Operationalizing GOFC in the Miombo Region and Questions of Carbon

Paul V. Desanker, PI; University of Virginia, desanker@virginia.edu

Co-Investigators:

David Reed, Michigan Technological University, ddreed@mtu.edu
Ian Davies, Australia National University, DAVIES@rsbs.anu.edu.au
Hassan Virji, START, Washington D.C. hvirji@agu.org

Regional Miombo Network Collaborators

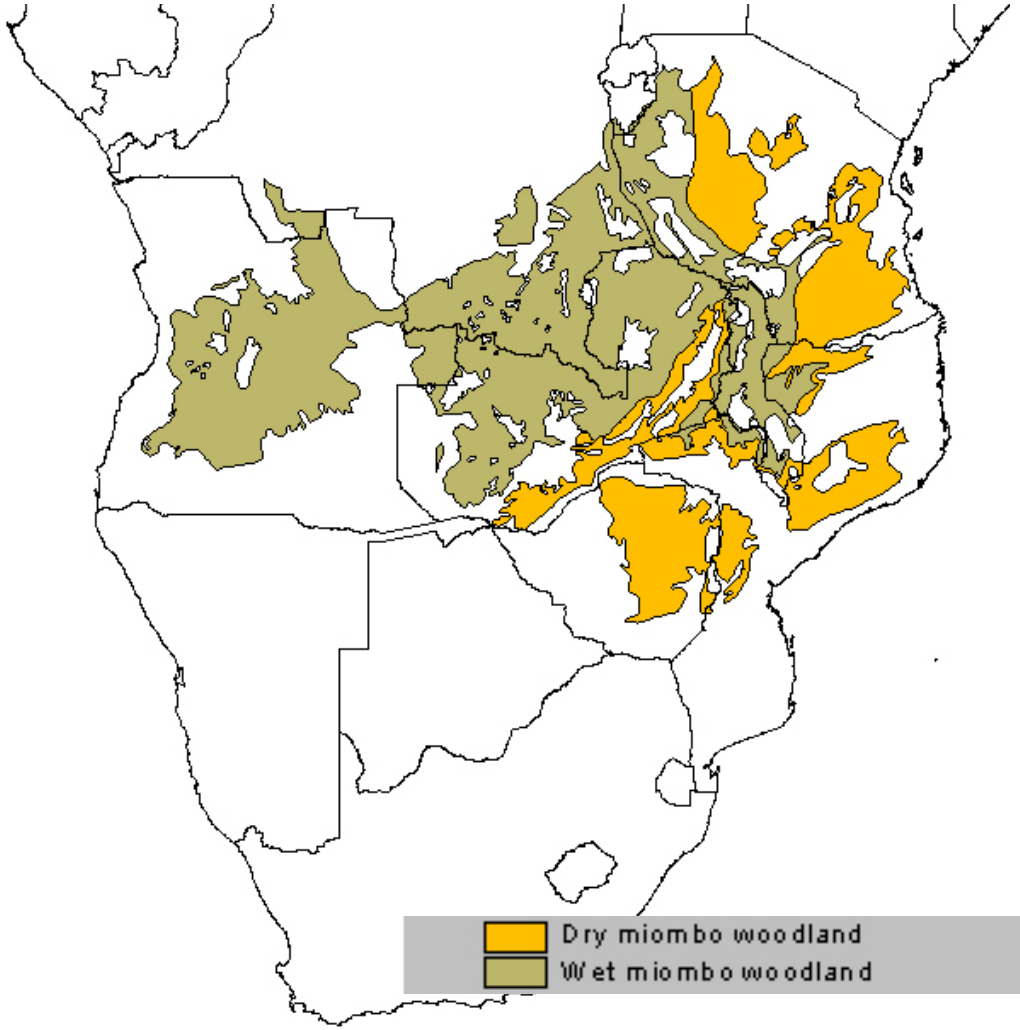
Leo Zulu, SADC FSTCU, Lilongwe, Malawi, lzulu@hotmail.com
Pius Yanda, University of Dar es Salaam, Tanzania, yanda@hotmail.com
Dominick Kwesha, Zimbabwe Forestry Commission, vegris@internet.co.zw
Manuel Ferrao, CENACARTA, Mozambique, manuel@carvalho.uem.mz
Patrick Mushove, FAO, Nampula, Mozambqiue, patrickmushove@teledata.mz

GECP

UVa

MIOMBO NETWORK

The Miombo Region, based on White's 1983 Vegetation Map of Africa



GECP

MIOMBO NETWORK

Different States of Miombo from intact woodland to tree-grass mixtures, in response to disturbance (fire, human use)

Ecological Transitions in Miombo

fire

Slash & burn

More fire

abandon

degradation

Objectives

Will seek to understand the miombo regional carbon budget, in particular, will develop an account for the 1990-2000 period.

