshop and Aircraft Schedule Botswana Government Departments on databases
Chair: Mr Lesolle, Botswana Meteorological Services

11h45 – 12h45

12h45 – 14h00 LUNCH

Plenary Session 6: Outline of Group work on seven workshop themes, choosing of Group Leader and Scribe
Facilitators: Harold Annegarn and Sue Ringrose

14h00 – 14h30

GROUPS A – Terrestrial Ecology – Land Processes
B – Land Cover – Land use Change
C – Aerosols and Trace Gases
D – Clouds – Radiation
E– Modeling
F – Socio-economic and policy issues
G – Hydrological issues

Groups to discuss SAFARI2000 Core Elements Activities:

(1) Researchers intentions? What activity at what times?
(2) Activity integration with SAFARI2000
(3) Project contribution to capacity enhancement/recognition within region
(4) Indicate which core element activities not adequately addressed (?by Science Plan)
(5) Assign member to Synthesis Team Working Group

19h00 - SUPPER International and national points of contact to dine together (ongoing group discussions informally after supper)

DAY 3 WEDNESDAY July 28, 1999

Plenary Session 7 Brief Report Back on Group Discussions (A-G)
Chair: Dr Bob Swap

09h00 – 10h30

10h30 – 11h00 TEA/COFFEE

Plenary Session 8: Regional Database and Official Procedures for Regional Collaboration
Chair: Otlogehswe Totolo

11h00 – 12h45.

(1) Development of regional database (NASA mirror site)-Simon Wills (FFM) and Bob Cook (NASA)
(2) Collaboration procedures for Zambia
(3) Collaboration procedures for Zimbabwe
(4) Collaboration procedures for Namibia
(5) Collaboration procedures for Tanzania
(6) Collaboration procedures for Malawi
(7) Collaboration procedures for Angola
(8) Collaboration procedures for Mozambique

(9) Collaboration procedures for South Africa
(10) C Collaboration procedures for Botswana (Issac Mazonde)

12h45 – 14h00 LUNCH

Plenary Session 9: Outline of Group work on SAFARI2000 Synthesis Themes (same groups as before-with scribe designated)
Facilitators: Hank Shugart and Sharon Gomez

14h00 – 15h45:

(1) Determine overlap/synergy between projects to maximise airborne and remote sensing resources
(2) Discuss how science ties to regional policy
(3) Discuss data management plans and needs
(4) Outline proposed collaborative activities
(5) Identify regional points of contact for synthesis teams
(6) Discuss gaps and evolve proposals to fill them

15h15 – 15h45 TEA/COFFEE

15h45 – 17h30 Continued Group Work - Emphasis on drafting Collaborative and Synthesising Proposals

16h45 – 17h30 Proposal Drafting in Groups

19h00 SUPPER

WHERE POSSIBLE THE GROUP REPORTS AND COLLABORATIVE PROJECT PROPOSALS SHOULD BE FINALISED IN UB OFFICES WHERE COMPUTERS ARE AVALABLE

DAY 4 THURSDAY July 26, 1999

Plenary Session 10: Synthesis Team Preparation time for group Reports – Get your bullets together for Plenary presentation

09h00 – 10h30

10h30 – 11h00 TEA/COFFEE

Plenary Session 11: Synthesis Team Feedback and Discussions
Chair: Choma Matale, Division of Mines

11h00 – 12h45

12h30 – 14h00 Pick up packed Lunch

14h00 – 15h45 Field excursions to:

a) Thamaga (pottery)-Lobatse (Back 5:00 pm)
b) Letlhakeng (Kalahari) (Back late)

19h00 SUPPER

DAY 5 FRIDAY July 30TH, 1999

Plenary Session 12: Finalisation of Regional Integration
Chair: Harold Annegarn/Sue Ringrose

09h00 – 10h30:

(1) Review of Who, What Where and When
(2) Summary of Science and Synthesis proposals
(3) Review of regional Coordination and Synthesis Team Points of Contact
(4) Regional Funding issues
(5) What is missing?
(6) Discussion of upcoming remote sensing meeting in Cape Town, March 2000
(7) Discussion of Aircraft Planning Simulation Exercise post Cape Town meeting
(8) Discussion of next SAFARI2000 planning meeting to be held ca. April-May, 2000, venue?

10h30 – 11h00 TEA/COFFEE

Plenary Session 13: Finalisation of SAFARI IMPLEMENTATION
Chair: Issac Mazonde, UB

11h30 – 12h30 Presentation by Dr Bob Swap: Revised Science Plan and Critical Pathway Forward
Discussion

12h30 – 14h00 LUNCH – END OF WORKSHOP

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GLOSSARY

AirMISR	-	Airborne Multi-angle Imaging Spectro-Radiometer
AOT	-	Aerosol Optical Thickness
APINA	-	Air Pollution Information Network for Africa
ARREX	-	Aerosol, Recirculation and Rainfall Experiment
BATGE	-	Biosphere-Atmosphere Trace Gas Experiment
BPRP	-	Bethlehem Precipitation Research Project
BHATTEX	-	Ben McDhui High Altitude Trace Gas Transport Experiment
CLS	-	Cloud LIDAR System
CSC	-	Commonwealth Science Council
DIS	-	Data Information System
DEBITS	-	Deposition of Biogeochemically Important Trace Species
EOS	-	Earth Observing Satellite
ERSI	-	Environment and Remote Sensing Institute, Zimbabwe
GCTE	-	Global Change and Terrestrial Ecosystems
KT	-	Kalahari Transect
LIDAR	-	Light Detection and Ranging instrument
LUCC	-	land use and cover change
MODIS	-	Moderate-Resolution Imaging Spectro-radiometer
MOPITT	-	Measurement of Pollution in the Troposphere
MOU	-	Memorandum of Understanding
NCS	-	National Conservation Strategy
NSF	-	National Science Federation
ORB	-	Okavango River Basin
PI	-	Principle Investigator
PSD	-	Particle size distribution
RCSA	-	USAID Regional Center for Southern Africa
RDC	-	Regional Data Centre
SABISA	-	Savanna Biogeochemistry Project in Southern Africa
SADC	-	Southern African Development Community
SAROS	-	South African Rainfall Observing System

SAVE	-	Southern African Validation Experiment
SAWB	-	South African Weather Bureau
SHADOZ	-	Southern Hemisphere Additional Ozonesondes
SRRP	-	Subsistence Rangelands Research Project
START	-	Global Change System for Analysis Research and Training
SEA	-	Strategic Environmental Assessment
SSR	-	Solar Spectral Flux Radiometer
S2K	-	SAFARI 2000
UB	-	University of Botswana
UN FCCC	-	United Nations Framework Convention on Climate Change
UVA	-	University of Virginia, USA
WMA	-	Wildlife Management Areas
ZIBBEE	-	Zambia International Biomass Burning Emission Experiment

SAFARI 2000 WORKSHOP – JULY 26TH TO 30 TH 1999
BOTSWANA NATIONAL PRODUCTIVITY CENTRE

DAY 1 MONDAY JULY 26TH - OPENING CEREMONIES

OFFICIAL OPENING: SCOTT DELISI, representative of Ambassador Robert Krueger, US Special Representative of the Secretary of State to the Southern African Development Community

Honourable minister Nasha, Vice Chancellor Sieverts, Distinguished Conferees, Ladies and Gentlemen:

It is a great pleasure to be here this morning and to have the opportunity to assist in the opening of the Safari 2000 Workshop.

My ambassador, Robert Krueger, was scheduled to be with you today but he, unfortunately, has been laid low by the flu bug that is working its way through Gabarone. So, taking a cue from American baseball, he asked me to pinch hit for him this morning.

I am of course delighted to do so, but as I sat down to prepare these brief remarks I had to ask just what I could add to this gathering. I am not a scientist and when we start to speak about pyrogenic and biogenic processes I must admit to feeling an inexplicable heaviness descend upon my eyelids.

Moreover, this is the *Southern African* Regional Science Initiative…thus, not only why a diplomat, but an American diplomat to boot?

There is, of course, and answer to that question and, unsurprisingly, I think I know what the answer is – otherwise I would never have posed the question in the first place.

Let me start with the latter part first…why and American? The answer lies in part in the fact that SAFARI 2000's genesis lies in the Southern African Environmental Review announced in March 1998 by President Clinton during his visit to Africa. The president's comment at that time was to improve America's understanding of environmental change… and environmental challenges in Africa. He vowed to work with our African colleagues to tackle significant challenges such as drought and desertification, and preserving biodiversity.

To that end, the University of Virginia and the Unites States' national Aeronautics and Space Administration has become a key partner with Southern African and European colleagues to study the effects of biomass burning and industrial and biogenic emissions on the southern African ecosystem and climate.

Along with scientists and academics from a variety of other American institutions, the University of Virginia and NASA will cooperate with our regional partners in conducting ground-based and airborne experiments. In addition, NASA's new-generation EOS satellites, scheduled for launch this year and next, will provide comprehensive satellite-based measurements to complement the ground-based and airborne data collected for SAFARI 2000.

It is also expected that through this process regional scientific capacity will be enhanced as southern African scientists work with and gain expertise in tools associated with environmental research using remotely-sensed data.

In making his commitment to engage the African continent more fully on environmental issues President Clinton was also recognising another vital reality of the late 20th century – no part of the earth's surface can for long remain unaffected by the activities which go on elsewhere on the planet.

And *that* awareness, brings me to the other part of my initial question… "Why a diplomat?"

Why a diplomat?…Because the world is too small a place today for any of our nations to live in isolation from each other. Because the issues of environmental protection, biodiversity, desertification, protection of wetlands, and climate change are no longer only of interest or concern to the scientists.

These issues affect nations and their citizens in ways never considered 100 years ago. Science, economics, sociology, politics…they are all involved and all interrelated and as we would tackle these problems there is a role for all of us, including diplomats – even when we are hard pressed to define… much less pronounce… anthropogenic.

Finally, there is one other – distinctively southern African reason – why Ambassador Krueger was so pleased to have the chance to help open this highly worthwhile endeavour.

Ambassador Krueger has the distinction of serving not just as the American ambassador to Botswana but also as Secretary of State Albright's personal representative to the Southern African Development Community (SADC).

As such, he has spent considerable time and effort encouraging a broader and deeper engagement by the US public and private sectors with the nations of the region. Equally, however, the American Embassy here and the United States government in general has sought to encourage the SADC member states to work more closely with each other on a range of issues, including environmental matters.

Our efforts through the US Agency for International Development, through the State Department's Bureau for Oceans, Environment and Science, through the National Oceans and Atmospheric Administration can only be complemented and enhanced by the undertakings that comprise SAFARI 2000.

You all probably understand far better than I the specific challenges faced by SADC members seeking to meet their obligations under the various environmental conventions to which most of them are signatories.

We all know, however, that if we do not understand the science at work behind the larger processes when looking at issues such as desertification or climate change, then we cannot take intelligent and effective steps to dealt with the problems.

SAFARI 2000 will, we all hope, help us to understand better those environmental issues with which the region, and the international community as a whole, will have to grapple as we enter the new millennium.

On behalf of Ambassador Krueger permit me to wish you all the best in your endeavours this week. We want your to know that the government of the United States remains committed to working with our colleagues in southern Africa and on the continent as a whole in meeting the challenges ahead.

KEYNOTE ADDRESS: The Honourable Dr MARGARET NASHA, Minister of Minerals, Energy and Water Affairs, Botswana

When I received an invitation some time in June, to come and deliver a keynote address at this workshop, my first reaction was "Why me?" I thought what is it that I can till a group of highly trained scientists from Southern Africa and abroad? After all I'm only a historian, a broadcast journalist, a diplomat, a campaigner for women's rights, and presently trying hard to become a politician! The last time I had anything at all to do with mathematics, physics, chemistry etc. was 31 years ago when I completed my secondary school education in 1968! Makes you wonder how young I am!

But then, I looked through your program and discovered that to a large extent, this workshop will actually focus on the environment, an area I seriously fell in love with some ten years ago. So, I didn't have to find a diplomatic reason to decline the invitation.

I must take this opportunity to welcome our friends from the SADC region and from abroad. In Botswana we say to our visitors, "All dogs have been tied, so our visitors can enjoy freedom of movement in our young city without fear."

You are most welcome.

As we all know, southern African Regional Science Initiative – SAFARI2000 – is an international, collaborative science initiative, aimed at developing an integrated understanding of selected aspects of the southern African

earth-atmosphere-human system. The foundations for this initiative were developed during the SAFARI 1992 and 1994 campaigns, when the significance of the atmospheric circulations around southern Africa was first realised. At that tie it was thought that the overwhelming majority of trace gases and aerosols in the atmosphere were due to biomass burning in the north central part of the region. If was soon realised, however, that increased industrialisation in the southern African region was also significant. We know all too well that development is a double edged sword. It has its own disadvantages. Later on, emissions from the natural vegetation cover were also added to the list of atmospheric constituents. SAFARI 2000 builds upon the scientific legacy and foundation of several other regional scientific initiatives. These include the Miombo Network, the Subsistence Rangelands programme, and the Kalahari Transect. The last two as you know are co-ordinated in Botswana by colleagues here at the University of Botswana. I want to take this opportunity to urge all of you to carry on the good work.

There have remained a number of unknowns, however, such as how such constituents as methane, ozone, various hydrocarbons and sulphur dioxide, change when they are being circulated through the atmosphere, and what effects the deposition of derived compounds may have on the surface. As yet little is known about the process of transformation and exactly what the final products of deposition are. Even less is known about how these products may affect either our climate, in terms of rainfall amounts, seasonality and radiation balances; or what these may be having on vegetation cover or crops. SAFARI 2000 project has therefore been designed to begin to answer some of these questions, and to help us understand some of the key scientific linkages between our atmosphere, biosphere and hydrosphere. If we are not in a position to understand these key scientific questions, then it will be impossible to develop meaningful environmental monitoring systems, and it will be extremely difficult to focus on the key driving forces of environmental change.

Distinguished delegates, we are living in a world of change, and as the countries of southern African grow and develop, both economically and socially, the environment has not remained constant either. We believe that some of these changes are a result of the following:

- Increased numbers of cattle, goats and sheep resulting in range degradation. I know that pastoral farming remains a largely untouchable subject in Botswana. A man is still not considered man enough if he does not have a cattle post. But we have no option but to keep pressing the matter home, that we have only one earth, and that we have to protect it for posterity.

- Increased human pressure has also resulted in land degradation – deforestation and soil erosion.

- Increased arable farming, industrialisation and urban growth have also led to an increase in dust and trace gases in the atmosphere.

We already know that the minimum temperature in Botswana has increased over the past 30 years, and we are subjected to increasing droughts and increasing floods whose levels of ferocity have gone up tremendously. The term El Nino has become commonplace. We also know that the water tables in the arid and semi-arid parts of the region including Botswana are declining. We need to begin to understand why this is all happening. We need to know whether these changes are just another phase in the geologically evolving climatic patterns or whether direct or indirect human impacts are having such an effect, that our environment is suffering irreparably, with potentially dire economic and social consequences. Through the SAFARI project we hope to obtain help in answering some of the key questions, primarily relating to the causes of the significant environmental changes which are currently enduring in Botswana and elsewhere in our region.

The SAFARI project will look at the land process; land use and land cover change; terrestrial ecology; aerosols and trace-gas chemistry and transport; surface radiation; cloud characterization and radiative effects; as well as hydrology. The ground and airborne measurements will be complemented by remote sensing observations from the new generation of earth observation satellites, such as the NASA TERRA platform scheduled for launch in August this year, the Landsat 7 and TRMM. In turn, the earth and atmosphere based observations of SAFARI 2000 will help validate the remotely sensed satellite observations on a regional scale. The possibility of being able to use new, improved satellite data, which we understand will be available to the scientific community on a free and open access basis, will be a great boost to regional Universities and Government Departments with environmental mandates. These data are available via the internet.

Locating a SAFARI 2000 data centre in southern Africa will also greatly improve access, and a means through which our scientists in the region can realistically communicate. We are hoping in particular that the University of Botswana remote sensing / environmental working groups will be able to work with participating Government

Departments, to help make this entire initiative a success. And I was glad to see that almost all our relevant Government Departments will be participating actively in this workshop. I have worked with all those representatives, individually in my previous portfolio and in the present one, and I know they are a committed lot.

A regional project, which has considerable import for Botswana, is the development of this regional data centre for the SAFARI project in Southern Africa. Botswana has the technological expertise (through FFM Botswana Ltd in conjunction with the University of Botswana), to develop such a site, with help of course from collaborators from NASA. The plan so far is to house the data site at the University of Botswana in such a way that all regional participants (including Government Departments) can have ready access to SAFAI data. Significant funding will have to be obtained for this database, These are costly project to undertake, but they have to be carries out. We are looking forward to a meaningful dialogue on this topic with some of the funding agencies represented here today.

SAFARI 2000 is also committed to regional scientific capacity enhancement and capacity recognition. Colleagues, we have a lot of expertise in this region, and it is about time we recognise that, and tap on it extensively. Through the Global Change System for Research and Training (START), the US National Science Foundation and the University of Botswana, SAFARI 2000 has enjoyed initial success with the funding of regional workshops and scientific fellowships. It is absolutely essential that additional regional and international funding agencies continue to support this initiative which promises to produce socially relevant science, applicable to the management of our region's precious natural resources. Science, in this region has been for a long time both under appreciated and under funded. We now have the opportunity to support high quality integrative research that will contribute to the formulation of sustainable development policies, and I must emphasise, sustainability is of paramount importance. I am convinced, that it is not too late, and there is hope, if we can intensity our collaborative efforts even farther.

Since Botswana's independence, in 1996, the need to protect the environment and the natural resources which are an integral part of our environment, has been increasingly realised and appreciated. The government of Botswana is committed to conservation measures and environmental protection. This is amply demonstrated by the large tracts of land designated as National Parks, Game and Forest Reserves and Wildlife Management Areas (WMAs). The sizeable populations of wild animals that are still found in this country, manifest this commitment.

Approximately 17 percent of this country has been allocated specifically for the conservation of ecosystems, historic features and wilderness areas. Such areas are an important source of natural resources. Tourism, which we value very highly in Botswana, depends almost entirely on these areas which provide a habitat of varieties of plants and animals. Eighteen percent of the country has been earmarked under Wildlife Conservation Policy (1986), as Wildlife Management Areas where resources and the environment are protected. A total or 35 percent of the country's land and water areas is therefore assigned to conservation uses. From a global perspective, Botswana is recognized as the country which has the second highest area allocated to nature conservation, in percentage terms, and we intend to keep it that way.

Water management is another major preoccupation. Ours is a semi-arid country with unpredictable rainfall. Considerable funds have been expended on the search for groundwater resources to make fresh drinking water available in as many towns and villages as possible. The North South Carrier project which will cost well over P 1.3 billion, will use a combination of surface and groundwater from the north east Botswana, to help overcome water shortfalls in the relatively heavily populated and industrialised south east parts of the country. We need more rain to fill up the Letsibogo Dam, which is presently only about 16 percent full, mind you we have already missed the last season. We need to ensure that our limited water supplies are fresh and free from pollutants. To this end we have established an air quality unit which monitors emissions from both our urban areas and mines, using state-of-the-art equipment. I am sure that both water resources and air quality personnel welcome the opportunity to interact with international and Botswana based scientists to develop a greater understanding of the environmental dynamics of the atmosphere-hydrosphere system, on which we depend heavily for future growth.

As indicated earlier, despite the long tradition of environmental conservation, Botswana has, in the last twenty years, been experiencing growing pressure on the available natural resource base. Government's concern at the growing pressure on the country's environment, led to the formulation of the National Conservation Strategy (NCS), which culminated in a National Policy on Natural Resources Conservation and Development adopted in 1990.

The NCS provides a basis for initiating new policies, legislation and programmes, aimed at promoting environmental conservation. A co-ordinated environmental education programme has recently been developed, to improve effectiveness in promoting public awareness about the environment. Dear colleagues, we have to ensure that our people are fully aware of the dangers of environmental degradation, from a very early age and here too we need to spend time and money, for the future of our children and their children's children. A project aimed at improving waste management and protecting ground water resources has resulted in formulation of policy and legislation on waste management. I am finally relieved that our newest department of waste management is now in place and its first Director, Mr Kodise Selotlegeng was also appointed only a week ago. Congratulations! I have a lot of faith in that young man. Government has made a decision to promulgate Environmental Impact Assessment legislation, which is expected to ensure that development actions are environmentally friendly. Funds have been secured for carrying our the first state of the Environment Review which is expected to indicate the mechanisms of natural resource use, as well as forming the basis for an integrated environmental monitoring system.

Data from the SAFARI 2000 project should enable us and other countries in the region, to continue to develop our environmental policies increasingly from a position of strength. Hence I would like to encourage everyone present here, to work hard and share all the available knowledge, on the atmosphere, biosphere and hydrosphere, and improve our knowledge of the environment. I sincerely hope too that other participants will be able to translate the specific findings into scenarios of global change, to enable Governments to react responsively to the increasing environmental pressures which are part of our lives at this time. We need data to be able to continue to develop both on the agricultural and industrial fronts. We need to protect our environment and wildlife, to be able to maintain our tourist industry, and we will be grateful indeed if the SAFARI 2000 project can help us progress into the 21st century, with a secure knowledge base which will enable all the countries in this region, to develop our industries and agriculture without endangering the environment!

Finally distinguished delegates, they say that, "all work and no play makes Tom a dull boy", I was happy to see that you will have time to visit Thamaga and Letlhakaneng villages. If only I were party to the drafting of this programme, I would have insisted that you drive a few kilometres beyond Letlhakaneng, through deep Kalahari sands, into one of my favourite Basarwa settlements within a designated WLM Area at Kandwane, just 5 km outside Kutse Game Reserve. You would need good 4 x 4 vehicles to do that, but I will still encourage our visitors to come back and see more of our country side.

I wish you very fruitful deliberations, and of course a lovely stay n Botswana. To us the word Pula means rain, it is also our currency, and in most parts of the country it means peace. In accordance with our tradition therefore I have to end, with our innocent slogan……PULA!!!!!!

BRIEF OUTLINE OF SAFARI 2000 PROJECT
Dr. BOB SWAP, Global Environmental Change Program, University of Virginia, USA

Key findings of the Southern African Fire-Atmosphere Research Initiative in 1992 (SAFARI 92) campaign, which provide the context for the initiation of the SAFARI 2000 Project include that:

- The region is tied together atmospherically, through the strength and persistence of a regional circulation feature known as the southern African anticyclonic gyre.
- Emissions originate from multiple sources, and include industrial, biogenic and pyrogenic releases.
- The establishment of scientific collaborations is necessary; the building of partnerships between regional and international scientists represented one of the more important outcomes of SAFARI 92.

Despite its achievement SAFARI 92 left a number of unanswered questions and a sense that a coordinated experiment that engages the region could reduce current uncertainties. Such future work could draw on a relatively rich experimental heritage which includes such activities as:

- SAFARI 92, the Transport and Atmospheric Chemistry near the Equator (TRACE A) initiative, and the 1995 Chapman Conference on Biomass Burning and Global Change
- SA'ARI 94
- IGBP/IGAC Biosphere-Atmosphere Trace Gas Experiment (BATGE) and the Deposition of Biogeochemically Important Trace Species (DEBITS) emissions (1994 - present)

- IGBP Regional Initiatives, including the Miombo Network, Kalahari Transect, and Subsistence Rangelands projects (1995 - present)
- BHATTEX(1996)
- ZIBBEE (1997)
- ARREX (1997 - present)

Many of the results of SAFARI 92 and TRACE A were published in:

- Fire in Southern African Savannas, Ecological and Atmospheric Perspectives, Edited by BW van Wilgen, MO Andrea, JG Goldammer and JA Lindesay; and
- A special issue of the Journal of Geophysical Research (Vol. 101, No. D19, 1996).

The goal of SAFARI 2000 is to understand the key linkages between the physical, chemical and biological processes, including human impacts, essential to the functioning of the southern African biogeophysical system. More specifically, SAFARI 2000 aims to:

- Characterize, quantify and understand the processes driving biogenic, pyrogenic and anthropogenic emissions in southern Africa;
- Use atmospheric transport and chemistry models, ground-based, airborne, and satellite-based observations to validate and extend our understanding of the transport and transformations of these emissions; identify where, when and how the emissions are eventually deposited, and determine their impacts, and
- Lay the foundation for monitoring the longer-term climatic, hydrological, and ecosystem consequences of these biogeochemical and physical processes.

To this end, SAFARI 2000 will undertake to:

- Exploit the synergy between remote sensing, modeling, airborne sampling and ground-based studies;
- Use the semi-closed continental atmospheric circulation as the integrating context between the living and physical systems;
- Combine expertise and knowledge base of regional and scientists to address key science questions; and
- Place the scientific results in a societally relevant context

The approach to be adopted by SAFARI 2000 comprises the following key elements:

- A bottom-up science initiative;
- Participation open to all, with the understanding that researchers find their own funding using the SAFARI 2000 Science Plan as leverage to access national, regional and international funding sources;
- Emphasis on International Collaboration with IGBP BIBEX providing an international framework and also allows for bilateral and regional initiatives;
- The enhancement of regional science capacity and recognition, thus laying the foundation for longer-term observations and environmental monitoring within the region; and
- The development of a broad umbrella for regional research within the scope of the SAFARI Project, making it 'inclusive' - but with a focussed 'Core Experiment', agreed upon data policy and planned scientific synthesis.

In assessing the relationship between SAFARI 2000, resource management and regional policy emphasis was placed on the following factors:

- African research needs to have societal relevance in order to be justifiable;
- Global Change research results need to be policy relevant, e.g.:
  - national emissions estimates and reporting are required in terms of the United Nations Framework Convention on Climate Change (UN-FCCC);

  - Implications for natural resource management must be understood, in terms of the role of fire on ecosystems and human health, and fire and land management issues (forestry, wildlife conservation);
  - Implications for local, regional and transboundary air quality
  - Carbon management and the Clean Development Mechanism
  - Contributing to regional assessment (IAM initiative)
- Proposed policy outreach workshop(s) as SAFARI science evolves - need to seek funding opportunities and collaborations (e.g. Air Pollution Information Network for Africa (APINA)

Key planning meetings to date have included Stellenbosch (1993) - SAFARI 92 results; NASA-HQ (1997 and 1998) – Funding; UMd Planning Meeting 1998; Blydepoort (1998) - Development the Science Plan; FRD (1998) – Funding; BiNational Commission (1999); Miombo Fire Meeting (1999) - Fire and Nat. Res. Management; Boulder (May 1999) - EOS, US and Aircraft Coordination; Gaborone (July 26-30, 1999) - Implementation Planning. Meetings still to take place will include the First Coupled Air/Ground-Based Intensive Campaign meeting - Aug./Sep. 1999; Second Coupled Intensive Campaign meeting - Feb./Mar. 2000; Coordination Meeting for Third Coupled Intensive - Mar/Apr 00; and the Third Coupled Intensive - Aug./Sep. 00.

The SAFARI Management Structure is outlined in Figure 1, and key elements of the SAFARI 2000 core experiment illustrated in Figure 2.

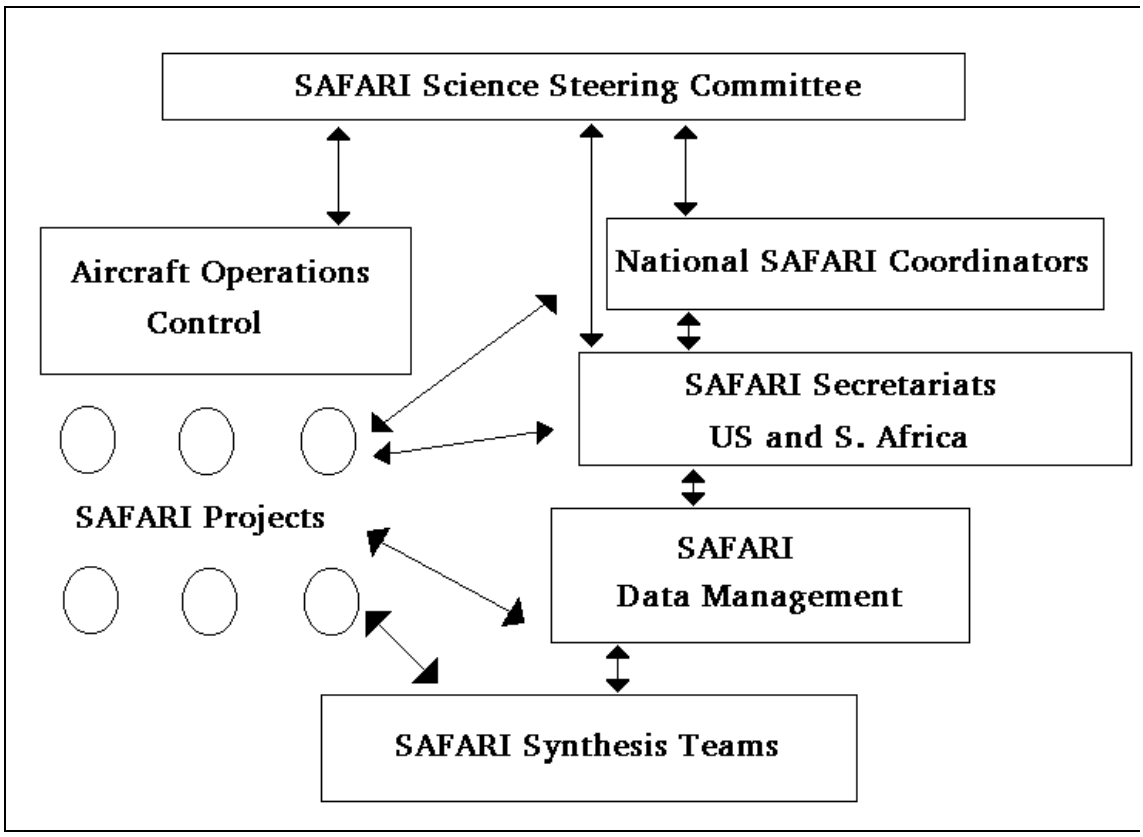

Figure 1. SAFARI Management Structure

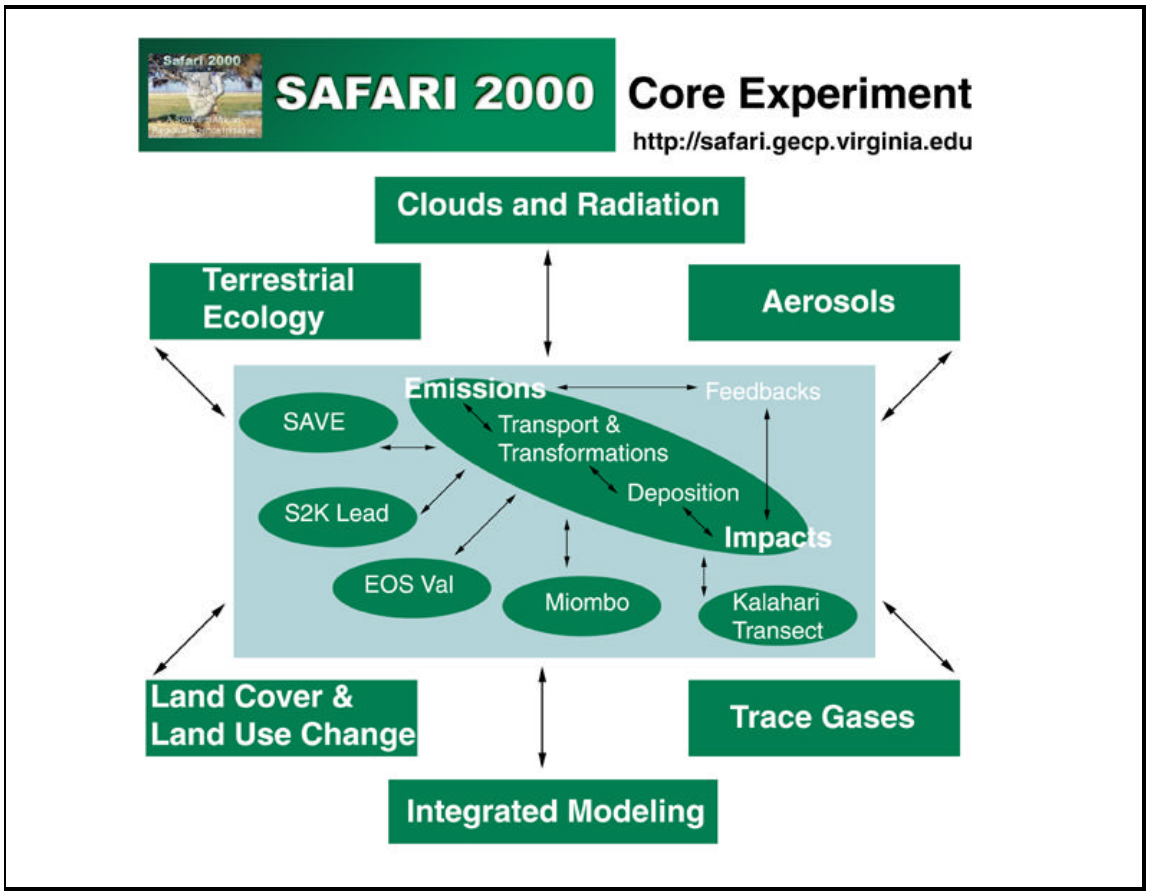

Figure 2. Key elements of the SAFARI 2000 Core Experiment

The success of SAFARI 2000 is seen to be dependent upon regionality, open lines of communication, community of trust, the ability to leverage and collaborate, a willingness to pursue value added science, and a commitment to capacity enhancement, recognition and the development of an intellectual legacy

PLENARY SESSION 1: OBJECTIVES OF MEETING – SAFARI 2000 SCIENCE PLAN
CHAIR: DR RABAN CHANDA (UB)

OBJECTIVES OF MEETING – OVERVIEW OF SAFARI 2000 PROJECT
Prof. HAROLD ANNEGARN, University of the Witwatersrand, RSA

The key objectives of the meeting are:

- Identification of regional activities related to SAFARI 2000;
- Identification of funding opportunities for regional participants; and
- Outline of aircraft based operations

These main objectives were geared towards answering the questions: WHO? WHAT? WHEN? WHERE? HOW? A process involving Discipline Specific Breakout and Synthesis Team meeting was perceived as the most effective manner in providing the information required.

Given that the goal of SAFARI 2000 is to understand the key linkages between the physical, chemical and biological processes, including human impacts, essential to the functioning of the southern African biogeophysical system – the following Discipline Specific Breakout Groups were suggested:

- Terrestrial Ecology - Land Processes
- Land Cover - Land Use Change
- Aerosols and Trace Gases
- Clouds and Radiation
- Integrative Modeling
- Socio-Economic and Policy Issues
- Hydrological Issues

It was recommended that a group leader and scribe be assigned each group, and that a report be put in place, synthesizing information on each current/proposed project being undertaken by people within the group. Information to be included was:

- Researchers intentions?
- Participants
- What activities at what times at what sites?
- Contribution to SAFARI 2000 goal
- Contribution to capacity advancement and recognition within the region
- Further opportunities/missing elements

Report backs were to be given by Discipline Group Leaders at the Plenary Session on Wednesday. The scribes were asked to submit their reports to the SAFARI 2000 Rapporteur - Ms. Yvonne Scorgie. The Synthesis Teams, which would comprise participants from each of the discipline specific teams, were to cover the following main issues: (i) Sources and Emissions, (ii) Transports and Transformations, (iii) Deposition, (iv) Impacts, and (v) Feedbacks.

The main tasks of the Synthesis Teams were to:

(1) Determine overlap/synergy between individual projects

(2) Discuss data management plans, formats and needs

(3) Outline proposed collaborative activities

(4) Discuss regional points of contacts for synthesis teams

(5) Discuss activity gaps and evolve collaborations / proposals to fill them

(6) Discuss science ties to regional policy

(7) Outline collaborative proposals

Comprehensive synthesis team reports were to be prepared for presentation at the plenary session on Friday and for inclusion in workshop final report. Through the discipline specific and synthesis team inputs it was hoped that regional integration could be finalised, based on:

- Presentation of Who, What, When, Where and How information
- Summary of Science and Synthesis Proposals
- Review of Regional Coordination and Synthesis Team Points of Contact
- Progress on regional funding issues
- Identification of unresolved issues

Products of this Workshop were summarized as:

- Comprehensive report containing detailed science activities of SAFARI 2000 linked science projects;
- Outline of mechanisms for communication and collaboration between science projects and between the national groupings;
- Data management plan;
- Outline proposals for new collaborations or activities identified at this meeting; and a
- Way forward - Presentation by Dr. Bob Swap, S2K PI

It was stipulated that investigators would be given 4 weeks as a deadline for the submission of their reports, subsequent to which a Draft Final Report would be sent out to the participants for comment. Six weeks after this latter date, the report will be finalised and the Final Report distributed to all interested parties. Distribution of the document would take place through the file transfer protocol (ftp) internet facility, with printed copies being issued from a mirror distribution point at the University of Virginia.

It was noted that future plenary SAFARI 2000 meetings will include:

- CSIR Remote Sensing Meeting, Cape Town, March 2000
- Regional Coordinator Meeting, Cape Town, to follow Remote Sensing Meeting
- Aircraft Planning Simulation Exercise, Pietersburg to follow Cape Town meeting

PRESENTATION OF THE SCIENCE PLAN
Dr. BOB SWAP, University of Virginia, USA

The Science Plan development processes comprised:

- Initial Discussions at UMd, end of June, 1998
- SAFARI 2000 Blydepoort Meeting, July 1998, which facilitated:
  - Development of questions
  - Framing of the document
  - Development of the Executive Summary
- Articles giving an overview of SAFARI 2000 were published during July-Dec, 1998, and included:
  - IGBP Global Change Newsletter
  - IGACtivities Newsletter

- NASA Earth Observer

- Early draft sent to Core Group - November, 1998
- Feedback from Core Group - April, 1999
- Final draft distributed for comment - May, 1999
- Posting on web and regional distribution - August, 1999

The Science Plan outline includes the following sections: (i) Executive Summary, (ii) Purpose of the Document, (iii) Rationale for SAFARI 2000, (iv) the Operational Plan, (v) Programme Management, and (vi) References. The Rational for SAFARI 2000 includes an analysis of the scientific heritage of SAFARI 2000, and the current understanding of land-atmosphere interactions in southern Africa. It also addresses why further study is needed by posing key questions, and discusses why southern Africa is the ideal location for study.

The Operational Plan outlines the goal of SAFARI 2000, making reference to key science questions identified during the Blydepoort (RSA) meeting, held 11-17 July 1998. Questions classifiable under the following topics were identified: (i) sources, (ii) transformations and transport, (iii) deposition patterns, (iv) impacts and responses, and (v) interactive processes.

The questions posed are given in Appendix A. It was emphasised that many of the questions have been kept broad to provide a framework within which more specific questions can be defined. It was anticipated that although some of the questions will be answered during SAFARI 2000, others will take longer to address e.g. interannual variability. It is intended that SAFARI 2000 will lay the foundation for these longer-term measurements. The nature of the SAFARI Core Experiment is demonstrated in Figure 3.

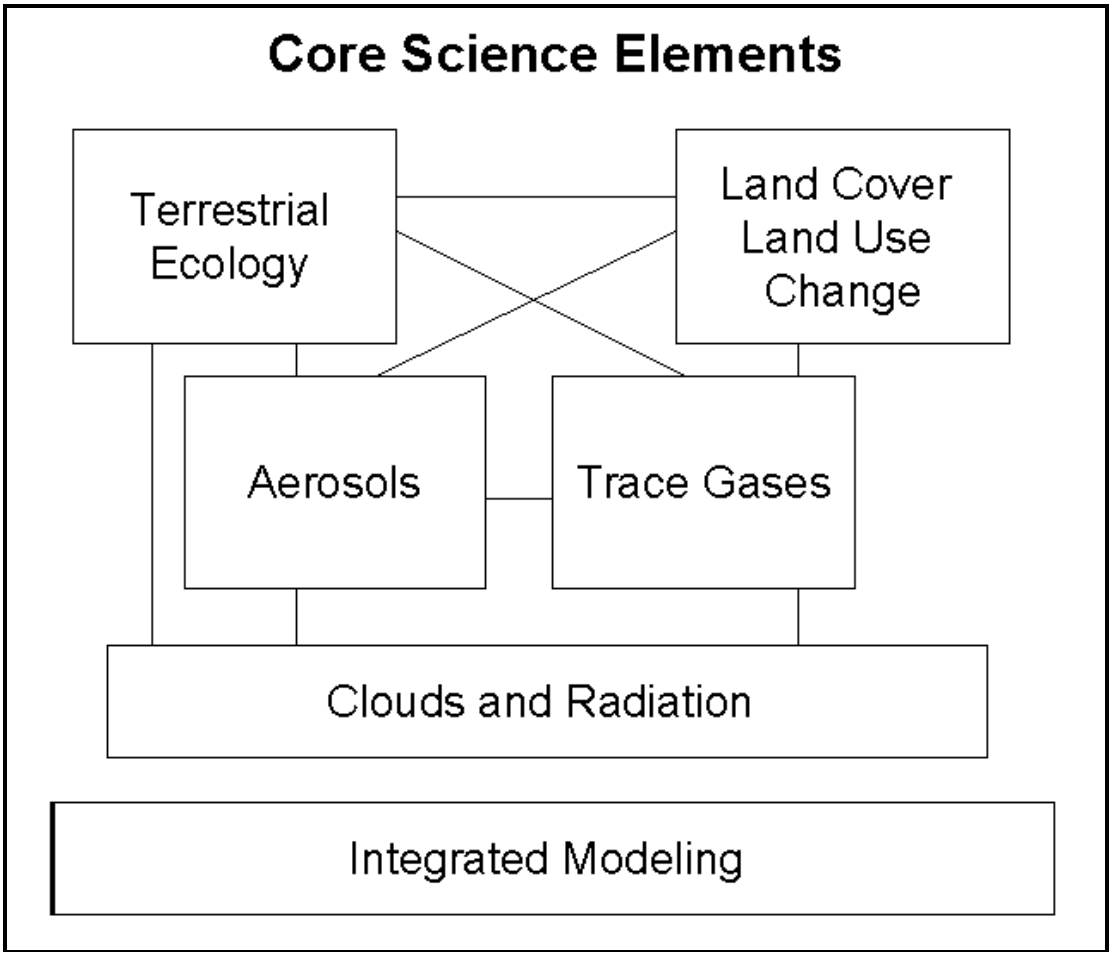

Figure 3. Outline of the SAFARI 2000 Core Experiment

The relationship between core elements and areas in which information are required is illustrated in Table 1.

Table 1. Relationship between core elements and areas in which information are required.

	Sources	Transports & Transformations	Deposition Patterns	Responses & Impacts
Terrestrial Ecology	✗		✗	✗
Land Cover & Land Use	✗			✗
Aerosols	✗	✗	✗	✗
Trace Gases	✗	✗	✗	✗
Clouds & Radiation		✗	✗	✗
Modelling	✗	✗	✗	✗

In addition to addressing the issues of "Who, When, Where and How", the workshop would need to determine the measuring requirement (ground-based, *in-situ* and satellite), and a structure for data and information sharing as part of the Operational Plan. In establishing mechanisms for the management of the programme, it was emphasised that attention be paid to the organisational structure, guidelines for participation, linkages to other research programmes, and societal relevance of the initiative.

Specific issues which were to be considered at this meeting, included:

- The S2K Science Plan as a framework for individuals to define their research questions and make scientific contributions;
- S2K's goal in terms of data policy of open access to and sharing of data between scientists, with no privileged data access period beyond essential data preparation. (Recognition of data sources and co-authorship for non published data sets essential.)
- MOUs to be established - given S2K's regional scope and visibility, regional and national protocols will need to be respected
- S2K as 'snap-shot' intensive campaign in a region with high interannual variability – with emphasis thus being placed on S2K as providing a foundation for long term monitoring within the region
- Funding for regional scientists
- Coordinate SAFARI 2K Aircraft Activities and Schedule:
    - prepare a draft aircraft data collection plan and schedule for the Gaborone meeting
    - define measurement needs for the intensive observation periods
    - determine overflight permission procedures, roles and responsibilities
    - agree on the decision making process for aircraft implementation
- US coordination for Gaborone Planning Meeting (July 26-30, 1999):
    - coordination between Research Activities
    - identification of Potential Partnerships
    - develop the concept of a 'Core Experiment'
    - acceptance of Data Policy and Principles
    - assess MOU needs
- Discuss potential contributions to EOS Public Relations and Early Science Initiative

- Produce an Executive Summary from the meeting - giving current status and scientific gaps

PLENARY SESSION 2: ONGOING AND ANTICIPATED REGIONAL SCIENCE PROJECTS IN ANGOLA AND BOTSWANA
CHAIR: DR LUANNE OTTER (CSIR)

Researchers conducting or planning regional science projects in Angola and Botswana were given ± 5 minutes each to inform the meeting of the nature and extent of their activities.

TOWARDS SUSTAINABLE NATURAL RESOURCE MANAGEMENT IN THE KALAHARI REGION
Dr Otlogetswe Totolo, Department of Environmental Science, University of Botswana

The Kalahari Transect represents a sub-continental scale initiative. The objective of a recent workshop at Gaborone held on the Kalahari Transect were as follows:

- To review past work on, and developments in the science related to biophysical and human issues relevant to the Kalahari Transect;
- Identify critical research gaps and scientists to develop proposals to address these gaps;
- Identify funding agencies for various Kalahari Transect research themes for targeting relevant proposals; and
- To establish linkages with regional and international research networks, e.g. SRRP, SALT, NATT and Safari 2000.

Themes covered in the workshop included: (i) Climate and hydrology issues of the Kalahari; (ii) Soil, vegetation and ecological processes in the Kalahari; (iii) Wildlife and natural products utilisation and management in the Kalahari; (iv) Agro-pastoral systems in the Kalahari; and (v) Policy and resource conservation.

At the Gaborone workshop a conceptual framework was developed in which the critical concerns were listed and the fields requiring study identified. Development, poverty alleviation and environmental protection were listed as the most critical concerns in terms of the Kalahari Transect. By gaining an improved understanding of the state and function of ecosystems, multi-species production systems and water resources, and information of ecosystem and atmospheric change, it was hoped that the basis would be provided for these issues being addressed.

OKACOM
Mr Isaac Motsele, Dept Water Affairs, Hydrological Division, Botswana

OKACOM is an initiative of the three Okavango River Basin states, Angola, Botswana and Namibia. The Commission has the functions of advising the governments on the sustainable development of the basin and of co-ordinating investigations and research activities. In 1994 the governments of Angola, Botswana and Namibia established the Permanent Okavango River Water Commission to co-ordinate and collaborate on the sharing of the basin's water resources.

OKACOM is made up of three ministerial appointed representatives, drawn from the top government levels management in each of the three states. In addition it can co-opt as many advisors as necessary. This allows full and meaningful consultation and dialogue with government agencies, communities and interest groups, with the aim of:

- Establishing further effective co-ordination, consultation and co-operation between stakeholders. This will facilitate stakeholder participation in the Environmental Assessment and the development of the Integrated Basin Management Plan.
- Identify key areas of concern and gaps in knowledge of the physical and socio-economic systems of the Okavango River Basin.

OKACOM has carried out Diagnostic Assessment to evaluate the Environmental Assessment to address issues, priorities and gaps in information and understanding which will lead to the formulation of an Integrated Basin Management Plan.

OKACOM is looking forward to accept any assistance that may bee extended to it in any form let it be Technical, Financial or Material. There are may gaps in the data-base of the Basin as already recognised through the Transboundary Diagnostic Assessment in the three countries. Following the preliminary studies by the commission it was found necessary that we sustain the environment of the basin and we should have full understanding of all the resources in the basin. The integrated resources analysis of the basin will finally be achieved for the socio-economic purposes. OKACOM is currently planning for a donor conference to be held at the end of the year or early next year to solicit funds for research, and it is hoped that Safari 2000 will be informed and invited for such assistance.

SUBSISTENCE RANGELANDS RESEARCH PROJECT (SRRP)
Dr R Chanda, Dept. of Environmental Studies, University of Botswana.

The Subsistence Rangelands Research Project is a policy oriented initiative funded by the EU, which was born out of the 1996 Subsistence Rangelands Workshop hosted by the Botswana Global Change Committee. The project involved three countries, viz. Botswana, Lesotho and South Africa. The aim of the project is to analyse the dynamic relationships between rangeland state and rural livelihoods and to identify, within the southern African context, policy options and interventions that will optimise, sustainably, the welfare of the range communities while maintaining productivity and ecological diversity and integrity.

The main project objectives are given as follows:

- To determine how rangeland state influences the components of rangeland productivity (including agropastoral productivity);
- To determine how the components of rangeland productivity contribute to the welfare of rural communities;
- To assess the impact of current policies and practices (at scales ranging from the household to the international) on resource assess and use by different groups within the rural community and on their welfare;
- To assess as far as possible the impacts of the variability in biophysical process and socio-economic influences on rangeland state, rangeland productivity and human welfare;
- To collate and evaluate the data, derived models and relevant hypotheses, and develop policy intervention operation designed to optimise human and sustainable rangeland use; and
- To make preliminary estimates of the impacts of human-induced global changes on rangeland productivity and rural welfare.

SRRP's expectation of Safari 2000 comprises access to satellite imagery to enable analysis of landuse and land cover change over extensive areas of Botswana's Kalahari, i.e. beyond the Matsheng region. In turn, SRRP would be able to provide Safari 2000 with data on changes in land use and land cover change relevant to the estimation of:

- Changes in the emissions of volatile organic carbon compounds, and
- Wind-generated dust from areas opened up for various purposes (e.g. agriculture, settlements)

REMOTE SENSING PROJECT IN BOTSWANA WITH EMPHASIS ON HUMAN IMPACTS ON THE ENVIRONMENT
Dr Susan Ringrose, University of Botswana

The Department of Environmental Science at the University of Botswana has done most of the work in this regard. In the past their has primarily been four types of remote sensing projects, namely:

(1) Land degradation projects, which are national in scope and aim to investigate change over time. Landstat imagery is used, and bare soil areas and bush encroachment mapped.

(2) Land use and land cover projects, primarily within agricultural areas. Such projects represent the response to needs expressed in cultural areas.

(3) Specific ARGA analyses, for e.g. groundwater assessment and location – vegetation cover mapping and research into the effect of range degradation.

(4) Remote sensing research concerned with the darkening effect.

Broad scaled vegetation maps are available for Botswana. The most frequently used vegetation maps are those published in the 1970s in the Botswana Notes and Records. Much of the groundwater assessment work having been completed in available on MS Excel spreadsheet.

ADAS MASTS
Mr L Carlsson, Department of Water Affairs, Botswana

The Department of Water Affairs uses a method to determine evapotranspiration in a spatial way. This arose due to the investigation of an aquifer beneath the Kalahari sands at Serowe. It was unclear where the water was going, i.e. whether transpiration by vegetation was occurring or whether the water was being transferred down through the aquifer formation. It was therefore necessary to determine evapotranspiration fluxes and the ADAS monitoring system was implemented. This system records incoming solar radiation, outgoing solar radiation, evaporative fractions, ambient temperature, wind speed, rainfall (etc.). A benefit of the system is the automatic data acquisition system, and the ease of calibration and verification.

TROPOSPHERIC DYNAMICS OVER SOUTHERN AFRICA AND ITS IMPLICATION FOR TRANSPORT OF AEROSOLS
Akintayo Adedoyin, Department of Physics, University of Botswana

A scheme has been developed to study tropical tropospheric dynamics with special emphasis on sub-Saharan Africa. In the scheme, a linearised invicid form of the hydrodynamical equations is solved under different atmospheric static stabilities. The equations are solved with a two-layer model of the atmosphere in order to correctly simulate tropospheric conditions in most parts of Africa, south of the Sahara. Results show that some modes of the wave-like disturbances, generated along the surface of discontinuity between the air masses, propagate and amplify with time. This amplification generates disturbances within the troposphere and have considerable influence on transport of aerosols. The effect of sea-surface temperature fluctuations on this mechanism is discussed as well as implications for air quality control.

The scheme comprises convective-scale simulations, and is able to reproduce wave-like disturbances along the surface of discontinuity between fluids of different densities. The scheme may be used to explain:

- The initiation, propagation and sustainability of African squall lines;
- Inter-annual variability in tropical African rainfall; and
- Frequencies of Atlantic hurricanes.

It is proposed to use the model to improve the parameterization processes in large-scale numerical modelling, i.e. RegCMs, and to customise the RegCM for the Kalahari Transect. The intention being to simulate for climate-change threats including: (i) Lagrangian kinematic trajectory analyses for the transportation of aerosols; and (ii) import on health, i.e. control of Malaria, Dengue and Yellow Fever. Facilities which are available or proposed as part of the project include:

- Seven computer laboratories in the Faculty of Science, each with about 25 personnel computers of the Pentuim series;
- A cluster of CPUs with NFS mounted disks from a LINUX box with large EIDE disks; and
- A pollution monitoring station with sensors for wind speed, wind direction, air temperature, CO, SO_X and NO_X is to be purchased.

The University of Botswana has existing links with *Abdus Salam* International Centre for Theoretical Physics, and the Edward Bouchet Institute for the Advancement of Science in Atlanta, US.

The project team includes: Dr Akintayo Adedoyin (Coordinator), Dr N. Nijegorodov, Dr K. Moloi, Mr K.M. Mphale.

AERSOSOLS MONITORING WITH REGARD TO SAFARI
T S Verma, Atmospheric Physics Research Group, University of Botswana

Participating staff on the project include: T S Verma, E R Jayartne and V R K Murty all of which are members of the Atmospheric Physics Research Group at UB. Monitoring to form part of the project proposed by the group includes:

- Ground Based Measurements:
  - Aerosols – concentration, particle size distribution, chemical composition
  - Greenhouse Gases – CO, CO_2, SO_2, NO_x, CH_4
  - Rainwater analysis – characterization of CCN
  - Meteorological parameters – temperature, pressure, relative humidity, wind field, rainfall, cloud cover, raditation, (etc.)
- Validation of Satellite Data

The Atmospheric Physics Research Group proposes collaborative participation in SAFARI 2000. Their aim would be limited to the ground based measurements of aerosols, greenhouse gases (SO_x, NO_x, CO and HC) and aerosol elemental analysis. The work plan of the group includes continuous monitoring of aerosols using Automatic Particle Counters (range 0.1 um to 5 um), and elemental analysis of aerosols by EDXRF.

The group proposed to undertake aerosol monitoring in Gabarone. The ground based measurements will include: aerosol (PSD, composition, chemical composition, concentration), greenhouse gases, rainwater analysis and meteorological parameters. The groups proposed participation further includes the analysis and interpretation of data and modelling.

Existing facilities include particle counters, Ion counters, EDXRF technique and instruments for meteorological monitoring. Additional equipment which is needed includes gas analysers for greenhouse gases.

CHEMISTRY OF SALT PANS
Dr Frank Eckhardt, Environmental Science, University of Botswana

A salt pan is a closed topographic depression that can occur in arid and semi-arid areas. Sediments include significant quantities of salt and feature limited vegetation cover. Southern Africa has some of the largest pans (Etosha in Namibia, Makgadikgadi Pans in Botswana), and some of the highest densities of pans (Karoo and Kalahari). 130 pans per 100 km^2 have been identified in South Africa. Salt pans currently undergo appreciable change due to water extraction, mineral/salt extraction, overgrazing along pan margins, and divergence and modification of inflow. Research in two areas is being undertaken:

(1) What goes into the pan?

Rainwater/aerosols, groundwater and surface water represent inputs to pans. Evaporation produces a series of different salts (nitrates, chlorides, sulphates). Questions posed in this regard are:

- What are the primary sources of their elements?
- What does this tell us about the biogeochemical cycles?

Pan in tectonically stable areas such as southern Africa are likely to receive significant atmospheric inputs.

The research aims are:

(a) Determine flux and nature of the atmospheric input.

(b) Identify the source of atmospheric sulphate.

Techniques to be implemented include: isotopic tracing, chemical composition of water and pan sediments. The research represents an extension of published work carried out in Namibia looking at the origin of sulphates.

(2) What comes out of the pan?

Pan surfaces are prone to deflation by wind which can disperse salts over a very long distance. Downwind deposition of slats is affecting soil and water quality.

Research aims:

(a) Determine fluxes from pans and contributions to soils in the region

Techniques include: Isotopic tracing, chemical composition of water and pan sediments. A preliminary study on Makgadikgadi is currently underway in conjunction with the USGS. Sampling has taken place, analyses is to flows.

(b) Identify main source and deposition areas of salts.

Techniques: multispectral remote sensing of pan surfaces and surroundings.

(c) What is the contribution of pan aerosols to the southern African atmosphere.

Pans act as inland sinks and can be used to understand long-term geochemical inputs an cycles. Dry/are pan surface provide aerosols which undergo dispersal by wind affecting downwind soil and water quality. With regard to the research question "what goes out of the pan", reference was made to the Double Lake in East Texas. Approximately 4 km^2 in area, the lake produces 750 tons of airborne salts each year which can be traced 25 km downwind in soils and groundwater.

The overall aim of the investigation is to understand geochemical sources, pathways and fluxes associated with salt formation and dispersal in a natural as well as anthropogenically altered system. Remote sensing represents a useful technique to study the contribution of pans to aerosols over the subcontinent (dust plumes).

CRITICAL REVIEW OF ENVIRONMETAL POLICIES IN THE CONTEXT OF CLIMATE CHANGE IN BOTSWANA
Dr D.L. Kgathi and T. Gwebu, University of Botswana

Studies done to understand the link between human activities and the physical environment have included: land cover conversion studies; land cover modification investigations; and research into the magnitude of GHG emissions. Results from such studies have included the following findings:

- Decrease in amount of biomass around settlements over time.
- Decrease in resource base in terms of preferred fuel-wood species.
- Households switching from fuel-wood to LPG and kerosene, despite the Government's coal campaigns.
- Increase in extent of crop land.
- Land clearing for agriculture (deforestation)

Of particular concern are areas which are been overgrazed, agricultural felling of trees, and veld fires. Despite the Herbage Preservation Act of 1977 put in place to control fires, 130 000 km^2 of land is burned according to an estimate made in the early 1990s.

The objectives of the research is to assess the implications of environmental policies on land use cover and land use change, and the implications of this for climate change. The capacity of the environmental and institutional framework in Botswana is to be considered, and the policy implications of SAFARI 2000 research results examined. The aim being to suggest alternative environmental policies, particularly policies aimed at reducing greenhouse gases.

SAVANNA BIOGEOCHEMISTRY PROJECT IN SOUTHERN AFRICA (SABISA)
Dr E Veenendaal, Harry Oppenheimer Okavango Research Centre

(Dr Veenendaal was not in attendance but submitted a written synopsis of his project for consideration.)

The groups objective is to develop a study of the biogeochemical cycling of carbon and nutrients in both managed and natural savannas in southern Africa. In the long term the study is planned to be a combination of measurements not usually undertaken by the same network of researchers: i.e. from eddy covariance measurements of gross carbon and water fluxes to estimates of the proportions of plant production passing through grazers and browsers in the studied ecosystems. The basis for this approach is that most savannas in the world (but especially in Africa) are grazed, either by naturally occurring fauna or by livestock such as cattle and/or goats. To understand the real nature of their biogeochemistry we must include and understand this complication, rather than exclude it (as is usually done). By comparing production and herbivore consumption in natural and managed savannas of close proximity and vegetation we hope to quantify the effects of management on these systems and also to provide new data and approaches to questions such as the evaluation of sustainable carrying capacity. By that we will contribute to current debates on appropriate livestock production practices in semi-arid Africa in particular (e.g. Scoones 1996).

The understanding of physiological responses of savanna vegetation at population and ecosystem level is essential strategy in this study. By following this strategy the project has been planned to provide fundamental insights in how savanna biogeochemistry processes are changing under changing climatic and associated environmental conditions, such as an increase or decrease in rainfall, or an increase in atmospheric CO2 concentration and temperature. It is anticipated, that the approach of comparing the influence of land use on biogeochemistry with the help of system ecological techniques such as eddy co-variance as sell as on (and in-) the ground measurement of savanna productivity and use will produce new and much more accurate parameter estimates. These estimates (for instance the accurate estimation of storage and release of carbon from the ecosystems under study) are needed to feed global models. In view of recent international developments on this issue ("carbon futures discussion") at the Kyoto conference, the results of the study will contribute to the debate on macro-economic implications of carbon management in savanna regions.

The first phase of this project was initiated in early 1999, with the installation of an eddy covariance tower and associated meteorological instrumentation near Maun (Botswana). This tower is being maintained by Dr Elmar Veenendaal (Harry Oppenheimer Okavango Research Centre) and a Botswana Ph.D. student will soon join the project investigating aspects of semi-arid woodland productivity in southern Africa. The tower in Botswana was the first long-term eddy covariance tower to be employed outside Europe and North America.

For more information on this project contact: Prof Jon Lloyd (Jlloyd@Bgc-jena.mpg.de) or Eveenendaal@ORC.info.bw.

PLENARY SESSION 3.1: ONGOING AND ANTICIPATED REGIONAL SCIENCE PROJECTS IN MALAWI, NAMIBIA, SOUTH AFRICA AND TANZANIA
CHAIR: DR FRANK ECKHARDT (UB)

LEAD PROJECT: N AND S DEPOSITION IN SOUTHERN AFRICA

Dr Luanne Otter, Council for Scientific Research, SA

The LEAD project which comprises a R3 million, 3 year project, was funded by the Department of Arts, Culture, Science and Technology. The initiative is an autonomous contributing project to SAFARI 200, representing the largest but not necessarily the only South African project in SAFARI 2000

The purpose and objectives of LEAD are as follows:

- Quantify the location, timing and magnitude of emissions of NO_x and SO_x from significant regional sources.
- Estimate the location and deposition rate of nitrogen and sulphur containing compounds in the wet and dry form.
- Validate both emissions and deposition rates using atmospheric and ground-based sampling in combination with transport, transformation and deposition models.