Prepare the way for full participation in GOFC forest monitoring for Southern Africa region

This will be accomplished through

1) Mapping the miombo region using Landsat 7 data by working in conjunction with Southern African national mapping agencies; *for Mozambique (in detail, and the miombo region broadly)*

2) Development of a regional spatial database for site characterization

3) Measurement of carbon densities in representative land cover/forest cover types of the region, while building upon existing forest inventory and national biomass studies;

4) Development of a carbon accounting model that will quantify carbon pools in the miombo region for 1990 and the year 2000, and the major C fluxes due to land cover changes;

5) Development of an information management system that will distribute satellite data for the miombo region, and serve as a database archive for field data about the miombo region, such as forest inventory records and site data for image classification.

GECP

MIOMBO NETWORK

Setting

There is great interest in the amount of carbon in forests and woodlands in the dry tropics as countries explore opportunities for clean development mechanisms and carbon sequestration/carbon trading projects under the Kyoto Protocol of the UNFCCC.

New interest in carbon sequestration through improved soil management and land use in drylands – FAO, IFAD, USAID etc interested in linking these to food security and poverty alleviation programs (expert meetings leading up to FCC COP-6)

Carbon projects in dry and degraded lands seen as a win-win strategy for implementing emissions reductions under Kyoto

Issues being guided by our ability to measure and assess carbon sequestration in a cost-effective manner, and amounts expected in different land management activities

GECP

MIOMBO NETWORK

Analysis and modeling of carbon will be organized around the following working hypotheses:

- **H1 – Land management and land use change exert a major control on carbon reservoirs and flux rates to determine source/sink status at the landscape/regional level in miombo** *<ideally assess significant change over 5-10 yrs, and in "project landscapes", role of disturbance>*.

- **H2 – The fate of forest products is a significant factor in the carbon balance for the miombo region** *<full accounting>.*

- **H3 – Carbon fluxes during the analysis period of 5-10 years (1990-1995-2000) will be larger than expected uncertainties due to the methods.**

GECP

MIOMBO NETWORK

Heritage for the research

- Miombo Network: study of Land Cover Change – baseline mapping, community network of scientists in Miombo Region
- Kyoto protocol identified international emissions trading, JI, and CDM as implementing mechanisms of emissions reductions. Offers potential for carbon seq in dryland soils and woodlands. Convention to Combat Desertification also very interested in applying carbon projects to support poverty alleviation and food security by improving soil fertility
- However, major science uncertainties remain, iunder discussion including:
  - <Geneva workshop: C Seq in Agric, USAID/FAO/IFAD>
  - <Dakar workshop: Pilot C Project, USGS/USAID>
- Interest in pilot projects to demonstrate feasibility by accounting for costs, errors, carbon accumulation etc in typical settings. Using miombo sites as a pilot (in Malawi and Mozambique)
- Methods for Biomass assessment: improved operational methods (sampling, mathematics linking scales – additivity, error propagation etc)

GECP

New Estimates of Land Cover based on Regional Map for 1992

	Tanzania		Zimbabwe		Mozambique		Malawi	
Land cover types	Area (sq.km)	%	Area (sq.km)	%	Area (sq.km)	%	Area (sq.km)	%
Nodata	165	0.0	-	0.00	1,917	0	-	0
Natural	25,911	2.5	107	0.03	21,798	2.76	828	0.69
Forest	1,313	0.1	1,562	0.40	-	0	1,418	1.18
Woodland	305,446	29.4	208,683	53.36	297,675	37.62	25,357	21.19
Bushland/	80,974	7.8	49,777	12.73	154,172	19.49	-	0
Wooded	110,302	10.6	12,184	3.12	148,242	18.74	394	0.33
Grassland	36,402	3.5	6,826	1.75	41,492	5.24	7,071	5.91
Barren	1,187	0.1	576	0.15	593	0.07	-	0
Water	156,135	15.0	2,977	0.76	5,654	0.71	24,430	20.41
Swamp/M	9,629	0.9	-	0.00	-	0	1,733	1.45
Cultivation	312,068	30.0	107,008	27.36	119,639	15.12	58,215	48.65
Built-up	566	0.1	1,377	0.35	-	0	225	0.19
Total	1,040,098	100.0	391,077	100.00	791,184	100	119,671	100