The project coordination structure of LEADS is as follows: Dr Robert Scholes (CSIR) is the principle investigator of the LEAD project; Dr L Otter is the scientific co-ordinator, with the alternate being S Piketh (Univ Witwatersrand); Prof H Annegarn (Univ. Witwatersrand) represent s the trace gas and aerosol community, with the alternate being Prof M Scholes (Univ. Witwatersrand); and Prof K Pienaar (Univ of Potchefstroom) represents the deposition community and the alternate is G Held (Eskom).

LEAD Projects include the following:

- Industrial and transport related emissions of sulphur dioxide and nitric oxide in southern Africa (M van der Merwe, CSI R)
- Temporal variability in alkyl nitrates and selected halocarbons at Skukuza (C. Anderson, Port Elizabeth Technicon)
- Contribution of domestic biofuel combustion to NO_x, CO, CO_2 and CH_4 emission in southern Africa (L Marufu, Wits Univ.)
- Daily rainfall data for southern Africa (R Scholes, CSIR, SAWB)
- Leaf area dynamics in southern Africa (R Scholes, CSIR)
- Pyrogenic emissions from southern Africa (R Scholes, CSIR)
- Species composition of southern African vegetation types (M Rutherford, National Botanical Institute)
- Soil NO emissions in southern Africa (L Otter, CSIR)
- Hydrocarbon emissions from southern African vegetation (L Otter, CSIR)
- Dynamics of canopy absorption of nitrogen in savanna systems in southern Africa (M Scholes, Wits Univ.)
- Mineral dust in southern Africa (H Annegarn, Wits Univ.)
- Airborne aerosol sampling and capital equipment (H Annegarn and S Piketh, Wits Univ.)
- Ground-based aerosol sampling in southern Africa (S Piketh, Wits Univ.)
- Transport modelling in southern Africa (H Annegarn, Wits Univ.)
- Monitoring atmospheric concentrations of NO_2, SO_2, NH_3 and O_3 (K Pienaar, Univ. Potchefstroom)
- Atmospheric chemistry modelling of N and S deposition processes (K Pienaar, Univ. Potchefstroom)
- Extension of wet deposition network, sampling and analysis (G Held, Eskom)
- Aircraft surveys of physical and chemical fluxes over southern Africa (M Jury, Univ. of Zululand)

- Sun photometer measurements to determine aerosol concentrations and transport patterns (H Winkler, Vista Univ.)
- Sub-continental and inter-continental scale modelling of S and N dispersion and deposition over southern Africa (M Zunckel, CSIR)

Information on passive sampling sites in southern Africa and on ESKOM's project to extend the wet-deposition network was presented.

ACRG (PUCHE) passive sampler sites in southern Africa include the following:

DEBITS sites:
- Okaukuejo, Namibia (Namibia Parks Board) – since 1994
- Louis Trichardt (Eskom) – since 1994
- Amfersfoort (Eskom) – since 1996
- Cape Point (Eskom) – since 1994

ESKOM sites:
- Elandsfontein - since 1998
- Palmer - since 1998
- Ben Macdhui (Wits Univ) – since 1997
- Inhaca, Macambique (Wits Univ) – since 1999
- Pafuri, Venda – since 1999

SAFARI 2000 / LEAD sites:
- Skukuza (Tower) – 1999
- Mongu, Zambia – 1999
- Cedara (KJV) – 1999
- Warden (KJV) – 1999
- Lichtenburg (KJV) – 1999
- Windhoek, Namibia (Namibian Weather Bureau) – 1999
- Upington (SA Weather Bureau) – 1999
- Port Elizabeth (SA Weather Bureau) - 1999

ESKOM's project "Extension of wet-deposition network, sampling and analysis" is to be undertaken during the period August 1999 to June 2001 (two rain years). Rain quality has been monitored by Eskom at many sites previously, but for varying periods, since 1985/86. The KJV project, a joint venture between the Department of Environmental Affairs and Tourism, CSIR and Eskom, currently supports 14 monitoring sites which are not necessarily well-positioned for the purposed of SAFARI 2000. The objectives of the project are therefore to:

- Evaluate the spatial distribution of the existing network;
- Identify gaps and decide which additional site would give maximum benefits in view of the overall objective of SAFARI 2000
- Operate this site for two rain seasons (1999/2000 and 2000/2001), analyse rain samples by Ion Chromatography and prepare annual reports after each rain season.

Outputs of this project will include: (i) concentrations of a total of 14 anion and cation species in rain water per event, (ii) pH and conductivity of rain water samples, (iii) results from 14 existing sites of the KJV project will be added, and (iv) wet deposition over the major part of South Africa.

AEROSOL, RECIRCULATION AND RAINFALL EXPERIMENT (ARREX)
Stuart Piketh, Climatology Research Group, University of the Witwatersrand, RSA

Participants of the ARREX experiment include: the Climatology Research Group and the Aerosol and Energy Research Group (Univ. of Witwatersrand), South African Weather Bureau, and the Max Planck Institute for Chemistry (Mainz, Germany).

The Aerosols, Recirculation and Rainfall Experiment '97/ '98 campaign comprised the development of a 9 year trajectory climatology aimed at identifying the main transport routes over subcontinent. The importance of

absolutely stable layers for the accumulation of material and transformation of this material was noted. The aims and objectives of ARREX are:

- Evaluate morphology and chemistry of aerosols over southern Africa.
- Undertake *in situ* measurements of air masses to further validate trajectory transport models.
- Investigate the possible impacts of anthropogenic aerosols on cloud microphysics and rainfall diminution.

Three flight campaigns were conducted to date within ARREX (Figure 4), viz.:

- November to December 1997 and May 1998 - Long-range transport and characterisation of air masses over southern Africa during summer and winter, respectively.
- January to February 1999 - Aerosol CCN and cloud interactions for continental and industrial air masses.

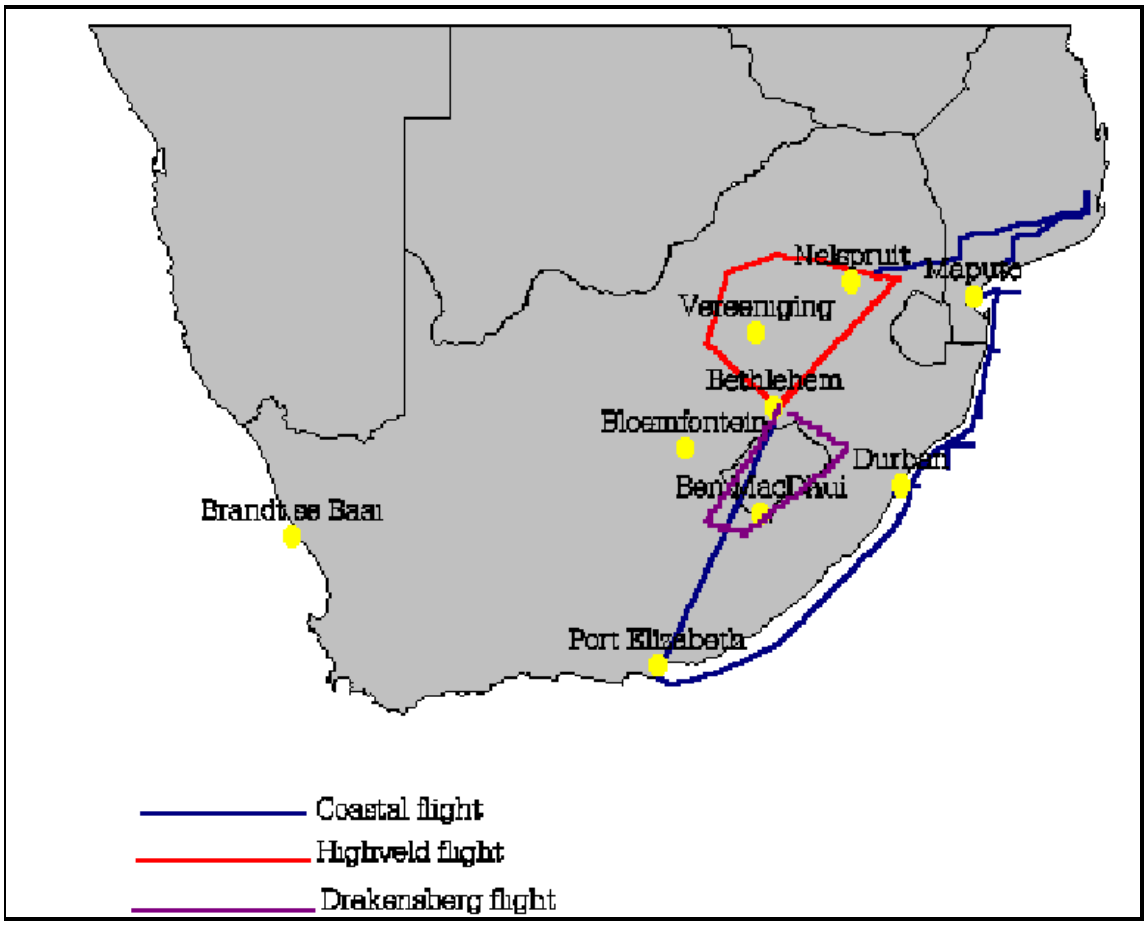

Figure 4. Flight paths during ARREX campaigns.

The ARREX campaign has two important links to SAFARI 2000, viz. (i) transport and chemical transformation and (ii) cloud and radiation. The transport and chemical transformation investigation includes:

- Characterisation of the atmosphere and seasonal variations.
- Transboundary transport of atmospheric constituents.
- Characterisation of source types and transformations from major industrial sources.

Trajectory modelling can be done by the group for each specific project for which they are needed, with the model predictions used for flight planning.

BETHLEHEM PRECIPITATION RESEARCH PROJECT (BPRP)
Nico Kroese, South African Weather Bureau

Rainfall enhancement represents the aim of the BPRP project in order to address South Africa's water scarcity. The impact of anthropogenic emissions on rainfall through cloud seeding is being investigated by the group.

As the national provider of meteorological services, the SAWB will, together with the meteorological services of other countries, support a programme with the following components as part of SAFARI 2000:

- General forecasting of area covering southern part of subcontinent up to just north of Zambia using numerical modelling, i.e. the ETA model with resolution of 48 km.
  - Data format is in gridded binary (GRIB format); the display system used is PC Gridds
  - The horizontal resolution of the output is 0.5 deg. X 0.5 deg.
  - Vertical resolution – 38 levels, from the surface to 25 hPa
  - Model runs are available twice daily: morning (06h00 to 07h00 GMT) and afternoon (18h00 to 19h00 GMT)
  - Approximately 350 meteorological variables are output from the forecasting.
- Aviation forecasting for the SAWB's 2 aerocommanders and for other aircraft involved in the campaign.
- Special requests of Safari 2000 participants. (Note: requests must be submitted in good time).

South African Rainfall Observing System (SAROS):
- Funding – Water Research Commission
- Time – January 2000 to December 2001
- Aim – Integration of satellite, radar and surface networks
- Products – real-time precipitation maps for use in meteorological, agricultural, hydrological sectors

Ground-based measurements and upper air monitoring are undertaken by the SAWB as part of the following projects:
- Special atmosphere Research Participation (Gerrie Coetzee)
- Ozone measuring project at Irene, Pretoria
- Trace gas monitoring done at Cape Point

Attention was drawn to the WMO International Dobson Inter-comparison workshop to be held in March/April 2000.

As part of Safari 2000, the SAWB will provide information from the South African Rainfall Observing System (SAROS) for use in the agricultural, meteorological and hydrological sectors. Funding is being received from the Water Research Commission; the timing of this project being January 2000 to December 2001,

The SAWB's proposed weather radar network will comprise sites at: Bloemfontein, Bethlehem, Cape Town, Durban, De Aar, East London, Ermelo, Irene, Mmabatho and Port Elizabeth. The range rings around these sites are in the order of 150 km. The purpose of the network is to allow for disaster mitigation, and hydrological and meteorological measurement. It is necessary to have the rainfall of Gabarone integrated or linked to the SAWB's network. There will be obvious advantages to the Botswana meteorological services (radar located at Gabarone).

SAFARI 2000: OF WHAT INTEREST TO AN INTERNATIONAL MINING COMPANY
MFF Ferraz, Geophysical Services Department, Anglo American Technical Services

Anglo American plc, its subsidiaries and associates operate in many parts of the world and face complex and varied local, regional and global environmental challenges. Each company sets its own environmental goals in accordance with legal requirements, international best practice with legal requirements, international best practice and good corporate citizenship.

Anglo American plc and its subsidiaries will give practical expression to its environmental vision by progressively implementing the following set of activities:

(1) Commitment

(2) Management
(3) Risk management
(4) Compliance
(5) Efficient operations
(6) Performance targets
(7) Care for the environment
(8) Public interaction
(9) Evaluation
(10) Reporting

Three activities were highlighted, viz.:
(4) Compliance:

> …..promote environmental education and knowledge amongst employees and the wider community.

(5) Efficient Operations

> ….Support and where appropriate, implement initiatives to develop cleaner technologies and improved, innovative practices in environmental management.

(8) Public interaction

> …Liaise and work with local communities, regulatory agencies, affected and interested parties on an ongoing basis to promote constructive interaction in matters of common environmental concern. Communicate company's environmental policy to stakeholders and public.

The Environmental Policy Unit is the forum for Anglo American plc. AATS – Envirolink carries out Environmental Impact Assessments and Environmental Management Programme Reports. AATS – Geophysical Services Department (GSD) mandates have been broadened to include greater diversification of its remote sensing (i.e. image processing, interpretation and integration) activities into the environmental field.

AATS promotes development of knowledge both within and outside of group, supports innovative research with regard to environmental assessment. It was emphasis that SAFARI 2000 participants should structure funding requests in terms of the goals and objectives of AATS. Although not a donor agency, AATS would fund groups to help them meet these objectives. Copies of the AATS environmental policy are available in hard copy.

Collaborative projects are encouraged between Envirolink and other groups. The opportunity therefore exists for the development of collaborative projects with regional and international agencies.

Benefits of SAFARI for AATS – GSD includes:

- SAFARI represents a profile-raising activity
- Opportunity to develop collaborative projects with regional and international institutions
- Assessment of new methodologies and satellite data from EOS-2/Terra

Benefits of AATS – GSD for SAFARI would comprise:

- Reflection of industry's interest in collaboration
- Providing local/regional access to specific technical expertise
- Making selected hyperspectral data sets available

REMOTE SENSING IN THE KRUGER NATIONAL PARK OF SOUTH AFRICA
H C Eckhardt, Kruger National Park, RSA

Current remote sensing tools include aerial photography, fixed-point photography and to a lesser extent satellite imagery. Aerial photography is conducted triennially between February and April at approximately 130 fixed transects (1 km by 500 metres), in an attempt to cover 35 different landscape types. Parameters measured include percentage woody cover (since grass/bare patch cover is still risky) and density of trees and shrubs. Difficulties arise in distinguishing between bare soil and vegetation cover.

Fixed-point photographs are taken at approximately 500 points, also on a triennial basis, during the month of April. So far only a little information has been extracted but it is possible to attain information on various structural parameters such as height and crown/stem diameter.

Although some historical satellite imagery is currently available from NASA (Jeff Privette), there has been no real application of this in the KNP to date. This is also due to the high costs (the sole supplier is SAC). Imagery is used to establish the overall picture, and to calculate vegetation/bare soil indices on an annual basis.

High resolution fire scar mapping is done as frequently as is financially possible, otherwise annually just after the rainy season has started.

The group intends to relate results of aerial photography (quantified woody cover and perhaps other indices) to those of satellite imagery (Landsat and EOS), and to validate the latter.

RESEARCH PROGRAMME (MW) : PRODUCTIVITY, USE, MANAGEMENT (INCL. FIRE MANAGEMENT) AND ECOLOGY OF MIOMBO WOODLANDS
Dennis Kayambazintho, Forest Research Institute of Malawi

The overall objective of the research programme is to generate usable information and technologies (e.g. management prescriptions) for the sustainable conservation and management of Miombo Woodlands. The main projects within the programme are:

- Productivity of indigenous tree SPP, especially fire hardwoods.
- Harvesting and utilisation of non-timber forest products
- Growth and yield of Miombo woodlands (through silvicultural treatments)
- Community-based (e.g. institutional arrangements, policy impacts – sectoral and multi-sectoral)
- Co-management of Miombo woodlands

The proposed Safari 2000 - Malawi (Miombo) transect site is the Chimaliro Forest Reserve Area. This area was proposed as a transect site due to the long-term preservation of the area and long-term research being conducted in the area. This area is also representative of the Miombo woodland in Malawi. Factors of interest at the site include:

- Site undergoing large changes in social, economic and political environment – resulting in large scale changes in land use and land cover (e.g. recent change of governmental policy).
- Ever-increasing population, population migration, trans-boundary activities (with Zambia)
- Opening up of agricultural fields (tabacco industry / deforestation)
- Annual burning: establish areas, hunting and creation of grazing areas – resulting in contribution to high levels of aerosols and trace gas emissions.

These anthropogenic perturbations, variability in regional climate and ecosystem processes contributes to and effect changes in the biogeochemical cycling of the region.

Data collection at Chimaliro will include SPP composition and structure, regional growth, biomass, soil moisture and carbon levels, using permanent sample plots (PSPs) (silvicultural and management trials, PSPs in co-management areas).

It is expected that SAFARI 2000 will contribute towards the evolution and development of physiological and hydrological research activities, resulting in modelling for growth yield prediction, carbon pool and flux prediction (GAP Models, etc.)

PLENARY SESSION 3.2: INTERNATIONAL AID / FUNDING AGENCIES BASED IN SOUTHERN AFRICA
CHAIR: DR FRANK ECKHARDT (UB)

USAID REGIONAL CENTER FOR SOUTHERN AFRICA (RCSA)

Ray Morton, USAID

The USAID first decides on the objective to be met and then determines appropriate projects to fund. The objective for natural resource management has been determined as: "**sustainable management of shared natural resources for regional development**". The natural resources background is provided by the following initiatives: CBNRM Wildlife TCU, IUCN – 1989 to date; NETCAB; NR Accounting; and Special Objective A: TBNRM.

USAID's attempts to work through networks (e.g. NGOs, research groups, private firms), its approach being *transboundary, complimentary to bilateral programs and supportive of policies, protocols and agreements*. It has adopted a transboundary focus in order to address challenges arising from unevenly distributed natural resources (e.g. water supply and demand). It is acknowledged that the sharing of natural resources across political borders could result in the potential for conflict (water, wildlife, etc.). The development of resources and the encouragement of policies for the management of such resources is therefore perceived to be beneficial. The USAID aims to promote *sustainable approaches*, and therefore advocates the move from community based resources management to transboundary resource management.

Improve ecological monitoring is seen as essential to provide good data and the necessary understanding for policy development or change. USAID approach comprises the *strengthening of existing institutions* since it does not see its role as being the invention of new institutions.

For RSCA purposes "Transboundary Natural Resources" means:

- Water
- Migratory wildlife
- Critical ecosystems at risk

Activities which illustrate the USAID's approach include the following:

- Assist SADC Sector Coordinating Units to develop and implement the protocols on shared natural resources (e.g. water, wild life, fisheries, land use, etc. policies)
- Develop TBNRM Models (transboundary national resource management)
- Develop learning sites (training in monitoring is a new area for USAID)
- Training in monitoring
- Develop monitoring guidelines
- Work at interface between decision makers responsible for managing resources and researchers
- Demonstrate link between sustainable development and improved quality of life
- Promote public-private sector NGO-community partnerships (currently in process of training members of several NGOs in environmental impact assessment)
- Support regional CBOs (400 to 500 NGOs in the region are currently focused on natural resource management, 50 in Botswana)
- Training for water management
- Special studies

RCSA resources includes:

- SADC National Resource Management Project - $5 million (Sept 00)
- Botswana National Resource Management Project - $24 million (Sept 00)
- NETCAB (NGO initiative) - $9.3 million (Aug 01)

- Natural Resource Accounting (Namibia Resource Council and University of New York) - $1 million (Dec 00)
- RAPID - $4.5 million
- STRENGTH - $1 million
- Other - $2.6 million

One third of the budget is set aside for agriculture and the environment.

The RCSA personnel structure comprises a team leader, and activity managers for policy, approaches and monitoring.

Results to be achieved by 2004 include:

- Increased cooperation among SADC member-states involving more stakeholders
- Functioning policies/agreements
- On-the-ground TBCAs/TBNRM
- River basin management plans
- Increased capacity for natural resource management

(It is estimated that $ 40 to 50 million will be spent between not and then.)

Lessons learnt by USAID in the past include the following:

- The methodology for relating natural resource management to development issues has been poorly developed
- Communities must organise themselves
- Communities need independence but also knowledge on natural resource management
- Governments must develop policies to manage natural resources and must delegate responsibility to do so
- Partnerships are required (donors moving out of this field) – need partnerships with private sector companies (e.g. AATS)
- Partnerships are sometime more important that results produced since they introduce a new element to the manner in which research is done

COMMONWEALTH SCIENCE COUNCIL
CSC Representative

The main aim of the Commonwealth Science Council is to promote partnerships between members of commonwealth through issuing grants and fellowships, but is not restricted to this.

The knowledge network is seen as critically important to the CSC and therefore it is currently involved in the creation of the Commonwealth Knowledge Network. A meeting is to take place in Durban, SA in December 1999 in this regard. The CSC will bring focus to international agreements which they can provide much funding for, such as: climate change, biodiversity, desertification, wetlands, and Ramsar. These exist opportunities to consider the science of SAFARI 2000 as providing inputs to this process. For example, assistance to develop adaptation measures for disasters which are important to climate change, desertification, (etc.).

Some SAFARI 2000 scientists did present at the long-range transport modelling workshop held in the Asian Pacific. This assisted in the spread of information about SAFARI within the commonwealth.

Applications for travel grants could be made to the CSC, through the completion of applications forms available at commonwealth focal points. A list of focal points will be made available to the SAFARI secretariat.

NATIONAL SCIENCE FEDERATION
F van der Waldt, NSF Representative

The NSF focuses it support on social and human sciences, in addition to science and technological development. Criteria for collaboration with the NSF are given as follows:

- Support foreign policy
- Strengthen research and science and development within country
- Participate in global initiatives
- Access expensive research facilities
- Mutually beneficial to parties concerns

SAFARI 2000 meets all of these criteria. For example, a presentation at the FRD last year to which the Department of Arts, Science and Culture was invited, culminated in LEAD funding being granted. The NSF prefers to bring people together and provides seed money. Funding comes in at a later stage.

DAY 2 TUESDAY JULY 27TH – PLENARY SESSION 4.1: ONGOING AND ANTICIPATED REGIONAL SCIENCE PROJECTS IN MOZAMBIQUE, ZAMBIA AND ZIMBABWE
CHAIR: DR ANNE THOMPSON, NASA GODDARD, USA

MOZAMBIQUE'S INPUT TO SAFARI 2000

Rogerio Utui, Eduardo Mandlane University, Mozambique

Colleagues include F Lucio (Instituto Ncconalde Meteorologia) and J Cumbane (Eduardo Mandlane University).

There is a general growing awareness of environmental issues among the Mozambiquan public. The MICOA is 5 years old, with bills on the environment having passed though parliament. However, very little expertise exists and almost no research has been undertaken to provide the scientific basis for such laws. Isolated activities are being undertaken at universities with few connections to outside groups. Attempts are currently being made to set up projects to fit into SAFARI 2000.

Attempts are being made to set up an air quality monitoring network, specifically to measure biomass burning which represents the main source of pollution in the country. The group hopes to gain access to satellite data and will contribution to ground based monitoring, and are currently working with people at the Schonland Research Centre for Nuclear Sciences (Univ. of Witwatersrand, RSA). Capacity building forms an important component of this project. It is hoped to train as many people as possible and inform general public.

Current research activities include:

- Air quality monitoring (DFUEM)
- Forestry management (FAEF UEM, DNFFB)
- Biomass burning (DChEUEM)
- Earth-sea interaction (DFUEM, IIP)
- Shared Rivers Initiative (DNA, IUCN, UEM)
- Others

The team will strive to integrate all relevant, **already funded** projects under the SAFARI 2000 umbrella and seek for local and/or international funds for additional work. Access to data being produced under SAFARI 2000 is seen as a benefit of this. It is expected that a SAFARI 2000 workshop will be organised in Mozambique since few researchers are aware of this initiative.

NAMIBIA METEOROLOGICAL SERVICES

Peter Hudsinson, Namibia Meteorological S ervices

Services offered by Namibia Meteorological Services (Weather@iafrica.com.na) includes:

(1) Forecasting
- Short-term forecasting
- Upper-air station (existing station Windhoek, plans for a new one at Walvis Bay)

(2) Climatology
- Historical data available – but not digitised (is progress in digitising it)

(3) Research, agromet and remote sensing:
(a) Satellites:
NOAA
NDVI
Flood Early Warning (NEWFIS)
Rangeland Biomass and Carrying Capacity
Desertification
METEOSAT
Forecasting
Rainfall estimation
Agricultural applications

Others
Long-range (seasonal) forecasting
Climate change
Health (Malaria forecasting)
Other Remote Sensing Units
EEI
National Remote Sensing Centre
Water Affairs (Flood Control)
Fisheries (Sea surface temperatures)

Questions and Answers:

Q Is Meteosat information collected on a daily basis and made available?

A Only rainfall data is used since the data set comprises to much data to handle. NOSA data is archived, and data is available from 1965.

Q Are aviation forecasts undertaken for Walvis Bay?

A Yes. Such forecasts are available.

ETOSHA ECOLOGICAL INSTITUTE (Northern Namibia)
J le Roux, Etosha Ecological Institute

Research at the institute main focuses on issues with direct implications for wildlife, and the focus seldom shifts outside of the park. Activities undertaken include:

- During 1993-4 the group operated a NOSA operating system, the products of which include data images for day-time and night-time overpasses, for the purpose of examining vegetation response.
- High resolution (1.1 km) block images from the NOAA 14 satellite's midday and midnight overpass is captured every day. These are processed into geo-corrected reflectance and brightness temperature channel images.
- A rainfall network has been established throughout the park, with the purpose of correlating vegetation cover with rainfall.
- The occurrence of fire events have been investigated; data is available in this regard. The maps of active fires and fire scars provide useful information on the spatial dynamics of savanna fires due to the high temporal resolution of the imagery.
- Floods are also considered.

Further work undertaken by the Institute includes research into the geology of the Etosha plan, and the geomorphology, land cover and land use change within the region (undertaken since 1993). The park also represents one of the DEBITS sites.

Interest in and contribution to SAFARI 2000: The group is interested in making comparisons between NOSA and NSRI data while both platforms are available. The group could map and validate fire events across northern Namibia.

ZAMBIA INTERNATIONAL BIOMASS BURNIGN EMISSIONS EXPERIMENT (ZIBBEE)
M M Mukelabai, Department of Meteorology, Zambia

Current and Anticipated Projects

Information on SAFARI 2000 has not spread to the science community of Zambia. It is hoped that it will not do so and increase Zambia's participation in the initiative. The Zambia International Biomass Burning Emission Experiment (ZIBBEE) was carried out in 1997 in collaboration with NASA, EPA and US Forest Services. The activities of this experiment will be expanded in the SAFARI 2000 programme. Anticipated projects include air quality monitoring by the Environmental Council of Zambia (ECZ), and flood monitoring by the Department of Meteorology. It is hoped to take advantage of the data generated by EOS for the latter project.

The ZIBBEE Study Objectives include:

- Quantify aerosols and trace gas fluxes from savanna ecosystems.
- Consumption of biomass
- Validation of aerosol retrievals from various satellite sensors
- Direct radiative forcing by biomass burning aerosols

AIR POLLUTION INFORMATION NETWORK FOR AFRICA (APINA)
B Chipindu,

Background

As African countries become more industrialized, emissions of sulphur, nitrogen oxides and other compounds into the atmosphere are likely to increase. Population growth, increasing urbanization, increased energy demands and vehicle numbers will contribute to the air pollution problems in Africa. The increasing threat of air pollution in Southern African and the consequent rise in the concentration of pollutant gases and acid deposition will have serious implications for human health, the functioning of ecosystems and corrosion of materials. Even countries that do not have high emissions of pollutants ma be affected by the impacts of pollution advected by wind across national boundaries (Transboundary Air Pollution).

To address the issues related to air pollution, a regional network of scientists, policy-makers and non-government organisations, known as the Air Pollution Information Network for Africa (APINA), has been established. Similar networks have been established in Asia (APINAP) and Latin America (APINLA). This forms part of a Programme on Atmospheric Environment Issues in Developing Countries coordinated by the Stockholm Environmental Institute (SEI) and funded by the Swedish International Development Cooperation Agency (Sida) under a project entitled "Regional Air Pollution in Developing Countries (RAPIDC).

APINA is coordinated through the Institute of Environmental Studies (IES) of the University of Zimbabwe. IES carries out research trough "Associates" who are affiliated to the institute. Currently the APINA coordinator is Dr Stephen Simukanga based at the School of Mines, University of Zambia. Contact persons for a number of SADC countries form a committee of country representatives for APINA.

The main role of APINA is to form a strong link between the air pollution scientific community and policy makers at national and regional levels. It acts as a conduit of knowledge and data derived in the scientific programmes and existing research to influence policy and decision-makers in matters related to air pollution. APINA acts as a link between different networks and programmes on air pollution in Africa.

Policy Dialogue

APINA, under the auspices of the Southern African Development Community Environmental and Land Management Sector (SADC ELMS), convened a policy dialogue meeting on the Prevention and Control of Regional Air Pollution in Southern Africa and its likely Transboundary Effects from 29-30 September 1998 in Harare, Zimbabwe. Participants in the workshop were policy makers drawn from various ministries (e.g. health, environment, natural resources, mines and energy), decision makers from industry and representatives from the scientific and research communities. The policy dialogue aimed to present the problems of regional air pollution to policy makers and to encourage broad discussion with regional and international experts and scientists. The main outcome of the 2 day Policy Dialogue was a resolution called *"The Harare Resolution of the Prevention and Control of Regional Air Pollution in Southern Africa and its likely Transboundary Effects"*.

The resolution resolved to request the SADC Council of Ministers, though SADC ELMS, to develop a Protocol on Regional Air Quality and Atmospheric Emissions, taking into account the following issues:

- The need for harmonised and strengthened legislation.
- The importance of creating appropriate incentive structures
- The advantages for developing strategies for increasing awareness and education
- The benefits accruing from improved information availability and accessibility to information that can promote understanding.
- The importance of encouraging the use and development of improved technologies.

- The need for further co-operation to enhance regional capacity to assess and analyse the origin and causes, nature, extent and effects of local and regional air pollution, using the in-house expertise in identified institutions, universities, colleges, etc.
- The need to identify appropriate financial resources required to carry out programmes, strategies and projects.
- The importance of developing, though SADC ELMS, a structure with required linkages in Southern Africa, to carry out coordinated programmes in building up and applying standardised methodologies to monitor emissions, concentrations, depositions and impacts.
- The importance of engaging stakeholders (industry, academic institutions, NGOs, communities, media, etc.) in these efforts and activities.

Role of APINA in SADC ELMS

Several meeting have been held between the Southern African regional coordinator of APINA and the director of SADC ELMS as a follow-up to the dialogue. A Memorandum of Understanding between APINA and SADC ELMS has been drafted and it should be signed soon. The MOU will act as an official recognition for APINA in the SADC region. It was also agreed that APINA will be invited to future workshops and meetings organized by SADC ELMS as a way of promoting APINA within the region. This opens the door for APINA to become and important player in the region (especially as a source of information) for the development f regional protocols on air pollution. APINA is well placed to develop these protocols with SADC ELMS and is being recognised by other groups in southern Africa as a link between science and policy making.

Future Activities

The APINA activities for 1999 will focus on the following areas:

- Information Collection:
  - Compilation of references (both physical at IES/APINA and on a database) on air pollution impacts, ecological work and other work done in southern Africa relevant to air pollution including industrial concerns, policy, legal matters and pollution control.
  - Compilation of list of air pollution experts and/or organizations.
- Networking Activities, including:
  - Local lobbying and distribution of the 1998 Proceedings of the Harare Policy Dialogue;
  - Web site development at University of Zambia, Lusaka;
  - Writing of pages for the web site;
  - Attendance of meetings organised by other networks (e.g. SADC ELMS, SAFARI 2000, AIR 2000, etc.).
- Policy Process:
  - Contacts with SADC through SADC ELMS will be maintained;
  - One APINA workshop is planned this year will cover: science and networking and policy development. (Workshop will be held in Lusaka during August/September 1999).

Role of APINA in SAFARI 2000

APINA can play an important role in SAFARI 2000 by providing an alternative means of informing the SADC community on the SAFARI 2000 initiatives which are related to air pollution. Information from SAFARI 2000 activities will be disseminated regionally and internationally via the APINA web site. The names of the researchers will be included in the APINA databank and the reports and published papers will be listed in the references that will be compiled by APINA.

The research findings of SAFARI 92 and SAFARI 2000 will be vital in understanding the boundary layer conditions that are necessary in modelling the dispersion of air pollution. The integrated and synthesized products of SAFARI 2000 will be used by APINA as part of the scientific basis for the SADC protocol on air pollution.

PROPOSED PROGRAMME FOR ERSI PARTICIPATION IN SAFARI 2000
Sharon Gomez, Environment and Remote Sensing Institute

The Environment and Remote Sensing Institute (ERSI) is a government research organisation mandated with undertaking research, consultancies and training in national environmental developmental programmes; more specifically with environmental programmes that could utilise remote sensing and GIS as tools for environmental management and planning. ERSI is involved in the further development of these technologies in Zimbabwe and the region. Currently ERSI has been developing pilot projects for watershed catchment planning and agricultural monitoring using remote sensing and GIS for small study areas; the pilot project methodologies are currently being tested for their viability and sustainability prior to expanding them into national level programmes.

ERSI would benefit from being involved in SAFARI 2000 in two main areas:

- The opportunity to further develop and consolidate professional collaborative linkages with regional and international environmental scientists from varying institutional frameworks; and
- The opportunity to be involved in the design and implementation of technical remote sensing programmes and methodologies, that would involve new satellite derived data.

In exchange ERSI would be able to contribute positively to the SAFARI 2000 programme by contributing specific technical expertise and conducting ground based measurements for some of the SAFARI 2000 themes of land processes, land cover and land use changes in Zimbabwe. For instance the agricultural monitoring pilot project currently being undertaken at ERSI was already tested for one agricultural season for 1 administrative district of approximately 6 000 km^2; the methodology utilised involved the development of an area-frame sample survey (using SPOT-Panchromatic data and air photos), collection of field data for 100 ha or 9 ha square field plots using a systematic sampling system, the development of a GIS using the field data and finally statistical analysis of the field data to obtain crop data. The field survey was conducted in February 1998 during the middle of the growing season and crop data (in terms of crop types) as well as other land use data were statistically compiled for this season. It is proposed that these field sample plots are used for the SAFARI 2000 ground-based measurements on land cover, as well as land use for a larger study area of approximately 10 000 km^2 during the growing season February – March 2000. More specifically the ERSI field campaign offers an opportunity to create synergies with validation efforts for products from the new Earth Observation System's MODIS sensor. A provisional plan to use ERSI data sets to validate the MODIS continuous field of tree cover product is currently being developed. Using air photos from the ERSI field campaign, plots of tree cover strata will be delineated and used along with Landsat TM data to measure the accuracy of the MODIS tree cover layer. Additionally the use of MODIS data for agricultural monitoring within the districts of ERSI field work will be examined. Through these means the local ground-based data sets of ERSI will be used to measure the utility of globally derived MODIS products in monitoring natural resources and land use processes.

The advantage to implementing this proposal is that the field survey campaign/methods for agricultural monitoring project and budgets have already been established for one district and thus can be duplicated and extrapolated for a larger study area as a straightforward exercise. It should also be noted that ERSI has the relevant infrastructure (a fully-fledged RS/GIS computer laboratory) and human resources to support such a collaborative programme.

DETERMINATION AND QUANTIFICATION OF POLYCYCLIC AROMATIC COMPOUNDS IN HARARE'S AMBIENT AIR
Vongayi Chirima, University of Zimbabwe

Exposure to poly-aromatic hydrocarbons (PAHs) has long been identified as being of environmental concern world wide. This is particularly so because of the carcinogenic and mutagenic activity associated with these compounds. PAHs are found in aerosols, suspended particulates and trace gases. The major forms being the first two. PAHs are made up of two or more fused benzene or cyclopentadiene ring systems and their derivatives. The major source of PAH is the incomplete combustion of organic based materials, including: coal, petroleum fuels, wood fuel, tobacco and smoked foods.

Aims and objectives of the project include:

- Development of a sensitive and robust method for determining PAH's in air, and hence provide

evidence for the need to continually monitor PAH levels in the air.

- Create public awareness about the need to continually monitor PAH levels in the air.
- Initiate the development of a method which can further be adapted for the systematic yet routine monitoring of PAH's in Harare.

The project comprises the development of a quantitative analytical procedure for monitoring the PAH levels in urban air particulates based on high performance liquid chromatography with fluorescence detection. A gas chromatography method will be used to validate the procedure.

Sampling and collection of the analyte will be done using glass fibre filters with a pore size of 0.45 µm at a sampling site in the urban centre of Harare. Soxhlet extraction will be performed on the filters using dichloromethane as the working solvent. The efficiency of this procedure will be checked with the extraction of Standard-spiked filters. Because of the inherent selectivity of fluorescence detection the sample clean up procedure will not be too stringent. Using acetonitrile and a C18 column the analyte contents will be analysed for polyaromatic hydrocarbons and also quantified.

OZONE PROFILES FOR SATELLITE OZONE VALIDATION DURING SAFARI 2000
Anne Thompson, NASA Goddard

Tropospheric ozone research has been conducted with southern African data since SAFARI-92, developing satellite ozone products (Kim *et al*., 1996; Hudson and Thompson, 1998) and interpreting ozone profiles from aircraft and with ozonesondes (balloon-based) (Thompson *et al.*, 1996a,b; Diab *et al*., 1996).

The groups most recent activity was the collection of a trans-Atlantic ozonesonde data set of the Research/Vessel Ronald Brown from the US to Cape Town, in January – February 1999 (http://saga.pmel.noaa.gov/indoex/index.html). High ozone concentrations in the free atmosphere over the South Atlantic resulted from biomass burning in northern equatorial Africa. Besides the *in situ* observations from ship, regional ozone distributions can also be seen in tropospheric ozone column maps from TOMS (see website: metosrv2.umd.edu/~tropo).

The groups participation in SAFARI 2000 is motivated by continuous interest in collaborating with southern African researchers on ozone processes and climatology in this region. Specifically, the group is funded in a NASA/EOS validation effort called SAVE (Southern African Validation Experiment, Principle Investigator - J. Privette) to collect and archive ozonesonde data during field intensives from sites to be worked our with the SAFARI Science Team. The South African Weather Bureau will be part of this effort.

A second are of on-going collaboration with African ozone colleagues is through a NASA-sponsored satellite ozone validation project called SHADOZ (Southern Hemisphere Additional Ozonesondes). In collaboration with NOAA and international partners, weekly ozone sounding are archived at NASA Goddard. A description of the project and the archive information can be found at:

http://code916.gsfc.nasa.gov/Data_services/shadoz/Shadoz_hmpg2.html

African and nearby sites include: Irene (South Africa), Nairobi (Kenya), Ascension Island and Reunion Island.

References:

Diab R D *et al.*, Journal of Geophysical Research, 101, 23823 (1996).
Thompson A M *et al.*, Journal of Geophysical Research, 101, 23797 (1996a)
Thompson A M *et al.*, Journal of Geophysical Research, 101, 24251 (1996b)
Hudson R D and A M Thompson, Journal of Geophysical Research, 103, 22129 (1998)
Kim J K, R D Hudson and A M Thompson, Journal of Geophysical Research, 101, 24317 (1996)

MIOMBO NETWORK INITIATIVE
Dennis Kayambazintho, Forest Research Institute of Malawi (Presenting on behalf of Peter Frost)

Background

The Miombo initiative is an intercore project activity of the IGBP and IHDP (developed in a workshop in Malawi, December 1995). The Initiative was refined during the land use and cover change (LUCC) Open

Science Meeting, January, 1996 – Amsterdam, Netherlands, through consultation and review by the LUCC Scientific Steering Committee (SSC).

Composition

The initiative comprises an international network of researchers working in concert on a 'community' research agenda – aimed at addressing:

- the critical global change research questions for the Miombo woodlands ecosystems
- capacity building and training needs in central, eastern and southern Africa if the Global Change System for Analysis Research and Training (START)

Research Strategy and Framework of Research Activities

The initiative will provide the basis for the proposed IGBP Terrestrial Transect study on land use and land cover changes in the Miombo ecosystems. It resides administratively within the LUCC programme with linkages to other Programme Elements of the IGBP such as Global Change and Terrestrial Ecosystems (GCTE).

The initiative is aimed at understanding how land use is affecting land cover and associated ecosystem processes; assessing what contribution these changes are making to global change; and predicting what effects global change in turn could have on land use dynamics and ecosystem structure and function.

Key Issues:

- Patterns, causes and rates of change in land cover in relation to land use.
- Consequences of land-use and land-cover changes on regional climate, natural resources, hydrology, carbon storage and trace-gas emissions.
- Determinants of the distribution of species and ecosystems in Miombo
- Fundamental questions of Miombo ecosystem structure and function.

Core Experiments:

(1) Land use dynamics
(2) Land cover dynamics
(3) Ecosystem dynamics and disturbance
(4) Nutrient limitation in Miombo (Miombo slow growing)
(5) Biogeography and distribution of Miombo
(6) Regional 1 degree and carbon balance of Miombo
(7) Sustainable natural resource management

Other integrating activities include: modelling (2 meetings in Malawi), developing shared data bases, and building regional research capacity.

Approach

- Each core experiment is undertaken by a consortium of participating institutions and individuals at a network of sites across the Miombo region.
- A Task Team (TT) for the Miombo Network guiding the scientific content and implementation of projects.
- TT consists of regional and international representatives of participating IGBP and IHDP programme elements.
- Network coordinators facilitates the activities of the network.

The initial phase of programme (1996-2000) comprised the building on existing activities, and individual scientists or groups of scientists developing specific proposals and seeking funding for the core experiments in liaison with TT and NC.

Initial activities included:

- Produced in collaboration with Data and Information Systems (IGBP-DIS)

- A Regional Database on CD-ROM to facilitate interdisciplinary research
- Capacity building and research proposals being submitted to funding agencies by START, LUCC and GCTE.

Products generated to data includes a regional data base available on CD-Rom. Workshops held include:

- Malawi – workshop on Inventory, Data and Spatial Modelling (June 1998, July 1999).
- Ecology and Management of Fire in Miombo (Matobo, Zimbabwe, April 1999) – workshop looked at ecology of fires in Miombo and related vegetation types, issues of management and use of fire, issues of remote sensing of fires, fuel loads and trace-gas emissions.

Particular contributions from the Miombo Network research are likely in the following areas:

- Land cover dynamics:
  - Land cover characterisation using remote sensing and field surveys.
  - Timing, distribution, arial extent and causes of fires;
  - Characterisation of both fires and burned areas.
  - Fire and land cover change.
- Ecosystem dynamics and disturbance:
  - Effects of fire and herbivory on plant growth and related ecosystems processes.
  - 1 degree production and fuel load dynamics
  - land degradation and impacts on productivity
- Nutrient limitation:
  - Trace-gas fluxes from Miombo landscapes
  - Effects of fire on nitrogen and potassium dynamics and on trace-gas fluxes.

Benefit of Safari 2000 for Miombo Network:

- Safari 2000 provides an opportunity for regional scientists to become involved in broader research programmes – through their own research projects and in collaboration with others.
- Many areas of research proposed are within the framework of Safari 2000 (i.e. some of them already identified within the Miombo Network Science prospectus (IGBP Report 41)).
- Safari 2000 stands to contribute substantially to eventual achievements of the Network's goals.
- High visibility (prominence) of Safari 2000 within the region provides opportunity to promote Miombo network perspectives on fire and land management and raise awareness of the issues in the region.

The need exists to strengthen and expand the societal and policy reference of the outputs from research in the natural resource sector. How best to do this and how such activities could be funded are issues that need to be discussed both at the Safari 2000 meeting and within the Miombo Network.

PLENARY SESSION 4.2: PRESENTATIONS BY BOTSWANA GOVERNMENT DEPARMENTS ON DATA BASES
CHAIR: MR G B CHIPETA, ZAMBIA METEOROLOGICAL SERVICES

BOTSWANA AIR POLLUTION MONITORING AND SURVEILANCE SYSTEM DATABASES

Mr Matale, Department of Mines

The monitoring of air pollution in Botswana started around the mid-70s using hydrogen peroxide to measure sulphur dioxide and high volume air samplers to measure total suspended particulates in the atmosphere. The monitoring stations were located in urban areas with more effort concentrated at Selebi-Phikwe area where BLC smelter operations result in the emissions of SO_2 into the atmosphere. In 1996 continuous gas analyzers were interfaced in Gabarone, Selebi-Phikwe, Tonota and Serowe. New air pollution indicators such as O_3, NO_x, HCs and CO were also introduced at some of these stations. Preliminary results showed that air pollution monitoring programme in Botswana needed to be broadened to bring it in line with international standards.

The idea of an air pollution monitoring and surveillance system for Botswana was conceived in 1996 with the following objectives:

- Establish a source scientific basis for policy development;
- Determine compliance with statutory criteria;
- Assess population and ecosystem exposure;
- Establish a base for public environmental information and awareness;
- Identify pollution sources and risks;
- Evaluate long term trends;
- Establish a basis for abatement strategy planning.

It was obvious that the above objectives could not be achieved without complete restructuring of the air pollution monitoring network and the establishment of appropriate laboratory facilities. A site study was conducted in early 1997 with technical assistance from the Norwegian Institute for Air Research. The objective of the study was to determine the location of each air pollution monitoring station and what pollutants to measure. As a result of this study a new air pollution monitoring network was developed.

In 1998 the government approved funds for the construction of an environmental laboratory in Gaborone. The facility at the time was congested and over-crowded and therefore could not accommodate any additional equipment that was needed for the new air pollution monitoring and surveillance system.

Most of the equipment has been procured, installed and commissioned at all stations shown in Table 2. A mobile air pollution laboratory was also commissioned during July 1999. It is equipped to measure SO_2, NO_X, O_3, PM10, H_2S, NH_3, THC, CO and various meteorological parameters (wind direction, wind speed, temperature, relative humidity, precipitation, barometric pressure, global radiation. Outstanding work is mainly within the area of dust monitoring. PAH is not yet monitored, but it is anticipated that the samplers will be in place by the end of the year.

The following databases are in various stages of development:

(1) Results from continuous gas analysers
(2) Acidimetric data
(3) Equipment management
(4) Emissions inventory

These databases will provide input to the dispersion modelling to be undertaken by the Department. Model results will be fed into a GIS and be used to show trends and environmental compliance.

Table 2. Botswana air pollution monitoring and surveillance system

Station	SO_2	CO	NO_x	HC	O_3	Met.	TEOM	PAH	Precip	PM10
Gaborone										
Civic Centre (curbside)	✗		✗		✗			✗		2f
Fire Brigade (commercial)	✗	✗	✗			✗		✗		2f
Old Naledi (residential)	✗		✗	✗	✗					
Marang (residential)	✗		✗					✗		2f
Lobatse										
Bus Rank (residential)			✗							
Moshopa										
Diratsame CJSS (background)					✗					16f
Palapye										
Morupule Colliery	✗									
Serowe										
Serowe TTC (background)	✗	✗	✗			✗		✗		
Selebi-Phikwe										
Water Utilities (diffuse em.)	✗									16f
Kopano (residential)	✗		✗							16f
Mines Office (residential)	✗							✗		
Rainway Track (max. stack)	✗	✗	✗			✗	✗	✗		16f
Francistown										
Information (curbside)			✗							16f
City Council (industrial)	✗									
Maun										
Research Centre (background)					✗				✗	
Tonota										
TCE (background)	✗									
Mmadinare										
Makome CJSS (long range)	✗	✗					✗			

DEPARTMENT OF WATER AFFAIRS – BOTSWANA
Mr Muzila, Dept. of Water Affairs

The overall objective of the Department of Water Affairs is to assess, plan, develop and maintain water resources for domestic, agriculture, commercial, industrial and other uses in the whole country. More specifically the Department aims at:

Serving as the government's focal point for policy formulation and implementation on water resources assessment, development and management at national level.
Serving as a focal point for effective planning and designing of water supply and sanitation schemes.
Ensuring that hydrological and hydrogeological data is collected, processed and analysed for planning and development purposes.
Ensuring sustainable supply of water throughout the country and protecting the environment.
Ensuring that all resources allocated to the Department are effectively and optimally utilised.

In order to achieve these diverse aims the Department has been divided into different Divisions, each dealing with a specific aim. The divisions are:

- The Hydrology and Water Resources Division, which deal with all matters relating to surface hydrology and long term water resources planning.
- The Groundwater Division, which deals with all matters relating to groundwater investigations and supply to all villages throughout the country.
- The Design and Construction Division, which is responsible for designing and constructing all village water supply reticulation systems.

- The Operation and Maintenance Division, which is responsible for the operation and maintenance of water supplies for 17 major villages in the country.

There are other divisions in the Department that are these to provide support on relevant activities, which mainly fall under different departments.

In keeping with the concept of sustainable development, the Department makes all attempts to manage the water resources in such a manner as to fulfil the requirements for sustainable water resources management. In keeping with its mandate the Department collects, archives and analyses relevant data to assist in achieving its objectives. The following data are collected and stored in different data bases:

- Private water connections and water consumption
- Surface water
- Groundwater
- Water quality and pollution
- Water rights

A synopsis of the Department of Water Affair's data bases and their applications is provided in the following table:

DATABASE:	APPLICATION:
EDAMS Billing	Consumers, consumption, billing records
EDAMS Engineering	Engineering, design, analysis and management system
HYDATA	Hydrological records
WELLMON	Well monitoring records
CHEMISTRY	Water chemistry records
POLLUTION	Pollution records
BOREHOLE ARCHIVE	Borehole records
WATER RIGHTS	Water rights records

The EDAMS Billing database is used for storing consumer and billing records for all the villages whose water supplies are operated by the Department. The EDAMS Engineering database is an engineering package which is used to design reticulation systems, and to monitor their hydraulic performance and to monitor losses in the systems. The HYDATA package is used to store all data on surface water for different flow monitoring stations and surface water storage reservoirs. WELLMON is used to store records of all production boreholes. The CHEMISTRY database is used to store all data on water quality for boreholes, surface water reservoirs and waste water treatment plant effluents. The pollution database is used to store records of all polluting activities. The Borehole Archive is used to store records of all boreholes in the country. The Water Rights data base stores records of approved water rights throughout the country.

An important aspect of the databases is that they should be integrated, so that the different data can be easily accessed for different applications. This has, however, not been achieved to data, and data can only be retrieved on an individual basis from each database.

NATIONAL CONSERVATION STRATEGY (NCS), NCS ACTION PLAN AND LINKAGES WITH SAFARI 2000 DATABASES

S C Monna, National Conservation Strategy (Coordinating) Agency

Introduction

The term environment is used herein to define all biogeophysical and chemical factors and conditions that influence the existence and development of an organism or system of organisms. With man as the principal participant in the system of organisms, socio-economic, aesthetic and cultural factors become an integral part of the definition. Components of the environment are intricately related through some dynamic interdependencies, such that when one component of this relationship is changed or disturbed, the influence is manifested in other parts of the environmental system. The question of the sustainability of resource based development consequently becomes an issue in this context.

This requires that there be a comprehensive understanding and definition of the complex interface between population growth and environmental resources and the resultant pressure that the former exerts on the latter, amongst others.

Environmental resources focus on the various attributes such as the land, water and the air and their various attributes, which are under pressure from the development process. The impacts of the pressures in the case of Botswana are manifested by;

- the depletion of fuelwood, ground water, wildlife species and indigenous veld products resources
- land erosion
- urban and rural pollution
- rangelands degradation

The foregoing are as identified during the wide consultative process that was part of the formulation of the NCS which involved all levels of society.

Potential Linkages with the NCS Action Plan

The Southern African Regional Initiative –SAFARI 2000- is an international collaborative science initiative aimed at developing an integrated understanding of the selected aspects of the Southern African earth-atmosphere human system. The goals are to understand the key linkages between the biophysical, chemical processes, including human impacts essential to the functioning of the southern African biogeophysical system.

These goals are in consonance with local initiatives such as the National Policy on Natural resources Conservation and Development commonly referred to as the National Conservation Strategy of 1990, whose goals are to increase the effectiveness with which natural resources are used and managed, so that beneficiary interactions are optimised and harmful environmental side effects are minimised. This is operationalised through the integration of the work of the sectoral ministries and other interest groups throughout Botswana, thereby improving the development of natural resources through conservation .

Fulfilment of these detailed goals entails designing development so as to minimize environmental costs and to enhance its quality. It likewise requires that, when "trade-offs" have to be made involving the use of natural resources, full account should be taken of the socio-economic and environmental costs.

The measures to be covered under the proposed NCS Act do include the following:

a) the requirement that all sectoral Ministries, departments, Local Authorities, parastatals, etc., shall, in the course of their work, show the due regard for the conservation and enhancement of the environment;

b) the need foe sectoral Ministries of Government, in particular, to work closely with the NCS Coordinating Agency in discharging their environmental responsibilities;

c) the necessity for new development projects (public and private) to be accompanied by professionally prepared and approved Environmental Impact Assessments (EIAs);

d) the obligation for the NCS/A to prepare and publish a periodic State of the Environment Reviews;

e) the provision of the necessary powers, where planning and other authorities can be required to prepare conservation and resource strategies at D/Local levels and to review them regularly;

f) the encouragement which government gives to NGOs in sharing responsibilities for the conservation and enhancement of the nations environment.

Implementation and Monitoring of the Action Plan through NDP 8

The National Policy on Natural Resources Conservation and Development, Government Paper No. 1 of 1990, as approved by the National Assembly on the 17th December, 1990, states under paragraph 7.12 that the NCS is to be implemented through an Action Plan, which will be monitored as part of the NDP process.

The main thrust of the NCS is the introduction of new and different strategic approaches to achieve the integration of conservation of natural resources into the development process. The objective of the NCS Action

Plan is accordingly, to define the strategic measures of the NCS in more detail. It define in specific terms and on the basis of the nation's environment and conservation policies, the strategic measures of the NCS which should affect policy formulation and implementation in the rest of Government.

The Action Plan formulates and describes the different measures to diversify Botswana's economy through the use of the natural resources base. It identifies the natural resources which have significant potential to create employment and incomes particularly where there are limited to no formal employment opportunities. The work also defines specific policies and instruments of a macro-economic nature which should serve as incentives and dis-incentives in the quest to improve the conservation of natural resources. These measures include fiscal and subsidy policies as well as other innovative measures hitherto unused for conservation purposes. It also proposes specific pieces of legislation and provisions which could play a positive role in promoting environmental rehabilitation and a strong role in stopping degradation. It also proposes amendments and where appropriate, new legislation or the consolidation of existing legislation and provisions.

The Action Plan further articulates how public awareness and environmental education and complementary training measures should be undertaken as well as the research that should be carried out. The Action Plan also articulates and describes the Integrated Multi-sectoral Conservation Programmes and Projects and defines and describes the costs in financial and manpower terms and the necessary institutional arrangements required to implement the projects. It also describes a monitoring and evaluation process for the continued assessment and review of the projects.

The Action Plan Consultancy reports are in five volumes as follows:

Volume 1: Policies, Planning and Administrative Measures;
Volume 2: Economic Incentives and Dis-incentives and Economic Diversification for Sustainable Development in Botswana;
Volume 3: Integrated Multi-sectoral Conservation Programmes and Projects:
Volume 4: Improved Public Awareness, Education and Training
Volume 5: Legislative Reforms and Provisions.

The Policies, Planning and Administrative measures examines the range of administrative procedures which affect environmental enhancement and natural resources conservation. It also examines the methodology of conceiving, preparing and approving development projects by the ministry planning units and the approval process, includes the Ministry of Finance and Development Planning (MFDP).

It makes proposals for the integration of the financial and environmental development approval process, and makes specific proposals on how conservation and environmental projects and policies should be integrated in the administrative procedures.

The proposed process should facilitate the integration of conservation and development into the national development planning and implementation process from the stage of conception of policies, programmes and projects, through a process of pro-active planning, project formulation, funding, implementation, monitoring, evaluation and decommissioning. Specific recommendations on the integration of the bio-physical, socio-economic and environmental development planning and implementation are also tendered. This is inevitable for sustainable development to be realised, and has common or general application across the sectors and is compatible with the NCS goals.

The volume also stresses the need to dispel any notion that conservation is a limited, independent sector largely concerned with bio-diversity or soils; and that ecological factors are impediments to development, which in some cases may be overlooked and in others may be treated or considered simply on a project by project basis and not as a matter of policy. Unfortunately, these beliefs have been implicit in the way policies are generally formulated and implemented.

These have three consequences:

a) The ecological effects of a particular development policy are seldom anticipated, and hence, the policy is not adjusted in good time to avoid expensive mistakes.

b) Those sectors directly responsible for living resources (notably agriculture, forestry, fisheries and wildlife) are often impelled to concentrate on production at the expense of maintenance,

with the result that otherwise renewable resources are dissipated, thus undermining the resource base for posterity.

c) Because of the previous lack of conservation, the policies of other sectors may be frustrated. The arable sector forecasts of plantation, for example, may completely be falsified by poor watershed management.

Even when ecological factors are considered, it is seldom at the critical policy formulation stage, when the basic pattern of policy is often fixed. Consideration at the project stage, though often necessary, is and should be no substitute for proper consideration at the policy stage- for at the project state, economic and social requirements will usually have been set so firmly that only minimal or cosmetic adjustments are possible.

There is competition within Government for scarce resources and a consequent pressure on all sectors to show results that can be directly related to economic performance. Economic performance can be measured in terms of GDP; employment in terms of the percentage of labour force employed; agriculture, forestry and fisheries production in terms of crop, timber and fish yields and the income derived from these. While such easily measured production may be won at the expense of diminishing the natural resources base, and although conservation can bring real benefits by ensuring that resource base, the costs and benefits are not easily related.

Consequently, opportunities for the joint planning and realisation of the conservation requirements of agriculture, forestry, fisheries and wildlife and so on, may be overlooked. Similarly, the interest of sectors not usually thought as deriving benefits from living resource conservation may be neglected. Health is an example; conservation may advance the achievement of the health objectives not only by ensuring a healthier environment through the maintenance of clean air and water, but also by preserving genetic resources needed for the production of medicine. Policy-makers in the health and industry sectors need to be satisfied that the genetic resource base of domestic pharmaceuticals can be ensured.

In the context of the foregoing, the NCS (Co-ordinating) Agency should foster the integration of a cross-sectoral conservation of the natural resource into the development process through the instrument used to implement anticipatory environmental policies, through the establishment of coordination mechanisms to ensure that a cross-sectoral conservation policy is applied, and by the adoption of national accounting systems to include measures of conservation performance.

Instruments for the implementation of anticipatory environmental policies include, inter alia,: taxes, charges and financial incentives and dis incentives (to encourage choices compatible with the maintenance of a healthy environment); technology assessment; design and product regulation; integrated environmental planning.

The successful execution of the these requirements ....“entails designing development so as to minimise the environmental costs and to enhance its quality. It like wise requires that, when ‘trade-off’ have to be made involving the use of natural resources, full account is taken of the economic, social as well as the environmental costs” (National Policy on Natural resources Conservation and Development, Government Paper No 1, 1990).

There is clearly a priority need to systematise the Environmental Impact Assessment (EIA) applications. A well defined operational EIA system that defines the scope and institutional responsibility for the of the EIA work—from defining the scope of the EIA to actual conduct and preparation of the Environmental Impact Statement (EIS), to the review and approval of the EIS, and post-EIA implementation and monitoring has been subject of a Cabinet Memorandum which sought Cabinet’s approval for the drafting of the Environmental Impact Assessment (EIA) and Management legislation. The Cabinet. Memorandum is now with the Attorney Generals Chambers who should expedite the drafting of the Environmental Impact Assessment and management legislation which is well overdue.

The envisaged legislation would be structured in such a way that it is to the extent possible, in line with the geographical characteristics and environmental needs, as well as the socio-economic and cultural setting of Botswana. It should be fitted into the existing legal and administrative machinery of Government, with the NCS Board and Co-ordinating Agency, being primarily charged with the general administrative and enforcement responsibility of the envisaged legislation.

The legislation should provide for the concept of Strategic Environmental Assessment (SEA) and Environmental Health Impact (EHIA) to focus on the overall environmental aspects of the cross-cutting/cross-sectoral planning issues and to provide for a more comprehensive and rigorous approach for the identification, prediction and

appraisal of the environmental factors which might affect an ecosystem and human health, as an integral part of the assessment, respectively.

The progressive application of EIA and audits of operations presents an effective opportunity for projecting environmental impacts and planning to prevent or minimise threats and consequences to the environment resulting from policies, plans, programmes and projects and the developments thereof. The legislation should thus provide for the mandatory EIAs to "enable competent authorities to reach decisions on public and private development investments with the full understanding of the environmental, as well as the social and economic costs and benefits which will be incurred in the short and the long term".

This should promote a broader application of economic instruments that promote sustainable natural resource uses and discourage damage to the environment, such as -

- cost recovery through cost-reflective tariffs, user charges, to facilitate a better allocation of financial resources amongst competing uses
- "polluter pays" principle to clearly establish the concept that the use of natural resources bears not only economic but environmental costs
- easing of subsidies in the long term, or if this could not be completely done away with, subsidies should be provided following careful and clear targeting of beneficiaries
- environmental taxes on polluting substances or activities

To fulfil these mandate, the NCS/A needs to establish effective horizontal and vertical liaison with Ministries and local Government authorities. In the short term, the NCS/A should serve as a reference group to the MFDP in the review and approval of development funding, while in the long term, the capacity of sector planning officers should be further developed to undertake full appraisals of the proposed development projects.