GECP

MIOMBO NETWORK

Comparison of 1992 Regional Map with FAO (FRA 1990) (sq km)

Country		Natural Forest	%	Plantation	%
Tanzania:	Reg-Map	331,360	32	1320	.1
	FAO	335,550	38	2200	.2
Zimbabwe:	Reg-Map	208,670	**53**	1560	.4
	FAO	89,000	**23**	680	.3
Mozambique:	Reg-Map	319,500	**41**	0	0
	FAO	173,300	**22**	400	.1
Malawi	Reg-Map	26,200	22	1500	1.2
	FAO	34,860	37	1800	1.9

GECP

MIOMBO NETWORK

Carbon Densities in Miombo Woodlands

Table 2b. Biomass in one hectare of miombo (Campbell *et al* 1998)	
Major organic matter pools	Organic matter kg/m^2
Woody plants	
Above-ground	3.80
Roots	1.67
Herbaceous plants	
Above-ground	0.05
Roots	0.07
Dead plant material	1.30
Siol fauna (depth 0.3 m)	0.07
Microbial biomass (depth of 0.5 m)	0.70
SOM (depth of 0.5 m)	8.70
TOTAL (above and below)	16.35 kg/m^2

Table 2c. Aboveground Wood biomass estimates by forest type in Zambia (Chidumayo 1994)	
Vegetation type	Biomass (kg/m^2)
Evergreen forest	15.147
Deciduous forest	5.589
Wet miombo	7.290
Dry miombo	5.589
Kalahari miombo	4.131
Munga	4.455
Mopane	4.455
Termitaria	2.430

Table 2e. Houghton et al. (1983) biome C densities

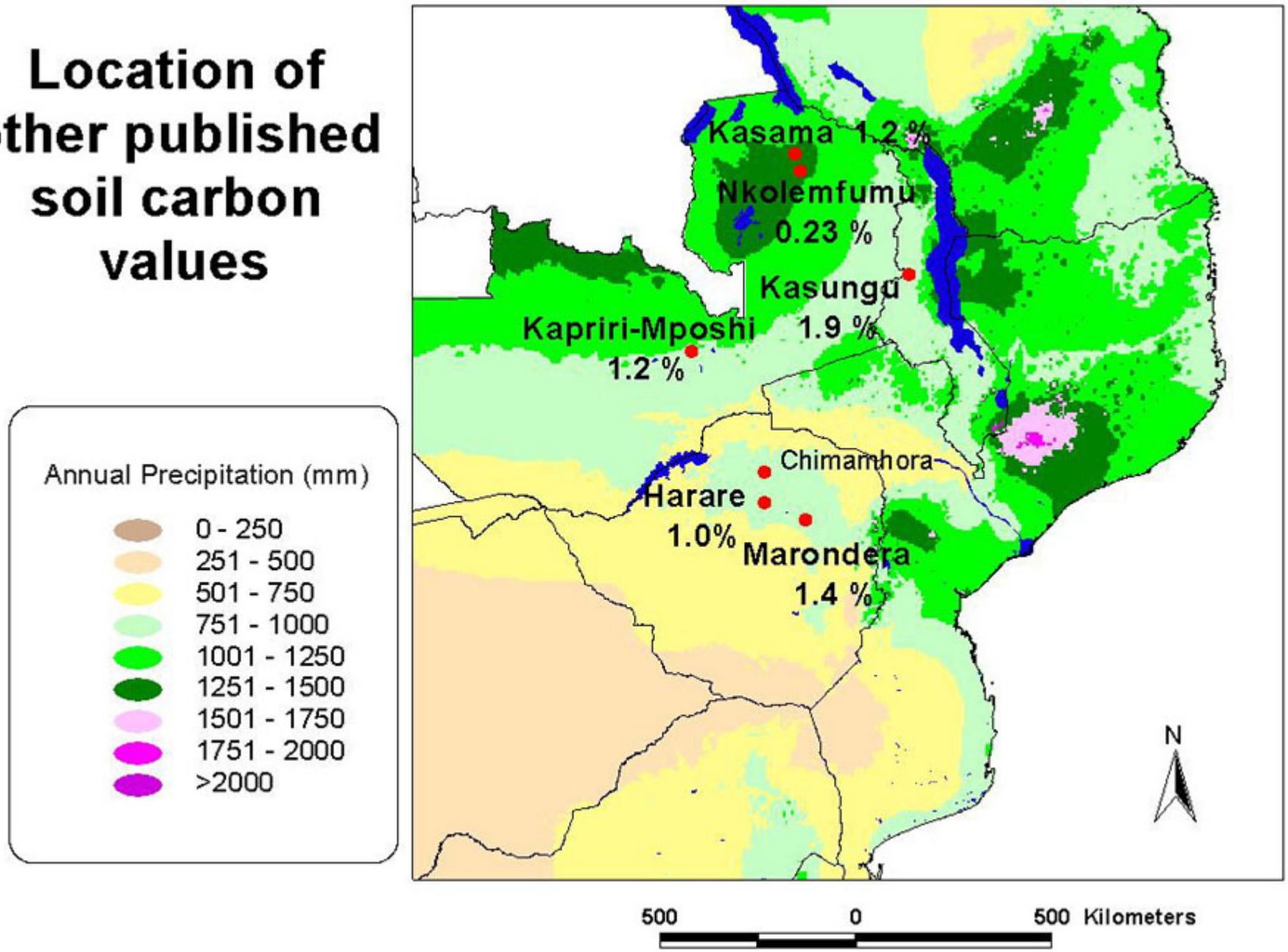
Biome	**Veg. C Density (kg/m2)**	**Soil C Density (kg/m2)**
Tropical Moist Forest	20.0	11.7
Tropical Seasonal Forest	16.0	11.7
Tropical Woodland and Shrubland	2.7	6.9
Tropical Grassland	1.8	4.2
Temperate Grassland	0.7	18.9
Cultivated Land	0.5	6.0
Pasture Land	0.7	18.9