The NCS/A also needs to firm up the operational links with other bodies, apart from the sectoral Ministries, that are involved in the management of environmental resources, such as, inter alia, the Agricultural Resources Board, Land Boards, for continuing policy review and reform, implementing guidelines for systematic EIA applications,

The functional links with the information centres of line ministries to ensure that environmental indicator are generated for the operation of the "State of the Environment Review" and for environmental monitoring at the national level. Environmental indicators represent a powerful tool for communicating synoptic information on the state of the environment to policy decision makers and the public. Indicators represent a bridge between the wealth of detail and the need for interpreted information focusing on the significance of interactions and changes in the environment. They are an effective compromise between the users' needs for quality, synoptic information and the statisticians desire foe data accuracy and precision.

These indicators can be based on the biogeophysical and chemical measures associated with environmental quality or natural resources. They summarise some aspects of the state of the environment, natural resources assets, and related human activities. To be useful in a sustainable development context, environmental indicators should relate environmental aspects to socio-economic factors. A key characteristic of environmental indicators is that they track changes over time.

The ongoing work aimed at formulating an integrated management plan for the Okavango Delta stands to benefit from SAFARI 2000. The Okavango Delta is one of the largest and most important inland wetland in the world, covering over 15 000 km2. Water supplying the Okavango River originates in the highlands of Angola and after passing briefly through the Caprivi Strip in Namibia, enters Ngamiland, in the northwestern corner of Botswana. The river then flows in a well defined channel for approximately 95 km, before fanning out into a Delta of interconnected rivers and reed-lined channels. Water Flows out of the delta in the Boteti River and , in years of high rainfall, has supplied Lake Xau. Within the Okavango Delta, five broad ecological zones have been defined – perennial swamps, seasonal swamps, seasonal grasslands, intermittently flooded land, and dry land. Approximately 140 000 people reside in Ngamiland and the Northwestern portion of the Boteti –Sub Districts, with 50 percent of the population in villages of less than 500 people. The economy of the region is quite diverse and includes floodplain and dryland agriculture, cattle rearing, wage labour and craft and tourist related enterprises.

Biodiversity Significance

Wetland ecosystems are among the most biologically productive in the world, but are disappearing globally at an alarming rate. The Okavango Delta is particularly significant as one of the largest remaining inland wetland ecosystem in the world today. While it is not known how many rare or threatened species of flora and fauna exist in the Delta, the wetland ecosystem as a whole is a critically endangered environment of international significance. The Okavango is the habitat for between 2000 to 3000 species of plants, more than 65 fish species, over 162 arachnid (spiders, scorpion, ticks and mites) species, more than 20 species of large herbivores, and over 450 species of birds, including the endangered Wattle Crane.

While it is understood that the perpetual change of the Delta's composition is necessary for the maintenance of the biodiversity of the wetland, the critical function of the flora and the fauna in this process is only beginning to be studied. It is thought that the reeds and grasses of the Delta play a critical role in the dynamics of the water flow and the salinity of the Okavango River. This variability and salinity control maintain a wetland environment in which both human and animal populations can thrive. Although much more research is needed on the Delta's resources, it is well known that numerous plants from the area are used extensively by local people for purposes ranging from construction to medicinal uses.

Pressures Facing Biodiversity

The Biodiversity of the Okavango Delta is threatened primarily in two ways: by the use of the Delta water resources for development purposes and by the lack of a comprehensive natural resources management plan which accommodates local participation and sustainable resource use. Additionally, tourism offers an incentive for conservation and a threat to sustainability, if unmanaged.

Regional Threats

The main threats to the Okavango River Basin (ORB) arise from patterns of unsustainable development. If these threats are allowed to persist, they will result in fundamental and irreversible changes in the basin's water balance, energy balance, and hydrochemical and hydrogeomorphological responses, all of which will impact on the productivity of the basin as a whole.

Key factors in the trends are; overgrazing which is already resulting in accelerated land and soil degradation in Namibia and Botswana; unplanned developments in Angola along the de-mined transport routes/corridors in the Cubango and Cuito sub-basins as post-civil-war resettlement occurs; and pressure for new and increased abstraction of raw water to service urban expansion and irrigated agriculture.

The foregoing trends are outpacing policy and institutional responses in the riparian countries. The primacy of national interests is resulting in the imposition of transboundary externalities on specific sectoral and cross-sectoral developments. These include the quality and quantity losses of water supplies for the cross sectoral activities which include inter alia, loss of biodiversity and compromised nature tourism. It is these intermediate causes related to policy and institutional failures where intervention is necessary.

Clearly, sustainable development must benefit from data basis being generated by different initiatives. It is not simply a matter of temporal trade-offs and inter-generational transfers. It is a matter of costs and efficiency rather than the rate and speed of economic growth. Sustainability requires alleviation of poverty, a decline in fertility, the substitution of human capital for natural resources, effective demands for environmental quality, and a responsive supply. These changes cannot take place on a sustainable basis without growth. They are contingent upon the attainment of higher levels of income.

The old argument that natural resources are a gift of nature to be enjoyed freely by all or that the environment is a public good that can not be traded in markets has been proven faulty by at least three development:

- natural resources treated as free goods or state property have soon been depleted; the environment as a public good or 'everyone's property' has turned out to be nobody's 'property';

- the poor, on whose behalf resources and the environment were ostensibly left outside the domain of the markets, have been the ultimate victims;

- many innovative approaches, mechanisms, and instruments for bringing natural resources and the environment into the domain of the markets have been developed and tested in recent years.

The linkages between macro economic planning and environmental conservation at the policy, programme and project levels provides a tremendous scope for decoupling industrial growth from toxic wastes, urban development from congestion and pollution, agricultural growth from deforestation and soil erosion, and resource extraction from ecological destruction and social dislocation.

Such linkages require that existing data bases be compatible between the different users in the Ministries and Departments, in order to foster the quest for sustainability can be made into a potent force for efficiency, productivity, innovation and growth, as well as conservation, and decision making would thus be enhance rather than squander the enthusiasm for sustainable development. This offers the advantages of directly linking the conservation mandate of the NCS with the major sectors of economic activity and the sources of foreign exchange, thus giving it a higher political and financial status, as well as linking it closely with the community based and operated natural resources management initiatives.

All the foregoing institutional options require a legislative basis that legitimises the NCS Board and its Coordinating Agency, which should play a key role in the operation of the NCS Act, and in cases of doubts concerning the obligations by the organisations and individuals under the Act, the NCS Board should provide guidance on how such obligations may best be met. The legislative basis would further legitimise the NCS Board and Coordinating Agency when they demand certain courses of action, in cases where the environment is being compromised through either policies or activities which merit review.

PLENARY SESSION 5: RESULTS OF THE NASA EOS SAFARI BOULDER WORKSHOP AND AIRCRAFT SCHEDULE
CHAIR: MR LESOLLE, BOTSWANA METEOLOGICAL SERVICES

RESULTS OF NASA EOS SAGARI BOULDER WORKSHOP AND AIRCRAFT SCHEDULE

Dr J Timothy Suttles, EOS Senior Science Advisor

NASA Science Interest in Southern Africa

Science Investigations and EOS Terra (AM-1) Instrument Teams comprise:

- Land:
  - Land cover and land use change – LAI/BRDF (MODIS, MISR)
  - Land surface temperature (MODIS, ASTER)
  - Fire properties (MODIS, ASTER)
  - Surface energy budget (CERES)

- Atmosphere:
  - Aerosol and clouds (MODIS, MISR)
  - < Tropospheric aerosols over land (MODIS, MISR, AERONET)
  - < Namibian stratus clouds (MODIS)
  - CO/CH_4 from biomass burning and resulting O_3 production (MOPITT)
  - Precipitable water (MODIS, AERONET)
  - Cloud mask – distinguishing clouds, heavy aerosol, fires and shadows; desert ecosystem especially difficult (MODIS)

NASA EOS SAFARI 2000 Workshop

Work undertaken at the NASA EOS SAFARI 2000 Workshop, held at the National Centre for Atmospheric Research, Colorado between 12th and 14th May 1999 was summarised. On the first day evolving plans were reviewed, the status of funded and planned investigations considered, and keynote presentations of Science Plan Core Elements given. On Day 2, Discipline Breakout Groups examined strategies and gaps, whilst the Airborne and surface measurement Breakout Groups assessed requirements, capabilities and gaps. During Day 3, Implementation Breakout Groups addressed the coordinating and integration of activities of the science team, airborne operations teams, and ground-based measurement teams.

Reports arising from the workshop included the following:

- Breakout Group Reports:
- Discipline Groups:
- Land – Modelling – Data
- Aerosols – Clouds and Radiation
- Trace Gases
- Airborne Measurement Groups:
- Remote Sensing (ER-2 and Proteus)
- *In situ* (CV-580 and Aerocommander)

Discussions at the workshop included the following topics: (i) US/In-region research coordination, (ii) potential partnerships, (iii) data policy and principles, and (iv) international agreements and protocols. General consensus was reached on the following cross-cutting needs:

- Interdisciplinary model component covering several time and space scales
- Modest resources to support integrated modelling activities
- Strengthening of research components linking surface emission processes (aerosols and trace gases) to atmospheric chemistry and transport of free troposphere via the PBL.

Specific activities identified at the workshop as requiring enhancement included:

- Flux tower measurements of trace gases (carbon dioxide, ozone and reactive nitrogen species)
- Deposition studies, especially dry deposition of aerosols
- Atmospheric profiling of the boundary layer and troposphere via balloon soundings, acoustic sounders and additional rawinsondes.

Relationship between NASA EOS and SAFARI 2000

SAFARI 2000 represents the largest single initiative being planned for EOS Terra (AM-1) validation, comprising:

- Surface networks:
  - SAVE tower sites (Skukuza, South Africa; Mongu, Zambia)
  - AERONET – global network of over 60 sun/sky radiometers
  - Fire emission/temperature towers for characterising carbon efficiencies (burning and smoldering phase)

- Airborne measurements:
  - NASA ER-2 (remote sensing with airborne simulators for sensors on Terra, PM-1, and ICESat spacecraft)
  - University of Washington CV-580 (*in situ* microphysics, atmospheric chemistry, spectral and angular radiation, aerosol optical thickness)
  - South African Weather Bureau (SAWB) Aerocommanders (aerosols, trace gases and cloud microphysics)
  - Proteus (radiative, thermodynamic and chemical properties)

EOS SAFARI 2000 Tower Sites

EOS / SAVE validation towers are to be deployed at Mongu (Zambia) and Kruger National Park (South Africa). There is currently interest at having an additional tower at Maun. Instruments are located on a platform at the top of the tower. Isolation and meteorological parameters are recorded, in addition to ground based leaf index measurements. Imagery will be undertaken of the terrain surrounding the towers.

AERONET (Aerosol Robotic Network)

There sites will include: automatic recording and transmitting sun/sky photometers. The data base generated includes: aerosol optical thickness, size distribution, phase function and precipitable water. Data is transferred by satellite link. The global array of AERONET sites is illustrated in Figure 5.

The AERONET network represents a collaborative initiative between NASA (instruments/sites and centralized calibration and database) and non-NASA interests (instruments/sites).

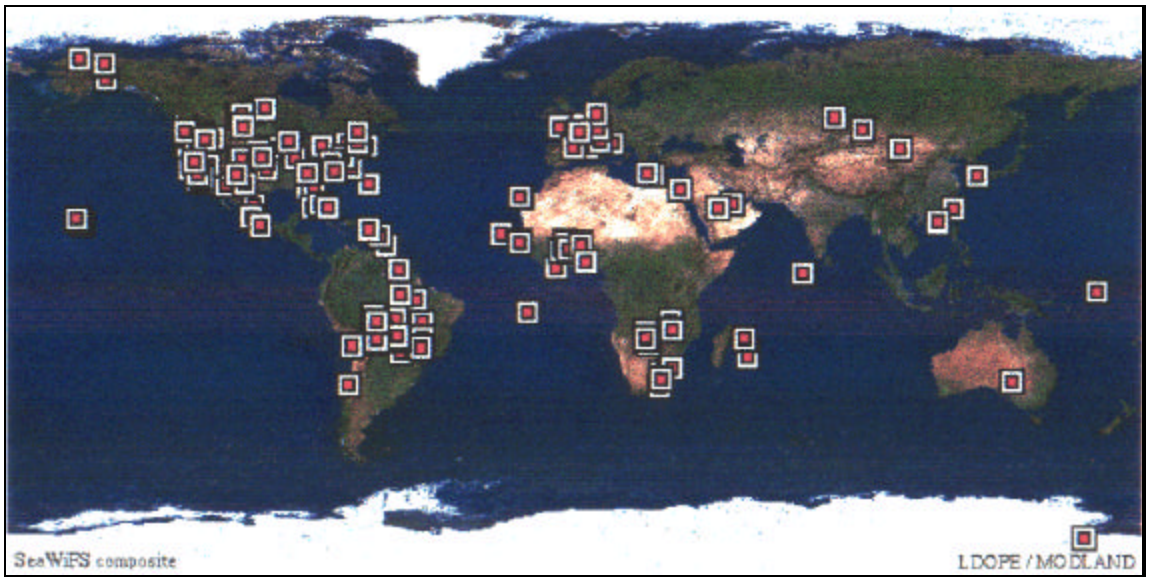

Figure 5. Location of AERONET (Aerosol Robotic Network) sites

SAFARI 2000 Schedule

Figure 6 illustrates the 3 year campaign comprising almost continuous ground measurements at the AERONET and SAVE tower sites, period airborne campaigns, and EOA Terra, Landsat 7, TRMM and AVHRR satellites.

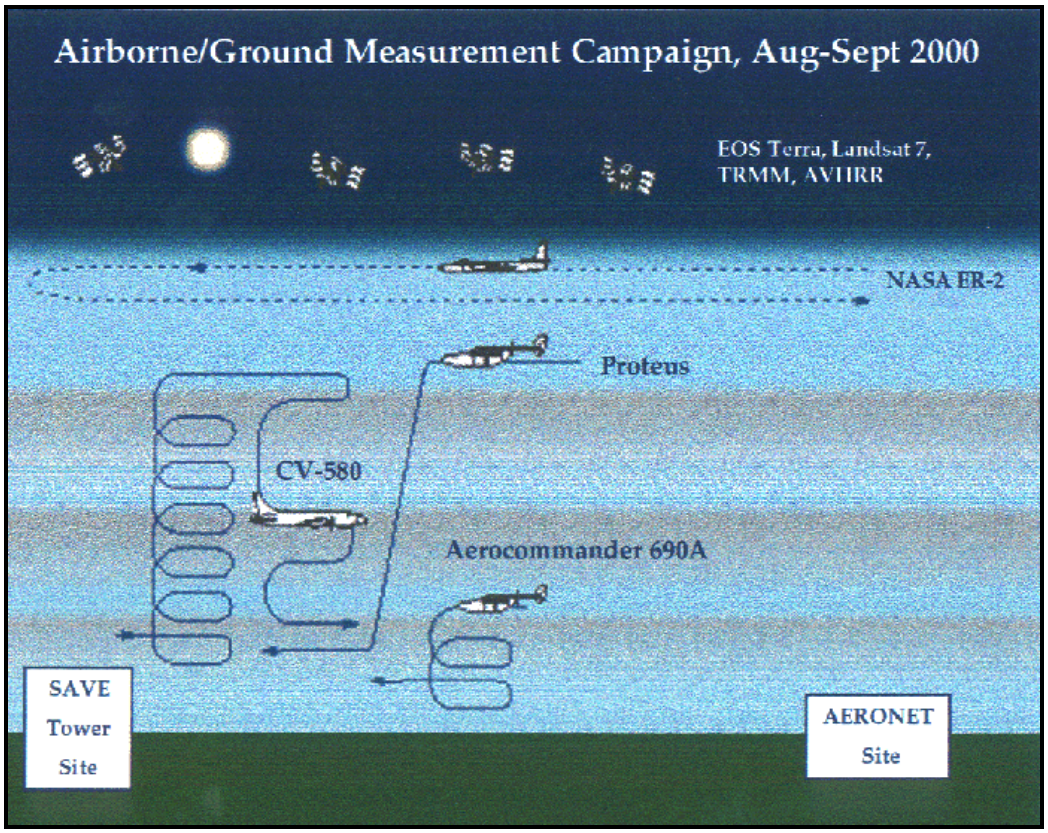

Figure 6. Airborne / Ground Measurement Campaign, August – September 2000

The vision is a 3-year ground-based and satellite data collection period, beginning in mid 1999 and ending in 2002, and period airborne campaigns including the following:

August / September 1999	:	1st Intensive Airborne / Ground Campaign (dry season)
February / March 2000	:	2nd Intensive Airborne / Ground Campaign (wet season)
April 2000	:	3rd SAFARI 2000 Workshop, location to be decided
August / September 2000	:	3rd Intensive Airborne / Ground Campaign (dry season)

NASA ER-2 Schedule for SAFARI 2000

ER-2 deployment at Pietersburg in South Africa. Proposed ER-2 deployment schedule (Year 2000):

7 August	NASA DFRC to Patrick AFB, Fla
8 August	Patrick to Recife, Brazil
11 August	Recife to Pietersburg, RSA
12 August	Open House Display
13 August – 22 September	Science flights (40 days)
25 September	Pietersburg to Recife
28 September	Recife to Patrick
29 September	Patrick to NASA Dryden

Approximately 14 science flights will be undertaken, of ~8 hours each in duration.
Key issues during the flight schedule include:

- USAF C-141 transport of equipment and personnel; and
- Meteorological forecasting and Meteosat imagery for flight planning

Convair CV-580 Schedule for SAFARI 2000

Approximately six weeks and 130 research flight hours are envisaged:

10 August 2000	Arrive at Pietersburg, RSA
12 – 23 August	Research flights based out of Pietersburg
24 August	Transit flight from Pietersburg to Vic Falls
26 August – 10 September	Research flights based out of Vic Falls
11 September	Transit flight from Vic Falls to Namibia
13 - 23 September	Research flights based out of Namibia
24 September	Depart Namibia for return to USA

Proteus Aircraft Schedule for SAFARI 2000

Proteus deployment at Pietersburg in South Africa. Proposed Proteus deployment schedule (Year 2000):

11 August	Arrive at Pietersburg, RSA
12 August	Open House Display
13 August – 22 September	Science flights (40 days)
24 September	Depart for USA

Key issues pertaining to the Proteus aircraft:

- Proteus being operated under contract to the NASA Langley Research Centre by: Scaled Composites Inc., Mojave, CA 03501-1663.
- Participation in SAFARI 2000 is contingent on obtaining additional funding.

Proteus instruments proposed for use in SAFARI 2000 include:

- NAST-I: Scanning Michelson Interferometer:
  - 3.5 – 16 microns (spectral resolution = 0.25 cm^{-1})
  - 45 km 13 element swath (2.5 km resolution from 65 Kft)

- NAST-M: 16 Channel Microwave Spectrometer
  - 50-60 GHz and 113-119 GHz (2300-6000 microns)
  - 65 km continuous swath (2.5 km resolution from 65 Kft)

- FIRSC: Far Infrared Michelson Interferom eter
  - Far Infrared (75-125 microns & 285 – 1000 microns @ 0.1 cm^{-1})
  - Nadir along track viewing (1.0 km resolution from 65 Kft)

- MicroMaps: Gas Filter Correlation Radiometer
  - 4.6 micron, CO profiling
  - Nadir along track viewing (1.0 km resolution from 65 Kft)

ER-2 PERSONNEL AND INSTRUMENTATION
Gary Shelton, Dreyden Flight Research Centre

ER-2 Personnel

Deputy Director, Airborne Science	Gary Shelton (661) 258 2919
Mission Managers	Glenn Hamilton (661) 258 3748
	Mike Kapitzke (661) 258 2575
Project Pilot	Ken Broda (661) 258 7586
Crew Chiefs	Jim Barnes (661) 258 7578
	Ron Norris (661) 258 7774

Performance of the NASA ER-2:

Altitude	:	up to 70 K feet
Range	:	3000 Nautical miles
Duration	:	8 hours
Speed	:	410 knots (467 mph) true airspeed
Payload	:	nose: 650 lbs; Q-Bay: 650 lbs (Q-Bay max 300 lbs with empty nose); Superpod: 650 lbs each

The instrument configuration is illustrated in Figure 7.

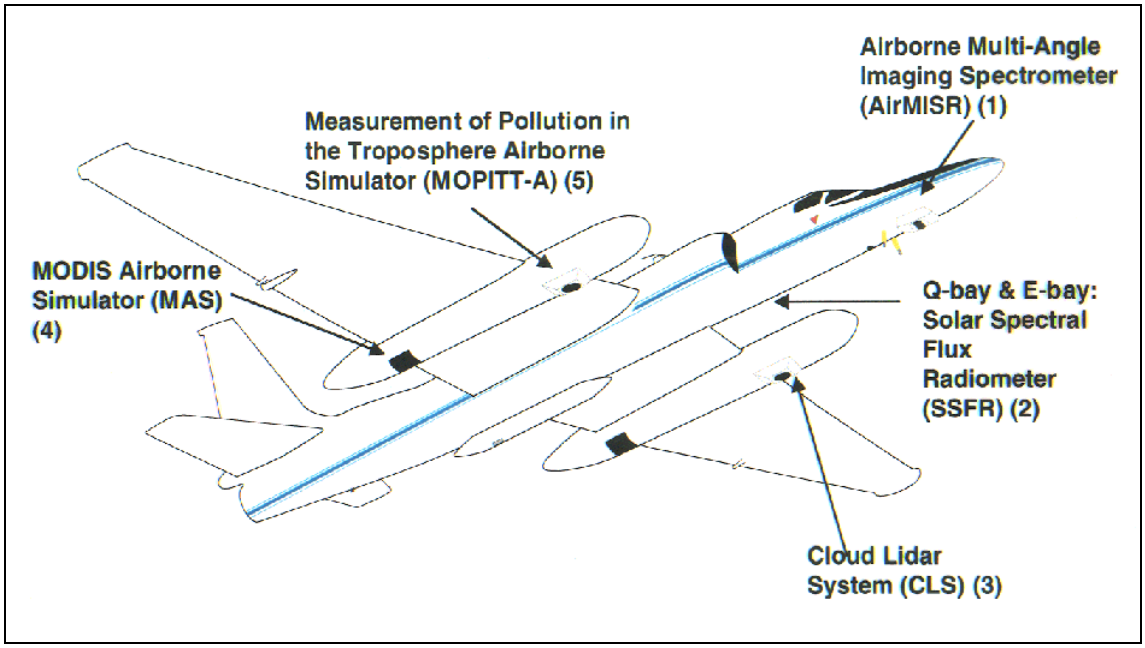

Figure 7. ER-2 instrument configuration

AirMISR (Airborne Multi-angle Imaging Spectro-Radiometer)

- Aircraft emulator of satellite sensor to study atmospheric dust and aerosols, ocean and land surface properties.
- AirMISR utilised a single camera in pivoting mount to view the same scene from different 'look' angles.
- The camera has four bands. The centre wavelength of each band, in nanometers, is 443 (blue), 555 (green), 670 (red), and 865 (near-infrared).
- Spatial resolution: ~6 meter in nadir position, coarser at other angles.
- Principal investigator: Dr Roger Marchand, Pennsylvania State University.
- Further reading: www-misr.jpl.nasa.gov/armain/html.

SSR (Solar Spectral Flux Radiometer)

- The SSFR measures spectral solar irradiance at moderate resolution to determine the radiative impact of clouds, aerosols, and gases, and also to infer the physical properties of aerosols and clouds.
- Spectral Range: 300 to 2500 nanometers
- Spectral Resolution: 5 to 15 nanometers
- Field of View: hemispheric or narrow (1 milli-radian)
- Principal Investigator: Dr Peter Pilewskie, NASA Ames Research Centre

CLS (Cloud LIDAR System)

- This LIDAR (Light Detection and Ranging) instrument provides the true height of cloud boundaries and the density structure of less dense clouds, by measuring the time interval and intensity of a reflected laser pulse.
- Range resolution: 7.5 m altitude
- Sample rate 20 m intervals at 200 m/s aircraft speed
- Principal Investigator: Dr James Spinhirne, NASA's Goddard Space Flight Centre
- Further reading: http://ltpwww.gsfc.nas a/eib/cloudlidar/html

MAS (MODIS Airborne Simulator)

- MODIS: Moderate-Resolution Imaging Spectro-radiometer, a satellite sensor on the EOS AM-1 satellite.
- MAS has fifty spectral bands, covering 0.4451-14.428 microns wavelength
- Spatial resolution: 20 m pixel size on ground, based on 20 km aircraft altitude.
- Principal Investigator: Dr Michael King, NASA Goddard Space Flight Centre
- Further reading: http://ltpwww.gsfc.nasa.gov/MODIS/MAS/Home.html

MOPITT-A (MOPITT-Airborne)

- MOPITT: Measurement of Pollution in the Troposphere, a satellite sensor on the EOS AM-1 satellite
- MOPITT-A is a nadir-staring infrared radiometer, using correlative spectroscopy with on-board gas cells to measure carbon monoxide and methane in the atmosphere.
- Field of View: ~1.8°, yielding a spot size on the ground of ~630 m.
- Principal Investigators: Dr James Drummond, University of Toronto; Dr Gary Davis, University of Saskatchewan.
- Further reading: http://cimss.ssec.wisc.edu/his/histech.html

The proposed ER-2 flight areas are illustrated in Figure 8.

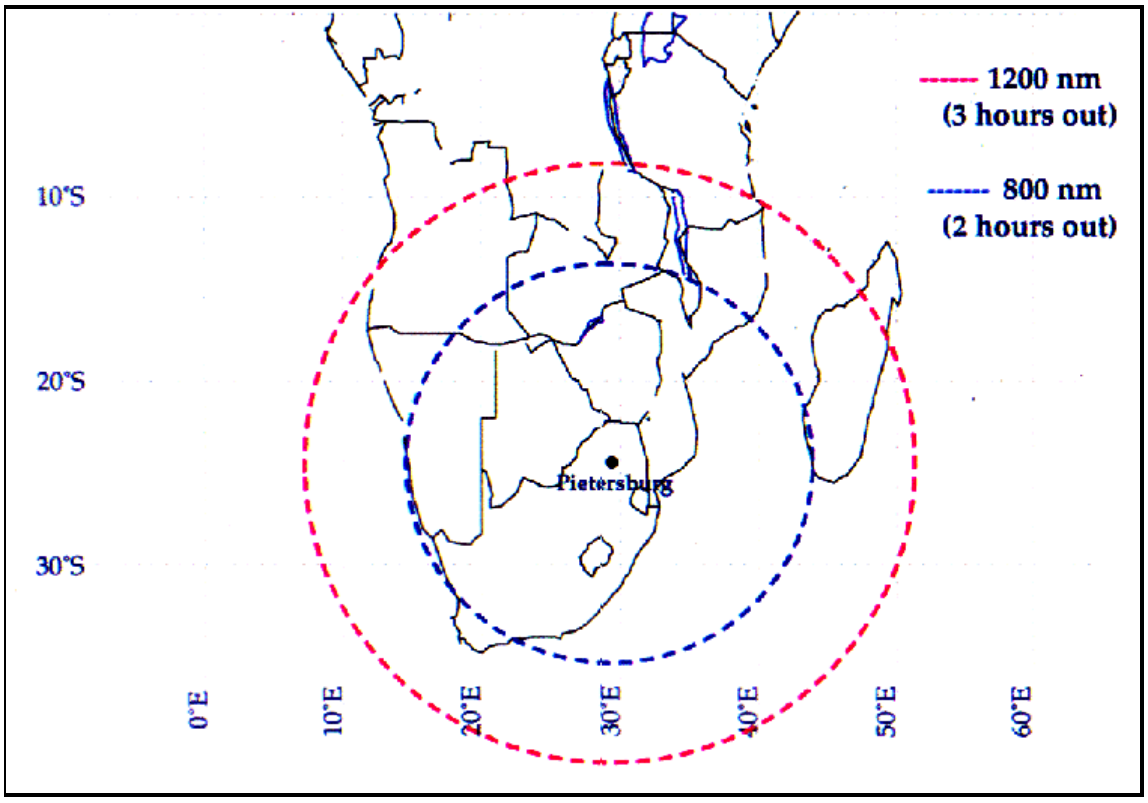

Figure 8. SAFARI 2000 ER-2 proposed flight areas

SESSION 6: GROUP WORK ON SEVEN WORKSHOP THEMES
FACILITATORS: HAROLD ANNEGARN AND SUSAN RINGROSE

GROUPS:

A. Terrestrial Ecology and Land Processes
B. Land Cover – Land Use Change
C. Aerosols and Trace Gases
D. Clouds and Radiation
E. Modeling
F. Socio-economic and Policy Issues
G. Hydrological Issues

Groups were requested to select a group leader and scribe, and to discuss the SAFARI 2000 Core Element Activities with the purpose of determining:

- Researchers intentions?
- Participants?
- What activities are to be undertaken at what times and at what sites?
- Project contributions to SAFARI 2000 goal.
- Project contributions to capacity advancement and recognition within the region.
- Core element activities are not adequately addressed, and identify further opportunities.

DAY 3 WED JULY 28TH PLENARY SESSION 7: REPORT BACK ON GROUP DISCUSSIONS
CHAIR: DR BOB SWAP, UNIVERSITY OF VIRGINIA

Members of each of the work groups is listed in Appendix A. A synopsis is given of the project proposals arising from the group sessions In Appendix B.

TERRESTRIAL ECOLOGY AND LAND PROCESSES WORK GROUP REPORT BACK

Dr Hank Shugart, University of Virginia

An overview of projects proposed by the terrestrial ecology and land processes core work team revealed two spatial scales (Figure 9):

- Research along north-south and east-west transects; and
- Intense site-specific studies.