GECP

MIOMBO NETWORK

Soil Carbon

Location of other published soil carbon values



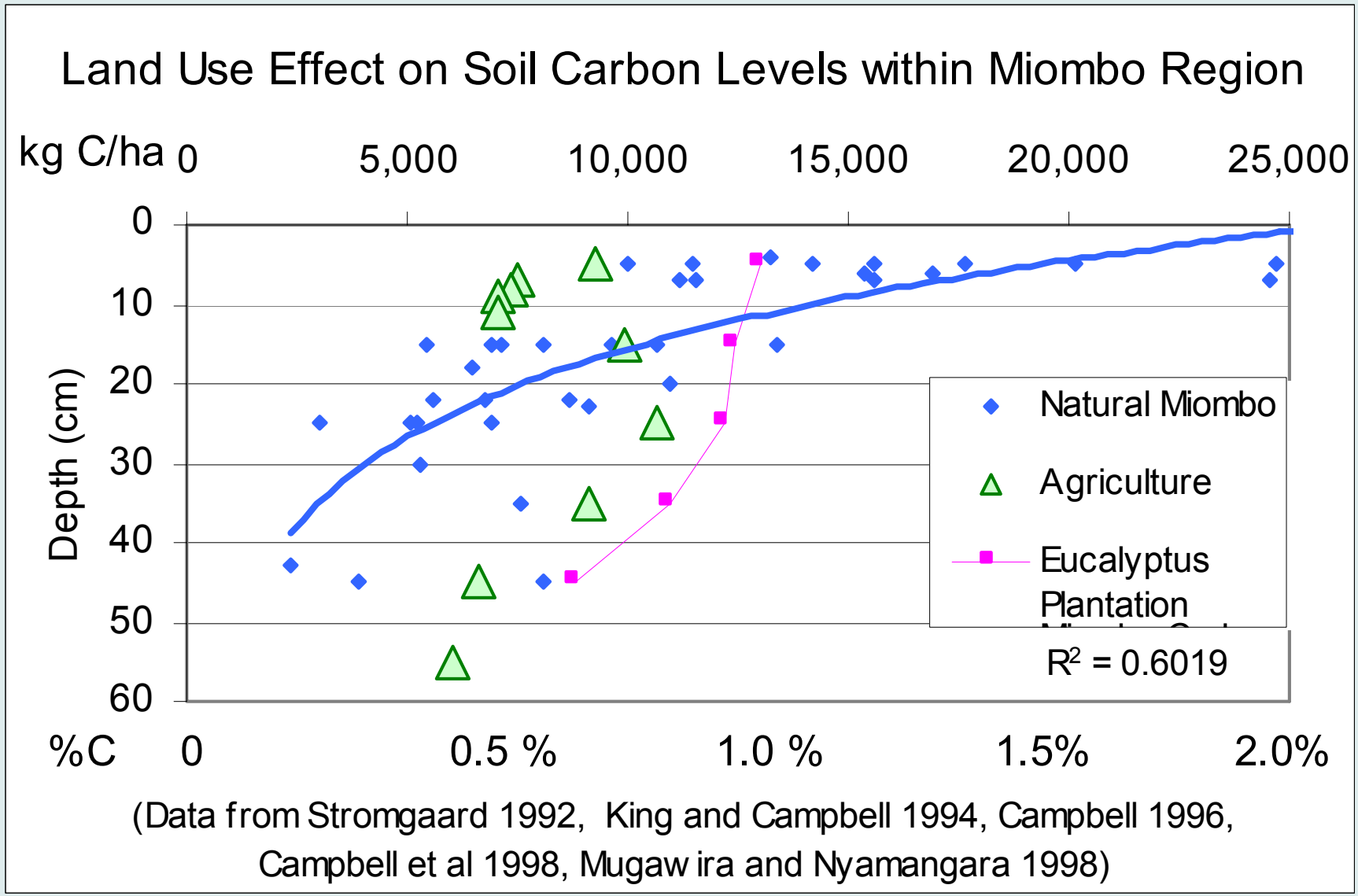
Soil Carbon in various arid and semi-arid regions:

Country	Natural Vegetation Type	% C soil		Total C kg/ha/20 cm	
		Natural	Cropped	Natural	Cropped
R. South Africa	Broadleaf Savanna	0.07%		1,820	-
Papua New Guinea	Savanna	0.19%		4,940	-
Botswana	Kalahari	0.25%		6,500	-
Senegal	Savanna	0.70%	0.3%	18,200	7,800
Rondonia, Brazil	Rainforest -->Pasture	1.28%	1.6%	33,280	41,600
Brazil	Short Cerrado	1.3%	1.4%	33,800	36,400
Malawi	**Miombo Woodlands**	**1.4%**	**0.6%**	**36,400**	**15,600**
Brazil	Tall Cerrado	1.9%	1.8%	49,400	46,800
NE Brazil	Savanna	2.0%	1.0%	52,000	26,000
Nigeria	sub-humid forest	2.2%	1.5%	57,200	39,000
Brazil	Semi-deciduous Forest	2.4%	1.9%	62,400	49,400
Brazil	Evergreen Forest	2.8%	2.6%	72,800	67,600
Belize	Pine Savanna	3%		78,000	-
Puerto Rico	Dry Forest	3%	1.8%	78,000	46,800

Scholes and Walker 1993, Gillison 1983, Ringrose 1998, Montgomery and Askew 1983, Neil et al 1997, Neil et al 1997, Lepsch et al 1994, King and Campbell 1994, Lepsch et al 1994, Tiessen 1998, Salako 1999, Lepsch et al 1994, King et al 1986, & Brown and Lu

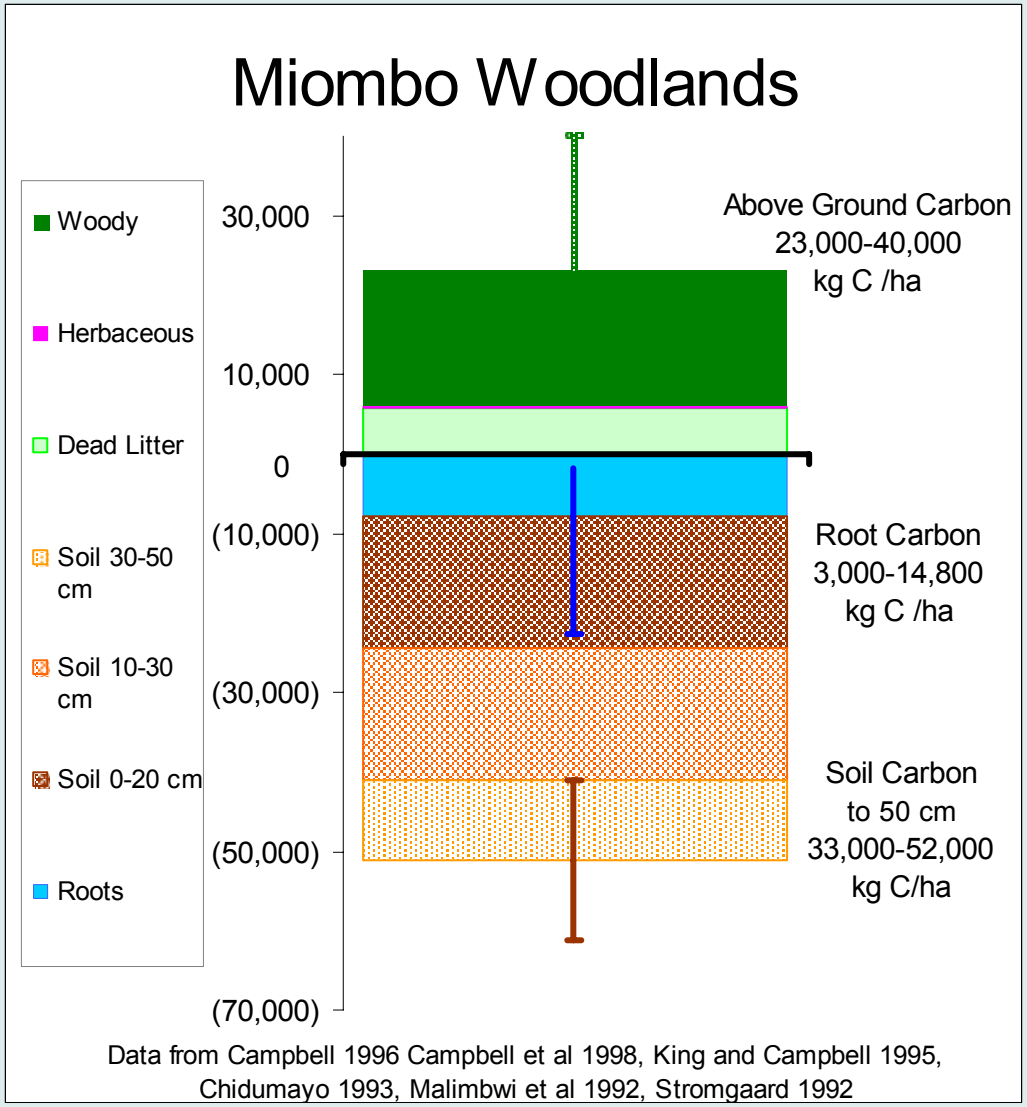
In Miombo, Carbon in soil ranges from 0.15% - 2.0%

SOC levels under different Land Uses:

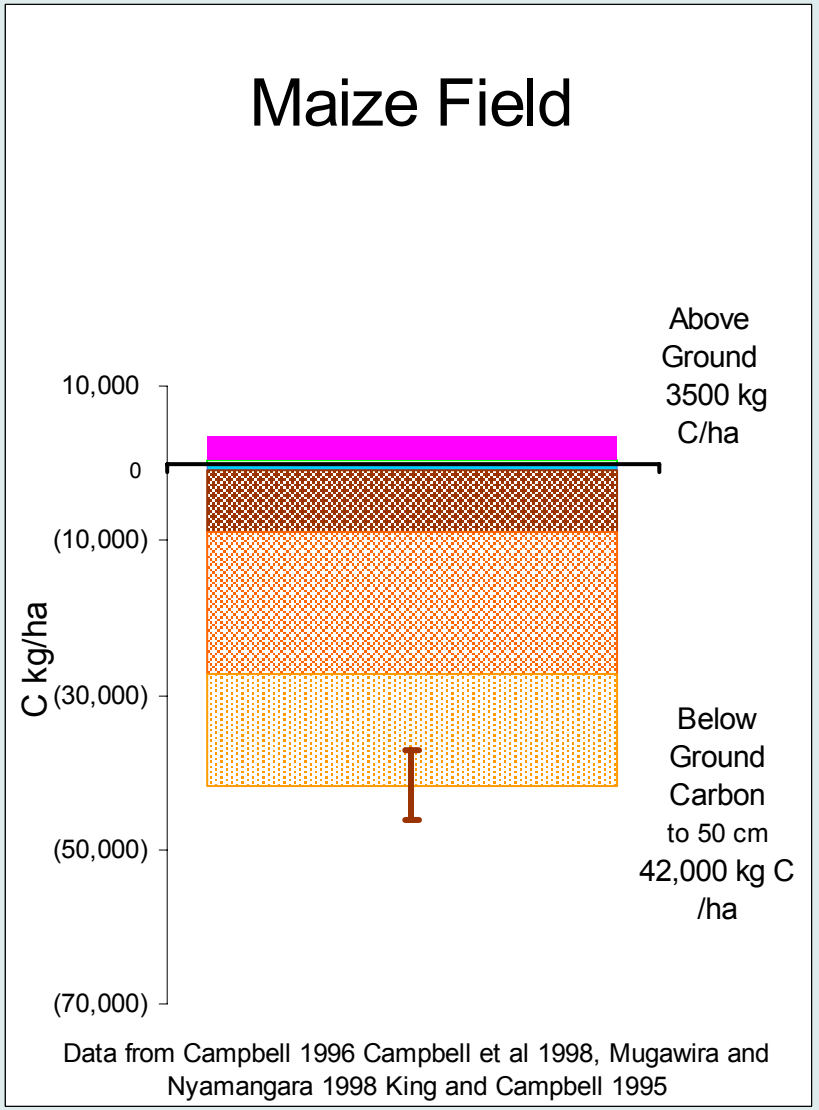


(Data from Stromgaard 1992, King and Campbell 1994, Campbell 1996, Campbell et al 1998, Mugaw ira and Nyamangara 1998)

Total Carbon Estimates within a Hectare:



Data from Campbell 1996 Campbell et al 1998, King and Campbell 1995, Chidumayo 1993, Malimbwi et al 1992, Stromgaard 1992



Data from Campbell 1996 Campbell et al 1998, Mugawira and Nyamangara 1998 King and Campbell 1995

Main Activities

Coordination Workshop - 20-22 July 2000: workshop report available <show main conclusions>; Special issue coming up in *Forest Ecology and Management* – Phase I

Acquisition of Landsat 7 during Phase I and processing through Phase III

Setup Miombo Information Management System during Phase I and II

Spatial Data for Miombo Region and use in Regional Characterization of climate-soils-landform in relation to soil carbon and aboveground biomass/vegetation – Phase I and II

Development of Full Carbon Accounting system for the Miombo Region during Years 1 and 2 <iiasa/ipcc approaches>

Linked Carbon-Land Use Change Modeling and Sampling Analyses – All Phases

GECP

MIOMBO NETWORK

Miombo GOFC Workshop Summary

Selected Conclusions/Suggestions

- Data acquired through Miombo Network very useful for applications in region for graduate study work and enhancement of existing projects that cannot afford expensive imagery
- Data samples for local areas needed for new/specialized sensors (Ikonos, MODIS, Radarsat, Aster, etc.
- MODIS 250m for Southern Africa desirable. Wall to wall Landsat 7 over 1999-2000 very desirable for creating a baseline for GOFC mapping and monitoring. Data would benefit numerous regional/national applications
- Better delivery of data for disasters needed.
- Viable Data access via the Internet not possible
- Special issue – will emphasize regional science outputs
- Miombo GOFC Data CD-ROM should include some spatial tools and models for carbon/biomass

(Lengthy report available)

GECP

MIOMBO NETWORK

Forest Ecology and Management Special Issue Proposal

THE GLOBAL OBSERVATION OF FOREST COVER (GOFC) PROGRAM IN THE MIOMBO REGION OF SOUTHERN AFRICA

Guest Editors: Pius Yanda (University of Dar es Salaam, Tanzania), **Paul V. Desanker** (University of Virginia)**, and Christopher O. Justice** (University of Virginia)

Goal of Issue:

Give definitive statement about the state-of-the-art in use of Landsat data (and others) in forestry and mapping in the Miombo Region, and develop a strategy for operational implementation of GOFC in Southern Africa in concert with global and national efforts. Papers will include contributions from individuals and working groups at the meeting.