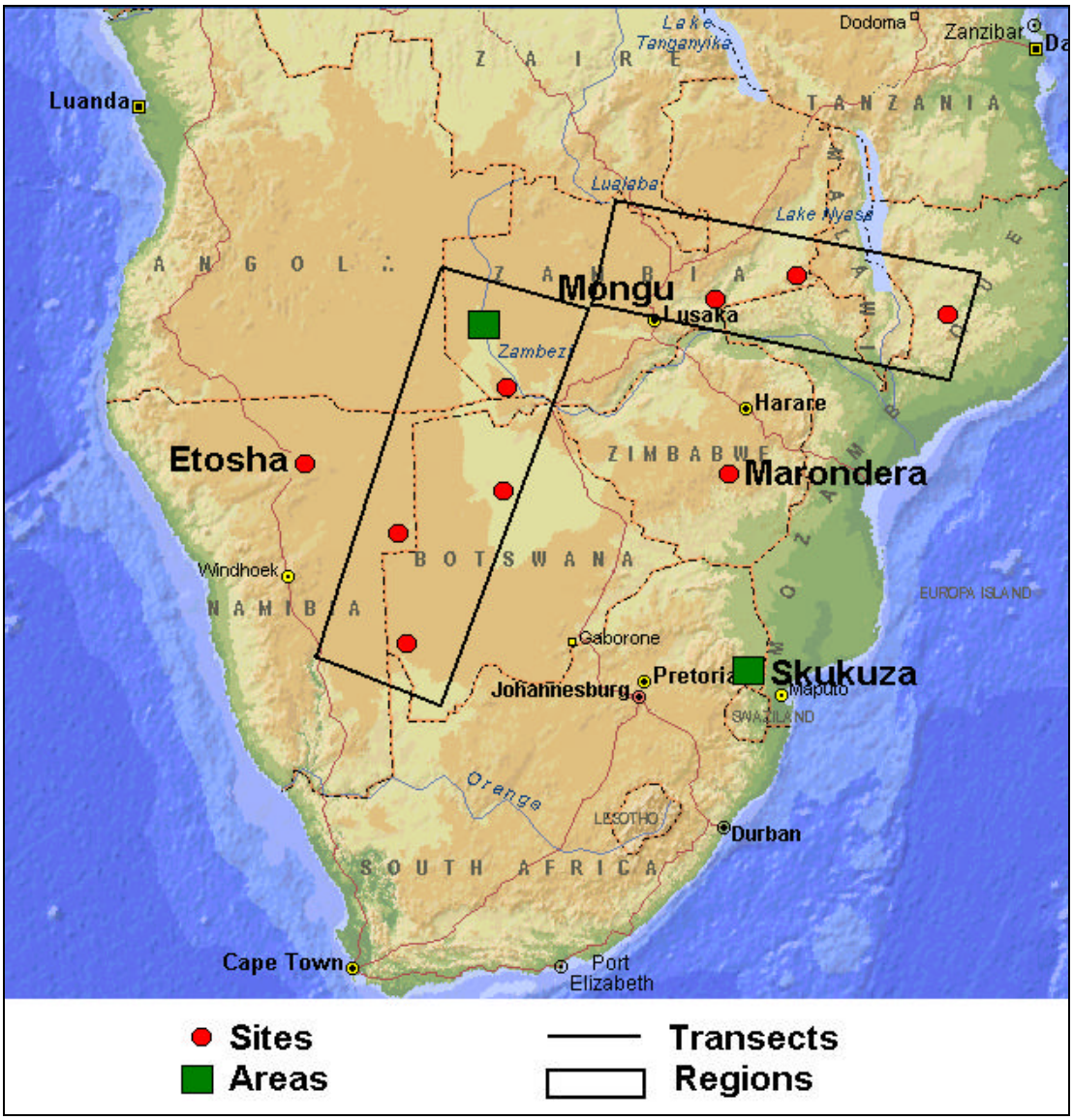

Figure 9. Location of project proposals received from the terrestrial ecology and land processes core work team.

The intensive spot sites were to be the focus of research during the August to December 1999 period, while work related to the transects would come into effect in March 2000.

Several gaps were identified by the terrestrial ecology and land use work group, most notably within the following fields:

- Elevation of mineral aerosols as a function of surface winds, soil types and land cover.
- Generation of marine S aerosols (DMS)
- Methane from wetlands, particularly seasonally within wet dambos.
- Combustion completes measuring for a range of fires, including wildfires and land clearing fires.
- Measurements on transformed land to gain understanding of land transformation processes.

Needs identified by the group included the following:

- LUIS aircraft simulation would be useful during the growing season to provide an indication of leaf variables.
- Additional wet deposition sites in the northern parts.
- Spring campaign to investigate NO_x and other NMHC emissions from surface.

Question and Answers

Q Did the group consider fog water?
A No. Fog was not mentioned. Wet deposition is not currently being characterised as well as was hoped and fog is considered to be even more exotic.

LAND COVER AND LAND USE CHANGE WORK GROUP REPORT BACK

Dr Susan Ringrose, University of Botswana

Participants in the work group comprised a mix of individuals from the region and abroad, and included representatives from government departments, national parks and research centres (Appendix A). A list of the proposed research projects submitted under each of the activities under the Land Cover and Land Use Change Core Element is given in Table 3.

In general, the researchers intended to expand upon past work in their area of expertise. Most of this work occurred at the national level. Only a few US researchers were found to be engaged in region-wide studies at present. Most other investigations involved issues which could translate across the region, but which were at present local or national in scope. Proposed research reflected past interests and was also largely national in scope. A few of the projects proposed were concerned with the study of grassland degradation, such as those proposed by R. Chandra and T. Gwebu, D. Mahube, S. Ringrose and N. Morrow. Other national land use initiatives included H. Hamisai's study of sustainability in a Zimbabwean catchment, and S. Gomez' land use study of Zimbabwean agricultural production. Of the land use/land cover change proposals, three were more regional in nature. D. Kayambuzinthu, D. Fuller and S. Ringrose proposed to study trans-national boundary effects of different land use practices and policies throughout Southern Africa. D. Kayambuzinthu also proposed studying woodland clearance with other foresters from the Miombo belt countries. He also put forward a more detailed, plot level study of Miombo ecology across the region.

Fire represented the focus of a further land activity. The proposed field validation exercise for EOS MODIS products comprised the involvement of a number of the participants and was intended to be regional in nature. It was clear that many of the site specific research efforts would benefit from participation in a fire study, including that of J. le Roux, H. Exkard and M. Mukelebai.

Table 3. Project proposals arising from the land cover and land use change work group session

Activity / Project Title	Project Team
Activity 1: Land Cover and Land Use Change Impacts:	
Land use and land cover change, land-atmosphere interactions and policy implications in Botswana's Kalahari	R. Chanda, T. Gwebu *et al.*
Vegetation change on both sides of the fence, Maun, Botswana	D. Mahube
Towards micro-catchment area for sustainable development: the case of Gutu District, Masvingo Province, Zimbabwe	H. Hamisai
Long-term biophysical aspects of range degradation in Botswana	S. Ringrose, N. Morrow, *et al.*
Transboundary assessment of land use and land cover change	D. Kayambazinthu, D. Fuller and S. Ringrose
Collection of land use data for crop estimates in Zimbabwe	S Gomez, M. Hansen *et al.*
Examining woodland clearance hot spots using TM and MODIS data	D. Kayambazinthu and M. Hansen
Structure, function and determinants of species and ecosystems of Miombo and their distribution	D. Kayambazinthu
Activity 2: Regional Fire Characterization:	
Validation of EOS MODIS fire products and relation to fire and vegetation properties	D. Fuller, J. le Roux, W. Hao, H. Eckhard and M. Mukelabai
Activity 4: Database Development:	
Safari 2000 Data Clearinghouse and Metadata System	C. Ezigbalike

Achieving the Goals of Safari 2000

All of the projects proposed address at least one of the Safari 2000 goals. While some are limited to a specific site, they do integrate the human-physical and remotely sensed-ground data aspects of research advocated by the Safari 2000 Science Plan. Only one lack this integration, that of the Miombo ecosystem, but it does fit into the regional collaboration goal of Safari 2000. The land cover/land use studies do not appear to match with existing Safari 2000 sites, except for those in Botswana. The fire proposal does, however, include experts located at or near Safari 2000 tower and test sites, including Mongu, Kruger and Etosha.

The Safari 2000 goal "exploration of earth-atmosphere-human linkages" figured prominently in the project proposals. Proposed studies of land use in Botswana and Zimbabwe examine these linkages but are limited in arial scope. The goal of "regional collaboration and integration of expertise" is addressed in the fire study, the study of trans-national boundaries, woodland clearance and Miombo ecosystem characterization. The Safari 2000 goal of "creating synergies between remotely sensed satellite and aircraft data and ground data" was addressed by all proposals. The capacity of regional scientists to better share and access data is meant to be improved through the data clearhouse proposal introduced by C. Ezigbalike.

A synopsis of the specific projects perceived to address each of the Safari 2000 goals is given as follows:

1. **Earth-atmosphere-human linkages are proposed for examination:**
   - Land use and land cover change, land-atmosphere interactions and policy implications in Botswana's Kalahari.

- Vegetation change on both sides of the fence, Maun, Botswana.
- Toward micro-catchment area for sustainable development: the case of Gutu District, Masivingo Province, Zimbabwe.
- Long-term biophysical aspects of range degradation in Botswana.
- Transboundary assessment of land use and land cover change.

2. **Region wide research collaborations are proposed which combine the expertise of regional scientists:**
   - Validation of EOS MODIS fire products and relation to fire and vegetation properties.
   - Transboundary assessment of land use and land cover change.
   - Examining woodland clearance hot spots using TM and MODIS data.
   - Structure, function and determinants of species and ecosystems of Miombo and their distribution.

3. **Synergy of remotely sensed and ground data are proposed for examination.**
   - Collection of land use data for crop estimates in Zimbabwe
   - All other projects are also relevant in this regard.

4. **Region wide data sets are to be assembled and stored in the region to aid in the integration and in the recognition of regional science advancements.**
   - Safari 2000 Data Clearinghouse and Metadata System.

Capacity enhancement is clearly enhanced by the meeting of the aforementioned Safari 2000 goals, through the fusing of human and physical elements in studies, the proposed interaction and knowledge sharing, the study of ground data in tandem with state of the art remotely sensed data, and finally, of improved data access. The capacity of regional scientists to perform basic science will therefore be enhanced.

Missed Opportunities

Missing in this exercise was a more representative group of land cover specialists. For example, only one researcher was interested in agricultural production studies. While this topic could clearly be a regional one and of interest to many southern African researchers, it was difficult to broader its scope due to the lack of participation from other parties with interests in this topic. The same could be said for some of the grassland studies. The restriction of certain studies to national levels does not therefore necessarily reflect a lack of regional interest, but more often, insufficient participation. Although this is understandable since land cover is not the primary driver of Safari 2000, it remains the reason for the topic remaining underdeveloped.

HYDROLOGY WORK GROUP REPORT BACK
Presented by Peter Hutchinson

Hydrologists are relatively new to SAFARI. The group included meteorologists, surface water hydrologists and ground water specialists. In identifying needs and concerns, three main activities were highlighted in discussions:

Activity 1: Atmospheric Processes
- Only interested in rainfall
- Physics of the problem are left to cloud and radiation groups (CES)

Concerns raised:
- Lack of regional coordination
- Insufficient spatial resolution
- Better quantification of amount and chemical composition of rain water

Needs identified:
- Increased number of rain gauges and ground radar
- Improved algorithms to derive precipitation from satellite (need for tuning algorithms for southern Africa)

Activity 2: Surface Processes
- Better estimates of soil moisture
- Higher resolution soil maps required – IGBP 5 degree resolution
- Vegetation maps required, including structure, types and heights of vegetation
- Digital terrain models need remote sensing data
- Drainage basin studies
- Water management issues
- Evaporation / evapotranspiration research

The group needs to know what work is being done throughout the region and what data bases are available. There is a clear need for the synthesis of data in order to put projects in place for the SAFARI 2000 campaign.

Activity 3: Sub-surface Processes
- Rooting depth
- Hydrochemistry
- Flow systems (hydraulics)
- Resources available (quantify aquifers)
- Water management issues
- Recharge-discharge mechanisms

Questions and Answers:

Q How could regional collaboration be facilitated.
A Fund someone to go around from region to region.

C (Bob Scholes) – Highly resolved rainfall data is also required for calculating biogenic fluxes.

C TRIM product should be brought on board and integrated with the ground data set. The TRIM data is available, and can be obtained by someone interested in using data within the region. The SAWB is currently using this data but are in the initial stages. University of Cape Town is also currently using TRIM data.

AEROSOL AND TRACE GASES WORK GROUP REPORT BACK
Presented by Harold Annegarn

Types of projects being undertaken / to be undertaken include: (i) Continuous Projects (ongoing routine measurements), (ii) Intensive Projects (i.e. Intensive field observations, including aircraft based observations; Intermittent measurements), and (3) Satellite Campaigns (remote sensing on satellites). Each of these types of projects were discussed in turn.

Continuous Projects

Continuous projects comprise ground based measurement of parameters which include:

(1) Full depth of the atmosphere
- Integrated aerosol depth measured using sun photometers
- Ozone column measured with ozone sondes

Sun photometers are automated. Continuous measurements using these instruments are being taken at the following sites:

- NASA Cimels:

- Skukuza, Mongu, Bethlehem – photometers in operation
- Etosha – photometer to be installed

- Vista / Wits / Max Planck Institute:
  - Yankee shadow band at Sutherland
  - Cimel (polarised?) – to be installed at De Aar in the central Cape Province

- Hand held instruments are being used in Zambia – comprises a network of ~30 hand held photometers.

(2) Surface measurements of:

- *Trace gases* - ozone, sulphur dioxide and oxides of nitrogen using continuous active monitors; and use of passive monitors to record sulphur dioxide, ozone, oxides of nitrogen and ammonia.
- *Aerosols* - including PM10, PM2.5 and elemental composition
- *Wet deposition* – rainfall chemistry is being recorded at 14 (+1) sites in South Africa only.

Passive gas monitoring is undertaken using passive diffusive samplers. Species monitored (on a monthly basis) include SO_2, NO_x, O_3 and NH_3. Sponsors of passive sampling include: DEBITS (4 sites), Eskom (5 sites) and the SAFARI LEAD project (8 sites).

Ground based aerosol sampling is done using streaker samplers which provide continuous (4-hour resolution) samples. Streaker sites (and groups responsible) include:
- Kruger Park, Mongu, Etosha (SAVE)
- Inhaca Island, Mozambique (University of EM, Maputu and Wits University)
- Springbok, NW Cape (Industrial)
- Etosha (?) (SAVE, EEORC)

Dust deposition is measured using 5 fallout dust samplers in the Okavango Swap (operated by Wits Geology and EEORC). Further dustfall sampling campaigns include: The University of Namibia Coastal Network of USGS sediment accumulation collectors with mineral analysis, and monitoring conducted on the Gauteng Highveld (~300 mining and background collectors comprising ASTM fallout samplers).

Intensive Monitoring Campaign
8 August to 20 September 1999

Aircraft Platform, comprising:

- Aerocommander 1 (20 flying hours)
  - Aerosols – 0.2 to 600 µm diameter using 4 separate aerosol probes to determine particle size, number, concentration and black carbon
  - Trace gases measured include: ozone, SO_2, CO (NO_x?), CO canisters
  - NASA radiometers / scanners

- Aerocommander 2 (20 flying hours)
  - Same as for Aerocommander 1

Intensive Monitoring Campaign
January – February 2000

Aircraft Platform, comprising:

- Aerocommander 1 (25 flying hours)
  - Aerosols – 0.2 to 600 µm diameter using 4 separate aerosol probes to determine particle size, number, concentration and black carbon
  - Trace gases measured include: ozone, SO_2, CO (NO_x?), CO canisters
  - NASA radiometers / scanners

- Aerocommander 2 (40 flying hours)
  - Same as for Aerocommander 1

Intensive Monitoring Campaign
12 August – 26 September 2000

Ground Based, measurements include:

- Full depth of the atmosphere:
  - Radiation at the surface – full suite – JPL site on Etosha or Makgadikgadi
  - Integrated aerosol depth – additional sun photometers
  - Ozone – additional ozone sondes

- Surface measurements:
  - Trace gases (NH_3, NMHC, CO)
  - Organics source characterisation – FTIR for oxygenated compounds, CO, CO_2, CH_4, NO_x and NH_3
  - Aerosols – organics
  - Aerosols – filter sampling for full chemical characterisation

Aircraft Platform, comprising:

- Aerocommander 1 (40 flying hours)
  - Aerosols – 0.2 to 600 µm diameter using 4 separate aerosol probes to determine particle size, number, concentration and black carbon
  - Trace gases measured include: ozone, SO_2, CO (NO_x?), CO canisters
  - NASA radiometers / scanners

- Aerocommander 2 (60 flying hours)
  - Same as for Aerocommander 1

- Convair 580 – University of Washington
  - Comprehensive suite of aerosol probes
  - Radiometers
  - Suite of trace gases (CO_2, CO, SO_2, O_3, NO_x, NO_y)

- ER-2 (114 flying hours)
  - See presentations of Tim Suttles and Gary Dreyden

- Proteus
  - See presentations of Tim Suttles and Gary Dreyden (Plenary Session 5)

Questions and Answers:

Q Are methylhalides to be measured?

A University of Port Elizabeth (RSA) specialises in such measurement (representative not present at this meeting). Measurements are primarily undertaken at Skukuza, providing useful information of the type and age of aerosols. Information is needed on bionic species, sulphate, potassium, calcium and nitrate – which can not be seen using PIXE – in order to enable the linking of the atmosphere to the biosphere.

Q Transboundary of pollutants from South Africa to its neighbours (Botswana) is of concern due to the persistence of the anticyclonic gyre which predominates over the subcontinent. Are the health impacts of this being considered.

A Aerosols are transported in concentrations far below health standards. The impact of local sources (biomass burning, etc.) on human health is a far greater concern.

MODELLING WORK GROUP REPORT BACK
Presented by: Peter

Modelling represents a new activity amongst the SAFARI activities, not having been included in previous campaigns. It was noted that many modellers were absent. Participation in the work group did, however, include modellers working in meteorology, chemical transport modelling, emissions and ecology.

Capacity building is integral to the development of the modelling activity. There is a need for:

- Modelling training of MSc and PhD students:
  - Department of Mines / Air Pollution Control, Botswana
  - Department of Physics, Eduardo Mondlane University, Mozambique
  - University of Venda – atmospheric transport modelling
  - University of Virginia – vegetation modeling / carbon cycling

- Funding opportunities need to be identified for supporting student visits and enrolment

Modellers require extensive amounts of data, in obtaining such data modellers could facilitate the involvement of data suppliers in modelling exercises if such suppliers wanted to be involved. Data needs identified by the modelling work group include:

- Emissions data (fossil fuel, biogenic, pyrogenic emissions)
- Integrated regional land cover / land use gridded data
- Station climate data

The need for a consistent grid to facilitate the integration of national data activities was highlighted. Modelling gaps were found to include:

- Modeling of aerosol optical thickness (AOT) – so as to link with satellite data. Transport modelling facilitates the generation of information on aerosol characteristics and particle size distribution data, but AOT needs to be modelled to plug into the models. Aerosol concentration / size distribution is being undertaken (Wits University / Potchefstroom University / CSIR)
- Radiative transfer modelling (?) – it is currently unclear if anyone was doing this work
- Fire spread modelling
- Synthesis modelling – integration and feedbacks. This did not feature in the work groups discussions and is anticipated to receive more attention at the tail end of the campaign.

Research currently underway in the modelling field was summarised as follows:

Meteorological Modelling

- Sulphur and Nitrogen dispersion and deposition over southern Africa is being modelled by Zunckel, D'Abreton and Everson of the CSIR
- Long-range transport of pollutants – Djolov (Venda); Pienaar (Potchefstroom University); Zilitinkevich (Sweden); and Chipindu (University of Zimbabwe)
- Transport modelling – Freiman and Piketh (Wits University); D'Abreton (CSIR)
- Prospective collaborators include – Mogami, Moffat, Lewkopane (Department of Mines, Botswana); Utiu (R. Mondlane University); and Modimoopelo (Department of Meteorology, University of Botswana)

Atmospheric Chemistry

- Nitrogen and Sulphate deposition processes – Pienaar (Potchefstroom University); Lacaux (France); Carmichael (University of Iowa).
- Nitrogen and sulphate dispersion and deposition over southern Africa - Zunckel, D'Abreton and Everson of the CSIR
- Prospective collaborators – Botswana Department of Mines

Ecological Modelling

- Primary productivity and fuel load modelling – Shugart, Dowty, Caylor, Gu (University of Virginia)
- Carbon and nitrogen biogeochemistry – Scholes (CSIR)
- Nitrogen biogeochemistry – Aranibar, Macko and Shugart (University of Virginia)
- Carbon/water fluxes – Hanan, Coughenour (CSU)

Radiation Modelling

- Canopy radiation modelling – Gu (UVA)
- Atmospheric radiative transfer modelling (?)

Emissions Modelling

- Industrial emissions – van der Merwe, Fleming, Scholes (CSIR)
- Domestic fuel – Marufu. Piketh, Annegarn, Tyson, Helas (Wits University / MPI)
- Soil NO emissions – Otter, Pisowski, M. Scholes, Meixner (CSIR / Wits University / MPI)
- Plant hydrocarbon emissions – Otter, Guenther (CSIR / NCAR)
- Mineral aerosols – Annegarn, Piketh, Gillies (Wits University)
- Pyrogenic emissions – Scholes (CSIR); Justice, Koronski (University of Virginia)

- Remote sensing of fire and fire scars is being undertaken by:

- Roy, Giglio (NASA), Justice (University of Virginia)
- Le Roux (Ministry of Environment and Tourism, Etosha Park)
- BRIMP Project (Botswana)

Land Use / Land Cover Modelling:

- Miombo – Desanker (University of Virginia)

Hydrological Modelling

- ADAS Masts / Remote Sensing model of evapotranspiration – Carlsson, Timmermans (Netherlands)

Questions and Answers

C Integrated modelling is a key component and should not be left until last. It should be done first so that it is known what information is required to run the model, what and when output is needed, and in what resolution the output should be. (B Scholes, CSIR)

C Transport models currently use many assumptions and limited data. It should be ensured that collected data is added to models to ensure value added meteorological modelling.

SOCIO -ECONOMIC AND POLICY WORK GROUP REPORT BACK
Presented by: Mieke van Tienhoven, CSIR

Areas covered by the work group included: (1) benefits expected from SAFARI 2000, (2) policy issues, (3) gaps in the Science Plan, and (4) projects foreseen.

Socio-Economic Benefits

- SAFARI 2000 will provide a clear understanding of sources, chemical transformation, transport and dispersion of aerosols and trace gases, and impacts on ecosystems

- It will provide and indication of the extent of land use change in the region
- Improved emission inventories
- SAFARI 2000 will contribute to capacity building of the regional scientists
- The project will strengthen and equip the upper air observational system in the region.
- SAFARI 2000 will facilitate the exchange of information on the environment in the region

Policy Issues for SAFARI 2000

- DATA issues – raw and processed data should be freely available to the regional participants
- Public awareness of, and participation in SAFARI 2000 should be promoted

The prevention of resentment and vandalism of sites was presented as one of the benefits arising from the promotion of public awareness and participation in the project.

Policy Issues (Benefits)

- The outputs of SAFARI 2000 may influence the formulation and review of national and regional policies on the environment such as:
  - Land use
  - Air pollution
  - Forestry
  - Rangeland management
  - Agriculture
  - Energy

- The SAFARI 2000 campaign may also result in improved regional capacity to negotiate international protocols (e.g. climate change).

Gaps in the Science Plan

Two main gaps in the Science Plan were identified, viz.:

- Lack of community awareness and participation in SAFARI 2000; and
- The underutilisation of the indigenous knowledge system

Projects Foreseen to be Initiated due to SAFARI 2000

- Review of the air quality standards and guidelines in the region.
- Review and evaluation of the current environmental policies in the region.
- AIR-2000: economic impacts of air quality in the region.

Question and Answers:

C The media (radio and television) should be used to publicise the SAFARI 2000 campaign, particularly during periods when intensive monitoring activities are being undertaken in a specific area.

PLENARY SESSION 8: REGIONAL DATABASE AND OFFICIAL PROCEDURES FOR REGIONAL COLLABORATION
CHAIR: OTLOGEHSWETOTOLO

DATA PROTOCOL AND DISTRIBUTION BACKGROUND FOR SAFARI-2000
Bob Cook, Oak Ridge National Laboratory

Topics covered in the presentation included: a proposed SAFARI-2000 Data Policy and data activities for projects, long -term archiving of data (ORNL DAAC for Biogeochemical Dynamics), and the development of a SAFARI 2000 Data Center in southern Africa.

SAFARI 2000 Data Policy - Draft

The following points were proposed for the basis for the SAFARI 2000 Data Policy:

- Goal being to synthesize results by 2002
- Provide open access to and sharing of data (e.g. ICSU/IGBP data policy - START -DIS model)
- No privileged data access period beyond essential data preparation (with the exception of protecting key data sets for graduate students)
- Recognition of data sources and co-authorship
- Mirror sites in the region and USA (e.g. dissemination via the Internet and by CD-ROMs)

Coordinated Data Activities

Coordinated data activities are recommended since they allows for synthesis, modeling, and validation of data and facilitate intercomparisons among sites and across environmental gradients. Further benefits arising from coordinated data activities include:

- Promotion of common methodologies
- Encourages Principal Investigators (PIs) to distribute and document data
- Provides back-up and security of data
- Ensures long-term accessibility of data
- Provides user support to data requestors

The flow of data from the investigator to users is illustrated in Figure 10.

Data Processing Activities

Such activities include: the determination of project needs, the promotion of data/metadata guidelines and the acquisition of data from individuals and networks. Metadata, data and QA results need be reviewed to ensure completeness and consistency, and to allow for cross-site comparisons and long-term archive perspectives. Site and regional data need to be synthesized into common databases, comprising site characteristics and summary data. All data should be identified and linked to the associated information.

Long-term Data Archive

Data collected under NASA sponsorship will be help at a NASA data archive (ORNL Data Archive for Biogeochemistry and NASA/Langley Archive for Air Chemistry). Regional researchers may want to establish a long-term data archive in southern Africa for regional data, including SAFARI-2000 data.

ORNL DAAC for Biogeochemical Dynamics

The mission of this centre is to acquire, document and distribute data for terrestrial ecosystems to the global change research community. Special emphasis is given to web-based data search and order interface, browsing/viewing of data before ordering, multiple distribution media, free and ready access, and a User Services Office.

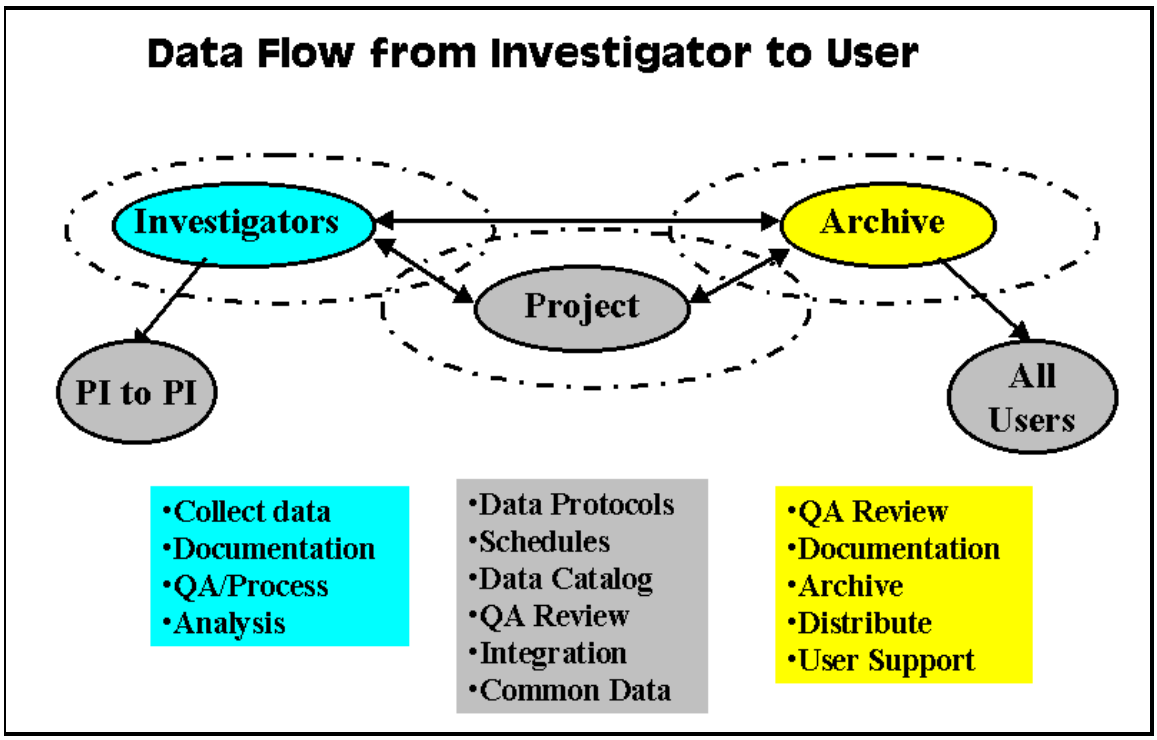

Figure 10. Proposed data flow from investigator to user

Archive Roles:

- Adds search and order descriptors
- Provides additional documentation
- Gives credit to data originators
- Enhances (collaborate with contributors)
- Marketing/distributes
- Post-project data support
  - provide long-term secure data archive
  - serve as a buffer between end-users and PIs
  - provide usage statistics to PIs and Project staff

DEVELOPMENT OF A SAFARI 2000 DATA OFFICE IN SOUTHERN AFRICA
Simon Wills, FFM, Botswana

It is proposed that SAFARI 2000 data be stored in southern Africa, including Remote Sensing data (Aircraft, TERRA, LANDSAT 7 and other), aircraft measurements and land data. The data base must be coupled with an easy-to-use search engine to find relevant data, a local data processing facility, and must facilitate remote access to data. The storage of data in southern Africa would enable access to raw data in instances when remote access via the internet is not a possibility (e.g. when the volume of data is too great). It is therefore needed to be able to work with the data in the region.

The following stages in the development of the data office are envisaged:

- Develop site at University of Botswana
  - Load with data and search engine
  - Develop local processing facilities

- Develop blueprints and guidelines for remote sites
  - Processing of data
  - Data formats
  - Search access
  - Obtaining data

- Enable remote access to data

Techniques required or available to assist the establishment of the data base include: a large and fast server (Unix based); Oak Ridge developed search engine called Mercury; disk, tape and optical data storage; and spatially enable commercial RDBMS which store raster, vector and textual data.

Constraints and challenges include the large amounts of data to be dealt with, and the large amounts of storage space required, both on-line and backup. Metadata must be kept up-to-date, otherwise finding and retrieving data will NOT work. A database administrator will need to be appointed and support provided for all commercial packages.

Points for Discussion:

- Determine Project needs for a data center
- Estimate number and volume of expected data
- Methods for early distribution and sharing
- Acquisition of data from PIs, sites and networks in timely manner
- Acquiring documentation
  - definition of format, missing values, QA process
  - ecological data - year, methods, references
- Compiling site ecological data
  - different PIs, multiple sources, published reports
- Electing person to data steering committee

COLLABORATION PROCEDURES FOR MALAWI

(1) Regional Research Work

Regional research work (e.g. through Miombo Network, SADC countries, etc.) must come through the SADC Coordinating Unit. This is with regard to forestry activities as Malawi is responsible for coordinating forestry and inland fisheries in the SADC region.

If the research work is to be done in the country, then the Coordinating Unit contacts the National Research Council of Malawi, who will authorise after looking into transfer and importation research materials, data, (etc.). A research permit is issued for this purpose. It is only subsequent to this that the local institutions, organisations or individual scientists can be engaged to work, collaboratively with international researchers.

Data generated from this work has to be deposited (i.e. a copy of the data) with the SADC Forestry Sector Technical and Coordinating Unit (FSTCU).

(2) Non-Regional Research Work

Non-regional research work does not need to go through the SADC FSTCU. An application need, however, be made to the National Research Council of Malawi, normally through the collaborating partner in Malawi. From then onwards, the procedure is the same as that described above.

(3) Materials for research work through the above two procedures are processed duty free.

(4) Data kept in the SADC FSTCU is freely accessible to all SADC countries at no cost just as the Unit acquires all data from all SADC countries.

(5) Due to the regional importance of SAFARI 2000, the SADC FSTCU has to be involved in the initial stages of the implementation.

Contact Point:

Mr Paulos Mwale
SADC FSTCU
Forestry Department
P O Box 30048
Lilongwe 3, Malawi

OFFICIAL PROCEDURES FOR REGIONAL COLLABORATION - ZAMBIA

The focal point on SAFARI 2000 will be the Meteorological Department in the Ministry of Communications and Transport. A Memorandum of Understanding (MOU) needs to be formulated and signed by the two parties, similar to ZIBBEX.

Contact persons:

(1) G B Chipeta, Director of Meteorology
(2) M M Mukelabai, Senior Meteorological Officer

Scientific equipment is exempt from customs duty. Prior authority need be sought from the Department of Civil Aviation for flights over Zambian airspace.

COLLABORATION PROCEDURES FOR TANZANIA METEOROLOGICAL SERVICES WITH SAFARI 2000
A D Kanemba, Senior Meteorologist, Meteorological Services, Tanzania

National Collaborations of the Meteorological Services, include:

- In day to day operational activities, the Directorate of Meteorology collaborates with Tanzania Aviation Authority (TAA) for safety efficiency, regularity and economy of aircraft in operations. By providing relevant meteorological information, such as temperature, wind speed and direction, pressure, storm warnings (etc.).

- The Directorate of Meteorology also has links with the Ministry of Agriculture, and issues information on drought, floods, seasonal forecasting, and onset and ceasing of rainfall. This information is required for timely agricultural planning, i.e. field preparation, sowing dates, harvesting (etc.).

- Air temperature and other weather information on various national parks is issued to the Ministry of Environment and Tourism.

- Meteorological services provides rainfall predictions when required to determine water levels in rivers so as to ensure the effective operation of hydro-electrical power facilities.

Collaboration with SAFARI 2000

SAFARI 2000 will undertake activities within the fields of terrestrial ecology and land processes, land cover and land use change, aerosols, trace gases, cloud and radiation, (etc.). Important information will most likely be generated on the carbon budget, canopy characteristics, land cover and use, incoming and outgoing radiation, and other aspects relevant to climate change. These data will be very useful for weather and climate studies within Tanzania. The development of precipitation is triggered by the presence of cloud condensation nuclei, hence information on aerosols is important. The boundary conditions which influence weather systems depends

on the canopy characteristics and land cover. The data collected by the SAFARI 2000 campaign will therefore be useful in understanding weather and climate change and prediction. (The need for permanent observations within the region was mentioned.) This message will be communicated to the Director of Tanzanian Meteorological Services, who will facilitate SAFARI 2000 activities in the country.

SESSION 9: GROUP WORK ON SEVEN WORKSHOP THEMES, CONTINUED
FACILITATORS: HANK SHUGART AND SHARON GOMEZ

Group work continued within the various groups (Terrestrial Ecology and Land Processes; Land Cover – Land Use Change; Aerosols and Trace Gases; Clouds and Radiation; Modeling; Socio-economic and Policy Issues; Hydrological Issues). A working group on Data Policy and Management was also established.

Groups were requested to consider the points for discussion raised in Simon Wills' presentation "Development of a Safari 2000 data office in southern Africa", viz.:

- Determine Project needs for a data center
- Estimate the number and volume of expected data
- Consider methods for early distribution and sharing
- Acquisition of data from PIs, sites and networks in timely manner
- Acquiring documentation:
  - definition of format, missing values, QA process
  - ecological data - year, methods, references
- Compiling site ecological data:
  - different PIs, multiple sources, published reports

PLENARY SESSION 10: WORKING GROUP FEEDBACKS AND DISCUSSIONS
CHAIR: CHOMA MATALE, DIVISION OF MINES, BOTSWANA

This session comprised the presentation of reports from each of the core element teams, viz. terrestrial ecology, modeling, aerosol and trace gases, hydrology, land use/land cover, and socio-economic and policy issues. A report back was also presented from the Data Policy Discussion Group, comprising representatives from each of the core element teams. Individuals participating within each team are indicated in Appendix C. Prior to the team report backs a statement was read by Penny Lesolle, head of the Climate Section of the Dept. of Meteorological Services for Botswana. The statement and team reports are outlined in the subsequent subsections.

METEOROLOGIST STATEMENT AT THE SAFARI 2000 WORKSHOP
Read by Penny Lesolle, Head of the Climate Section, Climatological Division, Dept. of Meteorological Services, Botswana

Mr Chairman, as we finalise the draft implementation plan for the Southern African Regional Science Initiative (SAFARI) 2000 Experiment, I request through you that the SAFARI 2000 steering committee record for their further consideration, the following comments;

Botswana sees the opportunities under SAFARI 2000 as threefold; (1) there is an opportunity to enhance our capacity to address issues relating to natural resources; (2) there are opportunities to strengthen institutional capacities and (3) there is technological advantages for us to take part in the Safari 2000 experiment.

Mr Chairman, as your are aware, the meteorological services, in collaboration with other national departments, have an enormous task of timely providing, on an operational basis, information, service and advise to the public and private sectors, on matters and issues related to weather and climate, rangeland condition, drought and adverse weather conditions, land use; to name a few. It is in this regard that I request that special consideration be made to take into account the need to operationalise the national meteorological service and to enable the meteorologist and national meteorological service to derive full benefit from the Safari 2000 experiments.

Mr Chairman, we have provided some input into the discussions on projects and we are fully supportive of the initiative and we view the Safari 2000 as a *grand* opportunity for use to collaborate and benefit from exposure into the new – methods for data analyses, information and technologies. Botswana has through a number of presentations by various departments and individuals demonstrated her support to the objectives of the Experiment. The tasks and projects we have committed ourselves are important in that, the results from these studies will enable use to spot-answer some of the major questions. There is however need for further support to enable use to be proactive and timely address the other operational programmes assigned to use and demanded of us, by the general public. This support to the meteorological service may be in the form of training attachments to centres of excellence; technician training son and for calibration and maintenance and analyses of remotely sensed data and information.

Finally Mr Chairman, we are ready, willing and prepared, to enter into further discussions, with potential and collaborating partners such as US AID, and others, to scope the needs of the national meteorological service. These needs are critical to our success in addressing the basic and national priorities such as food security, sustainable natural resources management, water resource management and other.

REPORT OF THE TERRESTRIAL ECOLOGY – LAND PROCESSES TEAM
Presented by Bob Scholes, CSIR

Activities are planned to take place at four spatial scales, viz.:

- Site-specific (e.g. Etosha)
- Areas (Skukuza and Mongu)
- Transects – Kalahari Transect and Miombo Network
- Regions

The calendar for projects undertaken within the field of terrestrial ecology as part of the SAFARI 2000 campaign are indicated in Table 4 below.

Table 4. Calendar for SAFARI 2000 Ecosystem Processes

Time Period	Co-ordinator	Site	Activities
Aug 01-20 99	Privette	Skukuza Mongu	Site characterization (structure) Radiation measurement Site characterization (structure)
Nov 99	Scholes	Skukuza	Land cover Structure Leaf Area Biogenic emissions
Feb Mar 00	Scholes Ringrose Shugart	**Kalahari Transect** (potential sites) Kalahari-Gemsbok Park ???? Sandveld Maun Senanga Mongu	Structure characterization Soil characterization Elemental characterization (C,N) Flux measurements Hyperspectral sensor Digital aerial photography Trace gas measurement
Aug Sep 00	Shugart/Le Roux Ward	Etosha Zambia	Fire completeness Active fires Burn Scar detection Emission coefficients
Oct 00	Otter	Zimbabwe	NMHC, NO_X emissions
Nov Dec 00	Scholes Desanker	**Miombo Transect** (sites undefined)	Methane, NMHC, NO_X emissions Structure characterization Soil characterization Elemental characterization (C,N) Flux measurements Hyperspectral sensor Digital aerial photography Trace gas measurement

The work conducted during the February to March 2000 period within the Kalahari Transect will represent the first large coordinated fieldwork campaign. Work scheduled to take place at Etosha during August to September 2000 will coincide with the dry season flying campaign, and will focus on fire completeness, active fires, burn scar detection and emission coefficients.

Non-methane hydrocarbon (NMHC) and oxides of Nitrogen (NOx) fluxes will be investigated during the spring (October 2000), due to the increase in such emissions during these wetter periods. Emission of these compounds will be considered at the moister Miombo site, with methane emissions also being investigated.

In terms of support from the Aircraft Campaign, the following would be required:

- Hyperspectral imagery for vegetation characterisation
- NOx, HC and ozone measurements, which are considered crucial

REPORT OF THE HYDROLOGY TEAM
Presented by Peter Hutchinson, Department of Meteorological Services, Namibia

Despite being relatively newcomers to the Safari initiative and experiencing difficulties in finding common ground, the hydrology team were able to list 3 projects for inclusion in Safari 2000. These following projects where seen as being crucial to the goals of Safari 2000, and are given as follows:

- Integration of satellite, radar and raingauge measurements to provide improved estimations of spatial rainfall.

- Estimation of evapotranspiration, using remote sensing imagery.

- Monitoring of groundwater levels and chemistry in regional (trans-border) aquifers (groundwater levels).

The objectives, participants and data requirements of each of these projects are described in Table 5.

Table 5. Objectives, spatial extent and participants of proposed hydrological projects

Project Title:	**Objectives:**	**Spatial Extent:**	**Participants:**
Integration of satellite, radar and raingauge measurements to provide improved estimations of spatial rainfall.	To upgrade and integrate present systems of rainfall measurement in order to provide improved estimations of spatial rainfall.	Region wide, SADC	All meteorological services within SADC, with SAWB as lead agency.(1)
Estimation of evapotranspiration, using remote sensing imagery.	To develop a system to estimate routinely surface evapotranspiration spatially in the SADC region	Area: Region wide, SADC	All meteorological services and Geological Surveys within SADC, ITC (The Netherlands) and the Regional Remote Sensing Centre (Harare) to co-ordinate.(2)
Monitoring of groundwater levels and chemistry in regional (trans-border) aquifers (groundwater levels).	To improve the understanding of groundwater levels, flow and chemistry in trans-border aquifers.	Botswana, Namibia, South-Africa, between 22° and 27° South and 18° and 23° East. (Comprises lower section of Kalahari Transect).	Hydro-geological services of the 3 countries, Mr. P. Phofuetsile of DGS (Hydrogeology Div.) .(3)

Points of Note:

(1) The South African Weather Bureau (SAWB) has already presented a project to the meeting involving the integration of radar, satellite and raingauge measurements. The first project proposal comprises an expansion to SAWB project to include radar installations from other countries and take advantage of new satellite systems.

(2) A "pilot" study is already carried out in Botswana with encouraging results. Plans are on the way to expand this to a national level.

(3) Overuse of groundwater is resulting in a lowering of groundwater table. A regional effort is required to investigate the changes (including chemistry).

In reference to these three projects it was emphasised that efforts should be made to ensure that the knowledge gained fulfilled specific purposes. It was proposed that, based on such work, systems be put in place to provide *daily* rainfall and evaporation information over the region.

A further possible project outlined by the hydrology group focused on the **Measurement of Rainfall Chemistry**, with the objective of observing chemical constituents of rainfall over the region, in order to provide inputs to other Safari-2000 projects. It was indicated that this may already be covered by other groups which did not participate within the hydrology discussion group.

Data requirements for each of the three projects proposed by the hydrology team are outline below.

Rainfall project:

- Daily rainfall from all synoptic stations (200), over 3 years.
- Quarter of half hourly satellite observations over SADC region with 1 km resolution, over 3 years.
- Radar observations from 10 stations in South-Africa, 1 station in Botswana, 4 in Zimbabwe.

Evapotranspiration project:

- Half or hourly satellite observations over entire region at 1km resolution.
- Approximately 10 ground stations per country, measuring (at a suitable frequency)
- Incoming solar radiation
- Atmospheric pressure
- Penman calculations (temperature, humidity, wind speed)
- Rainfall
- Pan-evaporation
- Sub-surface water flow (soil moisture)
- Atmospheric stability (profiles of wind speed, temperature, humidity)
- Sap-flow measurements

Groundwater level project:

- Daily water levels at 10 sites, over 3 years.
- Monthly conductivity at 10 sites, over 3 years.

FEEDBACK FROM LAND USE AND LAND COVER TEAM
Presented by: Nathan Morrow, University of Maryland, USA

The point was made that the group found difficulties finding common ground given the different areas which formed the focus of various members of the team. Subject to the previous presentation of the team, certain project proposals had fallen away and others refined. An overview of the remaining projects – comprising an outline of points of contact, locations, data requirements and products – is given in Table 6.

From the list of projects it is evident that regional scale initiatives are under consideration. The key concern, however, was to get a fuller compliment of people involved through contacting people in other countries able to cover areas not currently included. It was hoped that the proposed projects could be expanded through such inter-regional contacts.

Table 6. Land Use / Land Cover Project Proposals

Project Title:	Points of Contact:	Locations:	Data Availability and Requirements:	Products:
Validation of MODIS fire products	D. Fuller (George Washington Univ., USA); W Hao (USDA Forest Service); J le Roux (Etosha National Park, Namibia); H. Eckhardt (KNP, RSA); M Mukelabai (Zambia Met. Dept.); T Sejoe (Wildlife Dept. Botswana)	Kaoma – Zambia Etosha NP – Namibia Chobe and Central Kalahari G.R. – Botswana Kruger NP – South Africa	In-country Data: Topographic maps at various scales; climatic data; vegetation maps; soil maps EOS Data: MODIS 250 m and 1 km for duration of project	• Digital data on spatial extent of fires, with metadata attached; produced at low volume and low frequency (< 1 mb per file, <200 files total) • Distributed via e-mail
Transboundary assessment of land use/land cover change	D Kayambazinthu (Forestry Institute Malawi); D Fuller (George Washington Univ. USA); S Ringrose (Univ. Botswana); M Nkambwe (Univ. Botswana)	Border areas Tanzania / Malawi Botswana/Angola/Namibia Zambia/Zimbabwe/Botswana	In-country Data: Aerial photos; vegetation and land use maps EOS & Related Satellite Data: Several LANDSAT 7 scenes along the borders during the dry and wet season	• Hard copy and digital maps of land use / land cover change • Co-ordinated mapping across borders • 5 MSc. Theses from existing network
Land use and land cover change land-atmosphere interactions and policy implications in Botswana's Kalahari	Dr R Chanda, Dr T Gwebu, Dr N Moleele, Prof Musisi-Nkambwe, Prof Mazonde	Matsheng: Semi-arid, rangeland wildlife, livestock, settlements < 30 000 km^2 Okavango: semi-arid, rangeland, wildlife, settlements >30 000 km^2	In-country Data: APS, topographical maps (1:50 000) EOS Data: LANSAT TM, Matsheng 1 scene, Okavango 3 scenes	• Land use data • Vegetation data • Emissions data • Socio-economic data • Policies
Collection and land use data for crop estimates in Zimbabwe	Dr S Gomez (ERSI, Zimbabwe); M Hansen (UMD, USA)	T wo districts comprising 12 000 km^2	In-country Data: SPOT-PAN in digital, national cover, 1992; topographical maps; air photos; crop statistics EOS & Related Satellite Data: LANDSAT TM (7) 170-72, 169-72 – Feb '00; MODIS 250 m + 1km – Feb '00	• Field data for 1 ha plots (hard copes and digital copies, i.e. ArcView and Excel) • Statistical data for land use etc. • Classified image data
Examining woodland clearance hot spots using TM and MODIS data	D Kayambazinthu (Dept. Forestry, Malawi)	Chimaziro Forest Reserve area, Malawi; Blantyre, Malawi	In-country Data: Population, soils, transport EOS & Related Satellite Data: LANDSAT TM (7) – Dec 2000 to 2001; MODIS 250 m (R + NIR) for part of southern Africa (10 deg. E to 0 deg. N; 45 deg E to 35 deg. S)	• Area data on woodlands (site information on cleared land, etc.) • Classified TM data • Regional change product • Resulting accuracy analysis
Aspects of rangeland degradation	S Ringrose (Univ. Botswana); N Morrow (Univ. Maryland)	Botswana (to be extended regionally)	In-country Data: Rangeland classifications (MSS 1984; TM 1994); Biophysical data sets (soils, meteorology, land cover & ecology survey); Socio-economic concerns; Land use and tenure EOS & Related Satellite Data: AUHRR record (production, environmental variables) LANDSAT 7 ETM	• Annual Production of Rangelands • Biomass of selected transects • Analysis of distribution of rangeland degradation • Investigation of the spatial aspects of range degradation

REPORT OF THE AEROSOL AND TRACE GASES TEAM
Presented by Stuart Piketh, Wits University, RSA

It was stated that all the project proposals that had come out of the team's discussions would take place. Having reported during the previous team feedback session on the nature of projects under the aerosol and trace gas core element, attention was focused on data issues.

All participants working within the aerosol and trace gas discipline were asked to provide the following information:

- Parameters to be measured
- Data format
- Number and size of data sets
- Speed of communication possible, in terms of data being downloaded to the Safari 2000 Data Information System (DIS)

Given that many of the persons involved were not represented at the meeting, indepth information on these points were not available and would need to be forwarded to the Safari 2000 group subsequent to the meeting. Each activity group, as was listed and identified in the previous report back, gave details of the data provided and of possible difficulties in obtaining various data sets.

Methods of early distribution and data sharing were covered in the team's discussions. It was decided that each Principle Investigator would be required to ensure that the data was provided within the specified time frame, and depending of the data size forwarded to the data centre and on the appropriate medium. Each PI was made responsible for providing information which would assist the data centre to provide user friendly and easy access to the data. The PI was tasked with the need to provide a comprehensive description of the collection sites (ecological data and meteorological setting).

REPORT OF THE MODELLING TEAM
Presented by: Peter

Data issues related to modelling initiatives were identified as including: temporal and spatial scales and resolution issues, detailed inputs and outputs, and the size of the data outputs. It was noted that the list of projects proposed may be incomplete since many of the individuals who may have contributed were involved in other team meetings. Such people were invited to get involved if they had not been previously during group discussions.

Data Requirements

It was recommended that all *existing* data be collated for use in modelling projects, pending further data inputs from the SAFARI 2000 fieldwork campaigns. Data requirements were given as including the following main components:

1. Base GIS Layers
   - boundaries
   - towns
   - census
   - airports
   - refineries, industries, mines, oil gas fields, petrol stations and power stations

2. Meteorological data
   - ground station data where available
   - upper air data
   - available gridded rainfall

3. Emissions data
   - biogenic
   - pyrogenic
   - atmospheric

4. Land cover and land use grids

5. Aerial photos, DEMS, topographical maps

Model Output

Issues regarding the nature and accessibility of model outputs were considered by the team and the following recommendations made:

- Open and rapid access to data is highly encouraged.
- Opportunities for early viewing of data model outputs and draft papers should be given to participants only (restricted access), with provisions made to protect student work.
- Data distribution could be achieved through CD-ROM dissemination, with regular releases available on request.
- Metadata – only option for data model submission to data cover. Contact holders of data models would be encouraged to pursue collaborative work.
- Documentation should accompany model outputs; such documentation include model uncertainty, information on data and highlighting of weaknesses.

Model Archive

It was recommended by the modelling group that the data centre also comprise an archive for models. Model types may include the following:

- Model used for interpolation of data layers. This is to be supplemented with gridded data to provide a more complete picture.
- Primary algorithms and model components.

Such models may be submitted in various languages, but all models must be well documented.

Recommended Modeling Synthesis Activities

Activities identified by the modeling team as being beneficial to the Safari 2000 campaign include:

- Effects of land use (domestic, timber harvesting) on fuel load and pyrogenic emissions.
- Feedbacks between N deposition, plant productivity (fuel load) and pyrogenic emissions.
- Validation of long-range transport modeling using mobile sampling in Botswana
- Mesoscale plume modeling around Botswana to validate industrial emission estimates in association with ground-based sampling.

REPORT OF THE SOCIO-ECONOMIC AND POLITICAL TEAM
Presented by: Mieke van Tienhoven, CSIR

Four areas were addressed by the socio-economic and political team, viz. public awareness, public participation, capacity building and raw data and data outputs. Recommendations were formulated within each of these areas are presented in the subsequent subsections.

Public Awareness

- At scientific study sites public awareness could be facilitated through:
- Informing local leaders, chiefs, local government institutions about the Safari 2000 campaign
- Awareness raising could be undertaken at local schools or through open days (etc.)

- It was noted that it should be ensured that local awareness be considered prior to national/regional awareness campaigns

- At national scale, the following could be undertaken:
- identify relevant government departments;
- use printed and electronic media to disseminate information on Safari 2000 (radio seen to be particularly effective in this regard); and
- be sensitive to country specific procedures

- At the regional scale:
- identify relevant government departments and international organs e.g. SADC-ELMS, APINA, IUCN
- use printed and electronic media

Public Participation

- Researcher forming part of the Safari 2000 were encouraged to use local people for such tasks as:
  - ground-truthing exercises
  - security
  - instrument maintenance
  - measurements

Capacity Building

- Critical observations in this regard could include:

  - Student training
  - Established scientists on new instruments
  - Information management
  - Specific training for aviation forecasters
  - Seminars at universities, local colleges
  - Identify youngsters with aptitude for further scientific training (e.g. sun photometer study in Zambia)
  - Infrastructure e.g. towers

Raw Data and Outputs

Data management and use is seen as a political issue for the region, and it was cautioned that the following issues receive the necessary attention:

- A written agreement on data access issues is required.
- Data may be free, but not freely accessible due to hardware/software/capability constraints.
- Differential user needs need be noted. For example regional scale information is required for input to regional policy needs.
- There is a need to harmonize different data protocols (e.g. meteorological, land cover, atmospheric pollution data).
- National copyright laws should be considered especially with regard to data housing.
- Data which will NOT be freely accessible should be explicitly itemized.

- SAFARI 2000 outputs and how these can be translated into a readily useable and understandable format for policy should be considered.

Projects to be Initiated due to SAFARI 2000

- Review of the air quality standards and guidelines in the region.
- Review and evaluation of the current environmental policies in the region.
- Investigation of economic impacts of air quality in the region (AIR-2000).

The Team further suggested that a final conference be undertaken, bringing together SAFARI scientists and government officials to discuss science findings and possible consequences for policy-makers.

Safari 2000 - SADC Conference

It was recommended by the Team that a conference be undertaken comprising members from Safari 2000 and SADC.

- Aims of the conference include:
  - demonstrate scientific outputs of SAFARI
  - demonstrate need for preparation of an international protocol/convention

- Needs identified in this regard included:
  - support of participating countries
  - attract financial support
  - secure long-term outputs of Safari 2000 activities (e.g. regional data center and continued capacity building)

REPORT OF THE DATA POLICY DISCUSSION GROUP - SAFARI 2000 DATA AND PUBLICATIONS POLICIES
Presented by: Harold Annegarn, Wits University

Introduction

The SAFARI 2000 data policies proposed are based on open data sharing, co-operation and synergism.

A data policy is implemented to ensure that participants have access to data in a timely manner and that appropriate protection of intellectual property rights is ensured and that co-authorship, acknowledgement or credit are given to data originators and principal investigators.

Two sources formed the basis for the recommendation of the SAFARI 2000 data policy, viz. (i) the International Scientific Union's policy on open data and data sharing, and (ii) NASA's policy which stipulates that principle investigators submit preliminary results within 6 months from the date of measurement. A data submission period of 6 to 12 months has therefore recommended.

It is intended that the data policy will persist beyond the life of the Safari 2000 Steering Committee.

Archive and Public Domain

It is intended that SAFARI 2000 establish a Data Information System (DIS) which will provide tools for documenting, storing searching and distributing data and images. Data generated by SAFARI 2000 will be permanently archived in southern Africa, and after a time lapse (18 months?) become public domain. This regional data centre will be located at the University of Botswana in Gaborone. It has been recommended that this data centre not just represent a depository and retrieval centre, but rather be structured to be a focal point for training in remote sensing. Investigation on the application of remote sensing for agricultural and hydrological applications could, for example, be facilitated.

Sharing of Data

All SAFARI 2000 data should be made available to all S2K participants either through direct exchanges or submission through the DIS. The data (once validated, quality assured) will be deposited promptly in the DIS. Access to the DIS will be initially (18 months) be limited to SAFARI 2000 scientists, i.e. scientists whom have agreed to the Safari 2000 data policies

Student Protection

Special consideration will be given to limit use of data which are the subject of student theses or dissertations. Supervisors will be asked to register data sets reserved for students with the Safari 2000 Steering Committee, who will maintain a register of such data. Data reserved for student use may not be published or cited by outside parties prior to completion of the student's thesis. It should, however, be noted that this special consideration for students will take into account the academic statute of limitation on students, viz. 2 years for a masters student and 3 years for a doctoral candidate,

Time Frames for Data Submission

Time frames for data submission will vary by project. A time limit of within one year has been suggested as a reasonable guideline of expectations. No stringent enforcement of this is, however, contemplated, with co-operative submission considered to be the key.

Data Deposits by Country

This data policy does not replace or supersede the requirements of MOUs with individual countries to deposit data collected from individual countries at specified repositories.

Authorship

The analysis and interpretation of the data by all participants engaged in generating the data is supported. Co-authorships must include all who have contributed substantially to the work. In case of doubt, the offer of co-authorship should be made and individuals given the right of refusal. Given that collaboration signifies the spirit of Safari 2000, joint publications between in-region and out-of-region scientists will especially be encouraged,

Use of Data in Meta Studies

Where data are required for modeling or integrating studies, the scientist collecting such data will be credited appropriately either by co-authorship or citation. Investigators using data provided by other investigators as a substantial components of a paper are required to offer the originating investigator co-authorship. In cases where data from other investigators are a minor contribution to a paper, the data should be referenced by a citation.

Prior Data

The provisions of the data policy apply to data collected as part of the SAFARI 2000 Initiative. Data collected prior to S2K are specifically excluded from the open access policy. Access to such data shall be negotiated directly with the data owners, and the SAFARI 2000 name shall not be used to gain privileged access to prior data.

Access to Restricted Data Sets

The S2K Steering Committee will use its best endeavours to enable access to restricted data sets. This will include making contact, through the Country Representatives on the Steering Committee, with the relevant officials and institutions, to negotiate such access on behalf of SAFARI 2000.

Conflicts

Conflicts over the interpretation of this data policy, or its implementation will be submitted to the SAFARI 2000 Steering Committee. Participants agree to be guided by the decisions of the S2k Steering Committee in resolution of such conflicts.

Safari 2000 Acknowledgements

It is recommend that an acknowledgement be included in each publication, e.g. "This paper was part of the SAFARI 2000 Southern African Regional Science Initiative"

Unresolved Issues

Several points of concern and unresolved issues were evident from the data policy team's discussions, including:

- Legitimacy and representivity of the SAFARI 2000 Steering Committee.
- Limits of authority of the Steering Committee in enforcing data policy.

It is recommended that proposals be made as part of discussion of MANAGEMENT POLICY. It should be noted that the current Steering Committee is an INTERIM COMMITTEE and that this is the meeting in which to formalise the management structure.

Questions and Answers:

Q What is the difference between Oak Ridge and the Regional Data Centre (RDC)?
A There is no difference, the regional data centre is an exact copy.

Q How will quality assurance and quality control of data be done?
A QA and QC will first be done by the investigator, with secondary format checking being undertaken at the Regional Data Centre.

Q (1) Is the data to be first stored and processed in the USA and then returned to the RDC? (2) There is a need for real time data, e.g. for emergency planning; (3) Referring to the WHO protocol on meteorological data, how is this to be adapted to other disciplines?
A (Bob Cook) – Where and when the data is stored and processed will depend on time constraints and will be up to individual scientists. There should be a data policy subcommittee to determine this.
(Jeff Privette) – Some data must be requested in advance, e.g. at core sites

C (Bob Lazar) – The costs of sustaining a data centre need to be addressed.

C (Bob Swap) – Commitment for the data centre must come from the region.

PLENARY SESSION 11: FINALISATION OF REGIONAL INTEGRATION
CHAIR: HAROLD ANNEGARN AND SUSAN RINGROSE

SAFARI 2000 MANAGEMENT STRUCTURE

Harold Annegarn, Wits University

The proposed SAFARI 2000 management structure, comprising an Executive Committee, a Steering Committee, Regional and US Coordinators and Steering Committee representatives is illustrated in Figure 11. It was indicated that the Executive Committee would comprise 3 to 5 persons.

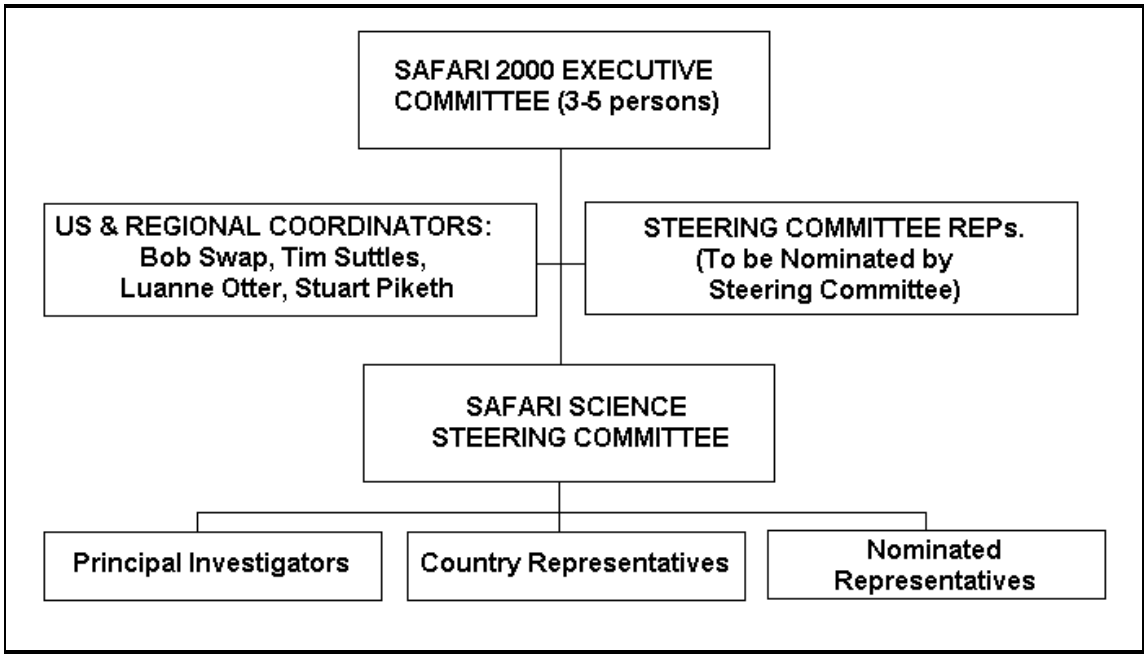

Figure 11. Proposed SAFARI 2000 Management Structure

The Steering Committee will be composed of:

- Principal Investigators (refers primarily to major funding blocks, i.e. ~>$100 000);
- Country Representatives (nominated by country participants); and
- Nominated Representatives (nominated by meeting participants).

Principal Investigators from **funded** projects under SAFARI 2000 who will be represented on the Steering Committee are indicated in Figure 12.

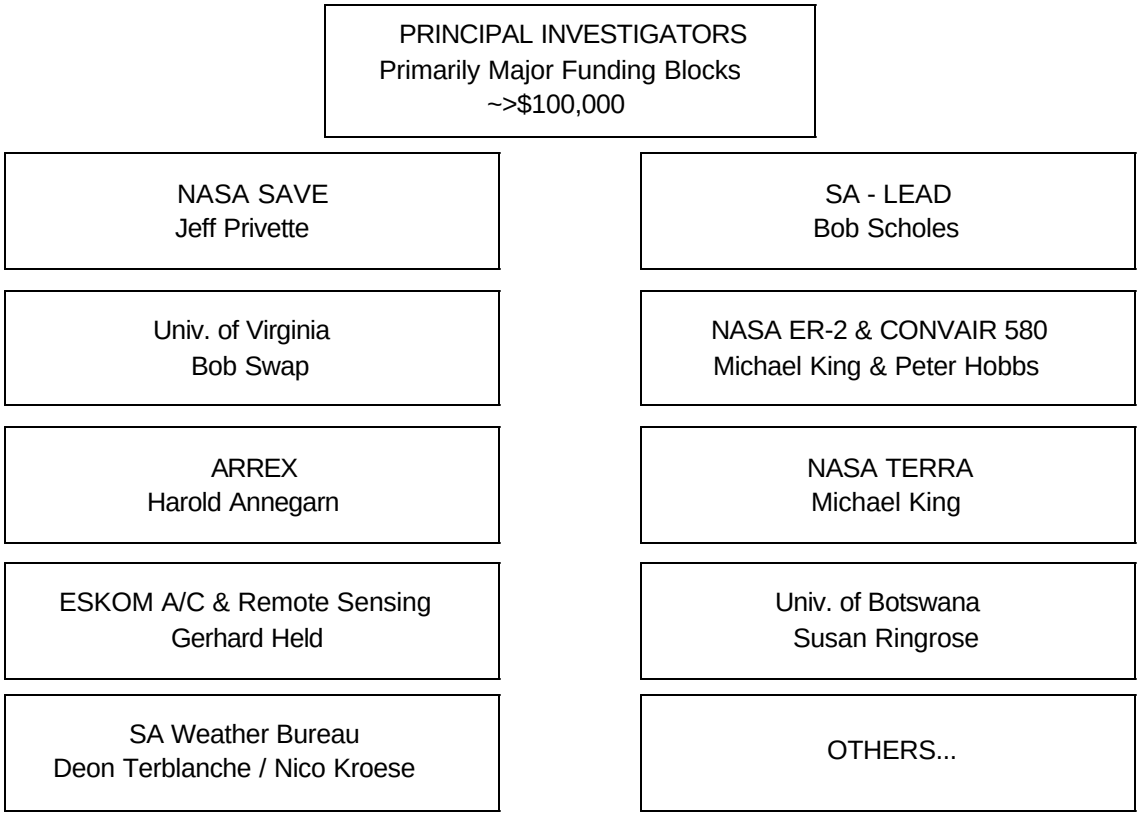

Figure 12. Principal Investigators from funded projects under SAFARI 2000 who will be represented on the SAFARI Science Steering Committee.

The countries for which nominations were requested for Country Representatives are given in Figure 13. Country Representatives nominated at the meeting are given in Table 7. In instances where no nominations were received contact persons, who would report nominations following discussions at home, are given. In defining the role of national coordinators, Luanne Otter proposed to put together the terms of reference for these positions.

Table 7. Nominations / Contact Persons for Country Representatives

Country:	**Name:**	**Details:**
Angola		No representatives at meeting
Lesotho		No representatives at meeting
Mozambique	Filipe Lucio	Contact person - discussions at home
South Africa	Luanne Otter	Accepted as country representative
Tanzania	Augustine Kanemba	Representative for interim – following discussions, director may be nominated
Zimbabwe	Barnabas Chipindu	Representative for interim pending discussions at home
Botswana	Susan Ringrose	Contact person - discussions at home
Malawi	Dennis Kayambazinthu	Contact person - discussions at home
Namibia	Peter Hutchinson	Contact person - discussions at home
Swaziland		No representatives at meeting
Zambia	GB Chipeta	Contact person

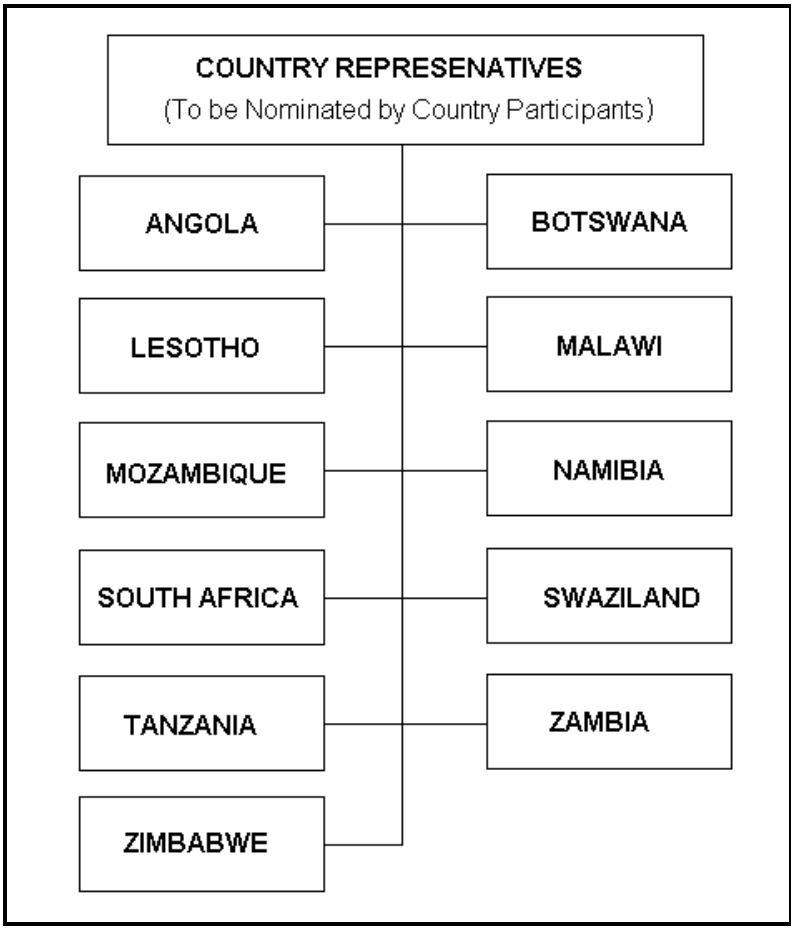

Figure 13. Countries for which nominations were requested for Country Representatives

The meeting were requested to elect Nominated Representatives. Nominations could include general representatives or special interest groups. The Nominated Representatives included:

- APINA - Steve Simukanga (Barnabas Chipindu as alternate)
- Miombo Network - Dennis Kayabizinthu or Paul Desanker - still need to be discussed
- Kalahari Transect - representative still needs to be identified
- Subsistence Rangeland Project - representative still needs to be identified
- SADC-Elms - representative still needs to be identified

The SAFARI 2000 Steering Committee needs to be finalised as soon as possible. Country participants were therefore requested to facilitate discussions at home regarding country representatives and to communicate nominations to the Safari Secretariat at the earliest date possible. A call for nominations for the Executive Committee will go out prior to the end of the year.

WHO? WHAT? WHERE? AND WHEN?
Bob Swap, University of Virginia

Intensive Sites

Initially only 2 intensive sites where envisaged as part of the SAVE project, viz. **Mongu** and **Skukuza**. Based on the proposals received it became evident that there are a further 2 intensive sites, **Maun** and **Etosha**. Having engaged new researchers, additional activities are also being proposed for these intensive sites.

Secondary Sites

A number of secondary sites were also recognised during the meeting, including:

- Inhaca (Mozambique)
- Kasangu (Malawi)
- Tshane (Botswana)
- Zimbabwe (to be determined)
- Tanzania (to be determined)
- Ben MacDhui (South Africa)
- De Aar (South Africa)
- Others

Contacts have been made at the meeting and lines of communication will be followed up in this regard. The list of secondary sites given above is not conclusive, other sites may have been left out.

SUMMARY OF SCIENCE AND SYNTHESIS PROPOSALS

A synopsis of field work to be undertaken by projects forming part of the SAFARI 2000 campaign was given (Table 8). The benefits of informing all SAFARI 2000 participants of the timing and location of specific activities was highlighted, with emphasis being placed on opportunities for joint ventures and collaboration. In the implementation plan to be compiled projects will be categorised by activity and by site.

Table 8. Date and location of field work to be undertaken by SAFARI 2000 projects

DATE:	ACTIVITY:	LOCATION:
July '99	Establish pilot network of sun photometers	Western Zambia
Jul – Aug '99	Collection of data for emissions inventory development	South Africa
Jul – Sept '99	Modelling of emissions for EI development for SA	SA
Aug '99	Surface radiation balance – ground surveys	Western Zambia
Aug/Oct '99	Perform QA of pilot sun photometer network & complete network	Western Zambia
Aug '99 – Dec '01	Site characterization and radiation measurement	Skukuza
Spt '99 – Dec '01	Aerosol sampling	Etosha NP, KNP (Skukuza), Mongu, Ben McDhui
Spt '99	Surface radiation balance – ground surveys	Western Zambia
Oct '99	Identify study region for crop estimates	Zimbabwe
Nov '99	Sampling system and collection of auxiliary data for crop estimation	Zimbabwe
Nov '99	Land cover, structure, leaf area and biogenic emissions investigated	Skukuza
Jan '00 on	Ambient air quality measurement of aerosols, TSP and trace gases	Harare, Bulawayo, Mutare, Gweru, Msvingo
Jan '00 on	Ambient air quality measurement of aerosols, TSP and trace gases	Remote areas – border towns, particularly lying in gyre pathway being studied by aircraft campaign
Jan ' 00 – Dec '01	Flux measurements – ecology team	Skukuza
Feb '00	Study of vegetation structure characterisation	Kalahari T ransect
Feb '00	Ozonesonde launches	Mongu, Zambia & Irene, RSA
Feb '00	Pulsed aerosol lidar, uv & handheld sun photometry	Mongu, Zambia
Feb '00/Mar '00	Aerocommander flights	Kalahari Desert
Feb '00/Mar '00	Field survey for crop estimation	Zimbabwe
Mar '00	Elemental characterisation, flux measurements, hyperspectral	Kalahari-Gemsbok Park, Tshane,

DATE:	ACTIVITY:	LOCATION:
	sensor, trance gas measurement	Chobe, Gobabis, Maun, Senanga, Mongu
May '00	Surface radiation balance – ground surveys	Western Zambia
May '00 – Apr '01	Radiation measurement	Mongu, Senanga and Sesheke
Apr '00	Establishment of 10 possible study sites for fire characterisation	N and S of Kaoma, Zambia
Apr '00	Establish expanded higher density network of sun photometers	Western Zambia
Aug '00	Salt and brine collection	Sowa Pan
Aug '00	Pulsed aerosol lidar, uv & handheld sun photometry	Mongu, Zambia
Aug '00	Surface radiation balance – ground surveys	Western Zambia
8 Aug – 20 Spt '00	Background CO, methane and ozone profile measurements	Continents & adjacent oceans (Indian & S Atlantic)
1-20 Spt '00	Aircraft surveys over Zambia	Katima, Ndola, Mongu
1-30 Spt '00	Conduct planned fires, post-fire inventory of vegetation	N and S of Kaoma, Zambia
Aug-Spt '00	Selection of sources for characterisation of smoke and fire, conduct tests, fuel and site description log	Mongu / Kaoma
Aug-Spt '00	Fire completeness, burn scare detection	Etosha
Aug '00/Spt '00	ER-2 Terra underflights over east coast of African continent and Indian Ocean	East coast of African Continent and adjacent Indian Ocean
Aug '00/Spt '00	Aerocommander flights	Kalahari Desert
Aug '00/Spt '00	Ozonesonde launches	Mongu, Zambia & Irene, RSA
Oct '00	NMHC, NOx emission investigation	Zambia
Nov '00	Methane, NMHC, NOx emission estimation	Miombo Transect
Dec '00	Soil characterisation, vegetation structure characterisation, flux measurements, trace gas measurement	Sites undefined
Dec '00	Field work for TM training	Hot spot locations, northern Malawi
Mar – May '01	Classification of woodland cover layer	Northern Malawi
Mar – May '02	Classification of woodland cover layer	Northern Malawi

Terrestrial Ecology and Land Processes (Hank Shugart) - Much progress was made, with the coordination of the May project made possible. A major campaign is being planned for the Kalahari Transect this coming March.

Aerosols and Trace Gases (Harold Annegarn) - The aerosol and trace gases work group comprised a broad and disparate group. The aircraft group made significant progress with plans for actual flight paths having been finalised. They also managed to bring in colleagues from the University of Zululand. Information on the various ground stations enabled the group to accurately determine measuring capabilities. The measurement of wind deflation dust in dry areas was identified as a significant gap in ground monitoring capabilities.

Modelling – The meeting was useful for land modellers since details were obtained on atmospheric models. Useful information was also obtained pertaining to data needs.

Hydrology – There was much interest in water resource management. It is important that contacts with the SADC subsector be made to determine what work is being done or proposed in this regard to ensure that no overlap with SADC ventures takes place.

Socio-Economic and Policy Issues (B Chipindu) – It is essential that SADC be informed about SAFARI 2000, and it is therefore hoped that the recommended SAFARI – SADC conference will take place. It is also important that country representatives inform the necessary parties so that public awareness can be raised.

DATA POLICY
Bob Cook, Oak Ridge National Laboratory

Participants were asked to provide the following information with regard to the data output of their individual projects: (i) Parameters; (ii) Formats; (iii) Number and size of the data sets; and (iv) Speedy communication lines. This information was not available at the meeting in sufficient detail and will therefore need to be

forwarded subsequently to the SAFARI 2000 representatives. Each working group did, however, give details of the data provided and of the possible difficulties in obtaining various data sets.

The following conclusions have been drawn from discussions at the meeting:

- **Methods of Early Distribution and Data Sharing -** Each Principal Investigator needs to ensure that the data is provided within the specified time frame and, depending on the data size, forward the data to the data centre on the appropriate medium.
- **Acquiring Documentation** – Each Principal Investigator is responsible for providing information which will assist the data centre to provide user friendly and easy access data.
- Principal Investigators need to provide a comprehensive description of the collection sites (ecological data and meteorological setting).

FUNDING ISSUES

Lackson Marufu has been charged with putting together a brief on projects proposed for North of the Limpopo requiring funding. The project proposals will go into a pool for regional funding by the Commonwealth Science Council

Significant funding will be required for the establishment of the Regional Data Centre and for training in this regard.

UPPER AIR RAWISONDE NETWORK FOR SAFARI 2000
Nico Kroese, South African Weather Bureau

After deliberating with the various Meteorological Services in the region, as well as input from the science and aircraft community, a preliminary plan of enhancing the current upper air rawisonde network is tabled. The considerations determining the choice of locations were the following:

(a) **Scientific:** The rawinsonde network should represent (give a good representation of) the meteorological conditions over southern Africa:

- This data will be crucial to act as input to enhance model (numerical forecasting models) output.
- It will also be important during the absolute stable layer analysis which will play an important role in determining the flight paths and flight levels of aircraft.

(b) **Aircraft:** Enhancing the meteorological forecasting capability for aircraft operations.

An inventory of upper air rawinsondes during the SAFARI 2000 intensive field campaign is given in Table 9.

Table 9. Inventory of upper air rawinsondes during the SAFARI 2000 intensive field campaign

ROUTINE ASCENTS:	NUMBER:
South Africa:	
Pretoria (Irene)	2
Cape Town	2
Durban	1* (70 instruments)
De Aar	1* (70 instruments)
Springbok	1
Port Elizabeth	1
Upington	1
Botswana	
Gabarone	2
Maun	1
Labotse	1
Lethlakane	1
Zimbabwe	
Harare	1

ROUTINE ASCENTS:	**NUMBER:**
Bulawayo	1
Zambia	
Lusaka	0* (130 instruments)
Mozambique	
Maputu	0
Beira	0** (130 instruments)
	TOTAL: 400 INSTRUMENTS

Notes:

* Indicates the stations that should receive aid in enhancing its capabilities to do 2 ascends per day.

** This station (Beira) needs to be aided to get complete system upgrade additional to the donation of instruments. An application for formal aid to international funding agencies will be forwarded soon. This station is not only important to SAFARI 2000 but to the meteorology in the region as a whole.

WHAT IS MISSING?
Harold Annegarn, Wits University

The following areas have been highlighted during the meeting as requiring further consideration:

- Extension of project to northern regions (Tanzania, Kenya and northern Zambia?)
- Dust deflation and deposition
- Oceanic influences

Comments:

- The NE regions are neglected. This includes the northeastern regions of Zambia. This may be addressed by extending the sampling campaign. (Charles Gatebe)

- Very little work has been done on wet deposition in the northern parts (Bob Scholes)

PLENARY SESSION 12: FINALISATION OF SAFARI IMPLEMENTATION
CHAIR: ISSAC MAZONDE, UNIVERSITY OF BOTSWANA

REVISED SCIENCE PLAN AND CRITICAL PATHWAY FOREWARD
Bob Swap, University of Virginia

It has become apparent that the success of Safari 2000 will depend on regional commitment, capacity development within the region, and the maintenance of open lines of communication between the northern hemisphere and the region. In order to reap long term benefits, it is imperative that researchers from the region drive the process.

Regional Environmental Data Management and Training Centre for Natural Resource Management

The SAFARI 2000 campaign will comprise the following elements:

- Basic Research
- Applied Research – in which findings and outputs (land use change maps, leaf area indices, etc.) are made relevant to politics.
- Training – the aim should be the development of intellectual capacity north of the Limpopo that lasts.

Rationale for the selection of Botswana for the Regional Data and Training Centre:

- The government of Botswana is willing to work with the University of Botswana to have one consistent GIS software package.
- The EIS component of SADC is located in Gabarone

The data centre will not work without regional support. It is intended that the data centre have long-term benefits for all countries, it must therefore be regional in its scope.

Science Plan

All participants have received copies of the Science Plan. Comments on the Science Plan should be submitted to Bob Swap. Should no comments or corrections be received it will be interpreted as an acceptance of the Science Plan.

Changes to the Science Plan arising from the workshop include the need to add information pertaining to:

- Data policy
- Hydrology
- Socio-economic, societally relevant policy
- Implementation information

The comments received and changes arising from the workshop will be addressed and the finalised Science Plan made available within the next 6 weeks.

CLOSING ADDRESS
Director of Mines, Botswana

Distinguished guests, ladies and gentlemen, it is with great pleasure that I participate in the closing proceedings of this very important workshop. Your have spent the better part of the week trying to come to terms with the complexity of the SAFARI 2000 project. You are all aware of the objective of SAFARI 2000 project, which is the exploration, study and understanding of the key linkages between the physical, chemical and biological processes, including the role of humans, in the functioning of the Southern African biogeophysical system. This project is a regional science initiative which requires transboundary collaborations.

The goal of the workshop has been to come together as individuals, with individual projects and ideas, discuss those ideas with colleagues from within and outside the region, and to produce comprehensive documentation and a coordinated implementation plan for the various activities which form SAFARI 2000. The initiative as outlined and discussed here in Gabarone this week has important implications for not only Botswana but for the whole Southern African region and beyond.

The workshop has managed to foster discussions on regional scientific activities which have a bearing on the SAFARI 2000 project. The workshop has brought together for the first time many interdisciplinary scientists who are engaged in research on environmental issues. The workshop has facilitated the articulation of scientific proposals, many of which are regional and international in their scope. Steps towards conducting truly collaborative transboundary research have been initiated: The fact that funding for many of these potentially exciting research efforts has not been secured should not dampen our spirits, in fact we should take it as a challenge to secure the necessary funds.

The workshop has achieved some consensus on the development of a coherent data management strategy which ensures access by scientists and provides protection of the intellectual property of those responsible for producing the data. Progress towards consensus on the SAFARI 2000 management structure has also been achieved. The region needs to capitalise upon this great opportunity to make use of the data streams from NASA's Earth Observing System of satellites. The proposed Regional Environmental Data Management and Training Centre for Natural Resources Management to be hosted by the University of Botswana will benefit regional as well as scientists from far afield. It is my sincere hope that the results of SAFARI 2000 will find their way into the policy and decision making processes at local, national and regional levels. We here in Southern Africa can no longer afford to do science for science's sake and SAFARI 2000 must make its results relevant to the development of our societies. For this to be achieved, the support of academic, governmental and private sector institutions is necessary.

You have begun to take steps towards getting the regional scientists "our of the scientific kitchen" and I hope that the new contacts, friendships developed during this workshop will continue throughout SAFARI 2000 life-span. With these few remarks ladies and gentlemen, I declare the workshop closed.

APPENDIX A :- KEY SCIENCE QUESTIONS IDENTIFIED AS PART OF SAFARI 2000, AS PRESENTED IN THE SCIENCE PLAN

SOURCES

- What are the sources, magnitudes, locations and temporal pattern of aerosol and trace gas emissions to the atmosphere in southern Africa?
- What are the main urban, industrial and transport activities within southern African responsible for aerosol and trace gas emissions, and what are the strengths of these sources?
- In what ways, and to what extent, do different land use practices contribute to aerosol and trace gas emissions?
- Which ecosystem processes are responsible for aerosol and trace gas emissions?
- How do climate and other environmental conditions affect these processes?
- How does vegetation structure, composition and phenology influence these processes?
- How do human activities interact with and alter the rate of these processes?
- What are the chemical properties of the emitted aerosols?

TRANSFORMATIONS and TRANSPORT

- How are aerosols and trace gases chemically transformed and transported between the surface and the atmosphere and within the southern African atmosphere?
- What are the controls, rates and end products of the regional chemical transformations, and how do these vary seasonally?
- How are these atmospheric constituents transported into and out of the region?
- What are the relationships between climatic variability over decadal, inter- and intra-annual timescales and the transport and transformations of atmospheric constituents?

DEPOSITION PATTERNS

- What are the temporal and spatial patterns of aerosol and trace gas deposition in and downwind of Southern Africa?
- What are the mechanisms of deposition, and how might climate variability and climate change affect them?
- What is the contribution of atmospheric deposition to the biogeochemistry, productivity, structure and use of southern African ecosystems downwind of emission sources?

IMPACTS AND RESPONSES

- How might changes in atmospheric aerosols and trace gas concentrations affect the regional climate, biogeochemistry and land use of Southern Africa?
- How does atmospheric deposition alter the productivity, biogeochemistry, structure and potential and actual uses of Southern African ecosystems?

INTERACTIVE PROCESSES

- How does the atmosphere interact with different southern African ecosystems, and how might these interactions be modified by environmental and anthropogenic changes?
- How do changes ecosystem functioning and land-surface processes affect emissions and thereby atmospheric chemistry and radiative forcing of the southern African atmosphere?
- In what ways and to what extent do climate and atmospheric composition influence the structure and functioning of southern African ecosystems, in particular biogeochemistry and hydrology?
- What are the natural disturbance regimes of southern African ecosystems, and how might they be modified by climate change?
- How do changes in land use and land-cover patterns affect ecosystem processes and dynamics?
- How might changes in climate, atmospheric composition and nutrient deposition interact with changing economic forces and growing human and livestock populations to affect land use and land cover in the region?

APPENDIX B :- ACTIVITES IDENTIFIED FOR EACH CORE ELEMENT TO BE ADDRESSED BY THE SAFARI 2000 CAMPAIGN

CORE ELEMENT 1: TERRESTRIAL ECOLOGY AND LAND PROCESSES

Activity 1: Carbon Budget

Measurement of NPP, NEP, carbon emissions and sequestration, and carbon budgets closure on scales from plot to landscape to region. Arriving at these answers will also requires an understanding of the N budgets and dynamics.

Activity 2: Nitrogen Budget

Measurement of NPP, NEP, nitrogenous trace-gas emissions, nitrogen deposition and uptake, nitrogen fixation, and nitrogen budget closure on scales from plot to landscape to region.

Activity 3: Soil Studies

Measurement of include soil chemical and physical attributes, soil moisture, soil microbiology

Activity 4: Fuel Studies

Measurement of woody and herbaceous plant growth, litterfall and decomposition, chemical characterization of fuels pre and post burn, and estimates of fuelwood availability

Activity 5: Canopy Characteristics
Measurement of species composition, canopy structure, leaf area indices, and phenology.

Cross-cutting Activity: Integrated Modeling of the Southern African System

Interdisciplinary synthesis of results.

CORE ELEMENT 2: LAND COVER AND LAND-USE CHANGE (LCLUC)

Activity 1: Land Cover and Land-Use Change Characterization and Impacts

Compilation and generation of regional data bases critical to the study of LCLUC, including vegetation characterization; land use and forest inventories; regional inventories of land cover and land-cover change derived from remote sensing; distribution and numbers of livestock, wild ungulates, and other major herbivore groups; regional soils data base; spatial and temporal variability in rainfall distribution; surface hydrology; human demography; and transportation networks.

Activity 2: Regional Fire Characterization, Emissions and Management

Includes satellite-based location and timing of active-fires and burned area; interannual variability of rainfall and the incidence of fire; characterization of fuel load and state, completeness of burn, and resulting pyrogenic aerosol and trace gas emissions; fire and natural resource management studies.

Activity 3: Land cover -land use, carbon and emissions

Includes quantifying carbon pools and fluxes in managed systems, determining options for carbon sequestration and emissions mitigation, point – local - regional NPP degradation studies, would also include biogenic production, both microbial and vegetative).

Activity 4: Land Cover and Land Use Modeling

Includes local and regional scale modeling of land cover and land use change and their impacts, case studies on the drivers of land use change including socio-economic and climate variability, case studies on the impacts of land cover change, integrated assessment modeling).

Cross-cutting Activity: Integrated Modeling of Southern African System

Interdisciplinary synthesis of results (includes coupling land use with vegetation and atmospheric models).

CORE ELEMENT 3: AEROSOLS

Activity 1: Aerosol Composition, Concentration, and Source Characterization

Identification and characterisation of sources and measurement of aerosol composition and concentrations both across the region and in the vertical plane using ground-based, airborne and satellite derived observations. Observations required of both organic and inorganic fractions of observed aerosol in different size fractions.

Activity 2: Aerosol Optical and Radiative Properties

Includes ground-based, airborne and satellite derived observations of aerosol optical thickness, direct and indirect forcing.

Activity 3: Aerosol Characteristics related to LCLUC

Measurement of concentrations, compositions, optical properties and sources related to LCLUC processes (biogenic, biomass burning, industrial) to arrive at regional emission estimates (includes air parcel transport studies).

Activity 4: Determination of Physical Processes Related to the Deflation and Deposition of Aerosols

Measurement of micro-meteorological fluxes, growth and decay of the planetary boundary layer, entrainment of boundary layer into the free troposphere.

Activity 5: Aerosol Deposition and Resultant Impacts on Biogeochemistry

Measurement of aerosol deposition and resultant impacts on biogeochemistry from plot to landscape to regional and continental scales.

Activity 6: Formation of Secondary Organic Aerosols

Gas to particle conversions.

Cross-cutting Activity: Integrated Modeling of Southern African System

Interdisciplinary synthesis of results (includes coupling land use with vegetation and atmospheric models).

CORE ELEMENT 4: TRACE GASES

Activity 1: Trace Gas Composition, Concentration, and Source Characterization

Includes ground-based, airborne and satellite derived observations of biogenic, biomass burning and industrial trace gases observations ranging from point to local to regional, chemical characterization of fuels pre and post burn.

Activity 2: Trace Gas Optical and Radiative Properties

Includes ground-based, airborne and satellite derived observations of aerosol optical thickness, direct and indirect forcing

Activity 3: Determination of Physical Processes Related to the Deflation and Deposition of Trace Gases

Micrometeorological fluxes, growth and decay of the planetary boundary layer (PBL), Entrainment of PBL into the free troposphere

Activity 4: Relating Observed Trace Gas Characteristics

Measurement of concentrations, compositions, optical properties and sources related to LCLUC processes (biogenic, biomass burning, industrial) to arrive at regional emission estimates (includes air parcel transport studies).

Activity 5: Role of Trace Gas Formation and Transport on Regional Atmospheric Chemistry

Measurement of CO, CH_4, NO_x, SO_2, NH_4, NMHC and VOC.

Activity 6: Trace Gas to Particle Formation

Studies of the formation of secondary organic aerosols; trace gas deposition and impacts on biogeochemical cycles

Cross-cutting Activity: Integrated Modeling of Southern African System

Interdisciplinary synthesis of results (includes coupling land use with vegetation and atmospheric models).

CORE ELEMENT 5: CLOUDS AND RADIATION

Activity 1: Linking CCN Characteristics to Observed Aerosols and Rainfall Production

Includes impacts of changes in aerosols on existing hydrology

Activity 2: Cloud Albedo and Radiative Transfer over both Continental and Marine Surfaces

Includes cloud and aerosol interactions, effects on CCN, rainfall production, changes in cloud albedo and therefore radiative transfer within the region

Activity 3: Relationship of Cloud / Aerosol / Radiation to Climate

Direct and indirect climate forcing of continental (cumuliform) and marine (stratiform) cloud systems over time scales from Micro to Meso to Synoptic to Climatological

Cross-cutting Activity: Integrated Modeling of Southern African System

Interdisciplinary synthesis of results (includes coupling land use with vegetation and atmospheric models).

CORE ELEMENT 6: MODELING

Modeling is a cross-cutting activity throughout the above elements, but given the need to integrate among different modeling initiatives, the main modeling studies are identified below. It is envisaged that modeling will be used both to help give direction to the field studies and to integrate among them. To this end, modeling will take place throughout SAFARI 2000 in close conjunction with the field campaigns.

Activity 1: Meteorological

Air parcel transport; growth and decay of the boundary layer; mixing and entrainment between boundary layer and free troposphere; atmospheric deposition, both wet and dry for aerosols and trace gases; across scales ranging from micro-scale to meso-scale to synoptic.

Activity 2: Atmospheric Chemistry

Photochemistry; oxidation; ozone formation; wet/rainfall chemistry; emission of NMHC, NOX; SO_2; CO; CO_2; Aerosols, including aerosol optical thickness (AOT), aerosol size distribution; and validation of satellite products. These models need to range across scales from micro-scale to meso-scale to synoptic.

Activity 3: Ecological

Photosynthesis; NPP; NEE; biogeochemical cycling; nitrogen cycling; carbon cycling; fuel load; ecosystem state; satellite validation. These models also need to range across scales from plot to landscape to regional scales.

Activity 4: Radiation

Radiative transfer; FPAR; NPAR; BRDF; AOT; aerosol size distribution; and validation of satellite products .

Activity 5: Emissions Modeling

Area burned; biomass burned; fire frequency; fire intensity; fire emissions; and validation of satellite products.

Activity 6: *Land Cover and Land Use Modeling*

Activity 6: Linkage of Models

Process and impacts of land-cover change.

Activity 7: Intercomparison of Models and Interdisciplinary Synthesis of Results

APPENDIX C: PARTICIPANTS IN VARIOUS CORE ELEMENT GROUPS

NOTE: Various delegates moved between the discipline-specific teams. This input to discussions within teams other than the initial team in which they were engaged is not reflected in the list of participants given for each of the core element teams.

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