Timetable

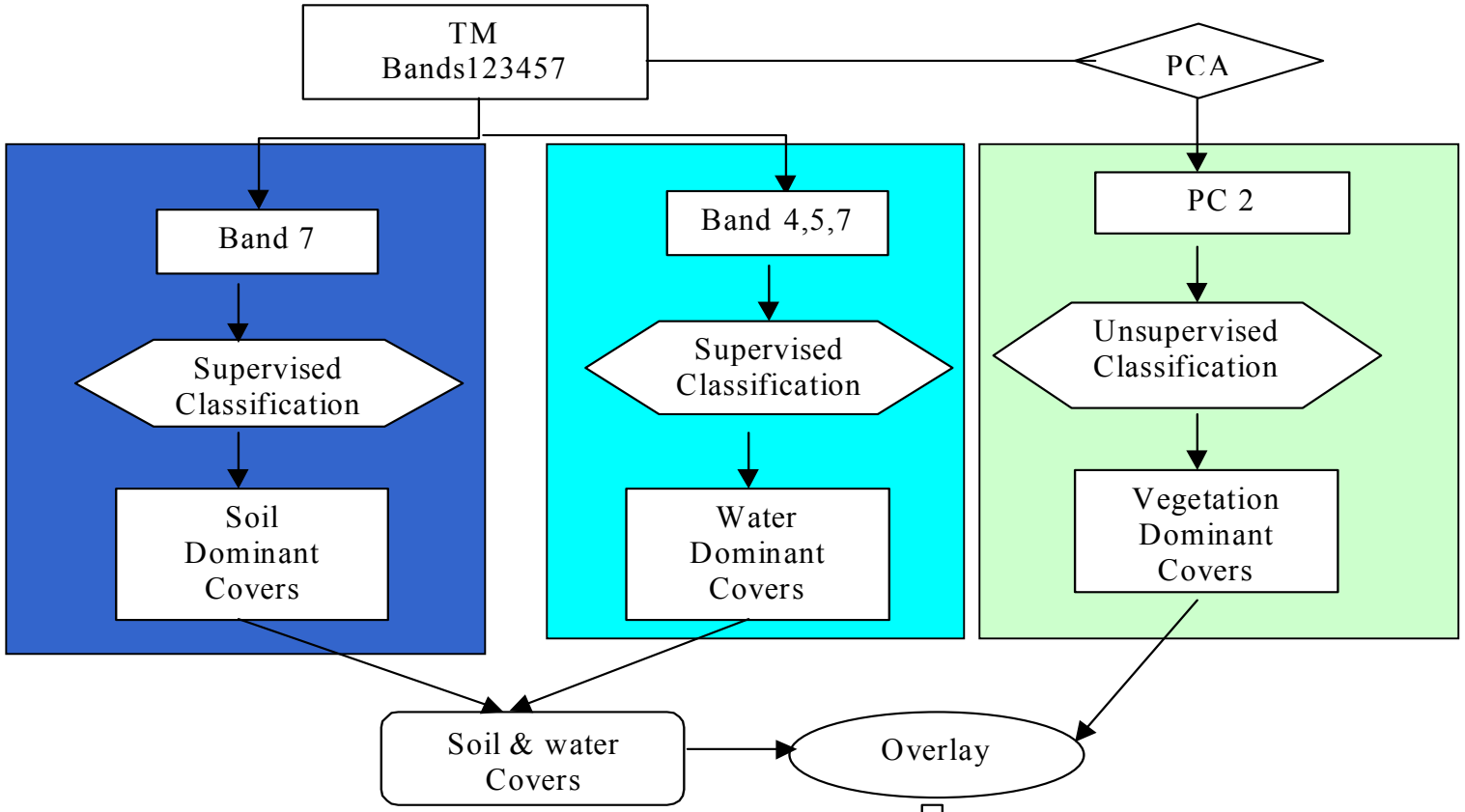
July 20-22, 2000: NASA/Miombo GOFC Workshop in Maputo, Mozambique (draft papers presented). Manuscripts due 1-3 months later.

August – December, 2000: Reviews and Revisions

GECP

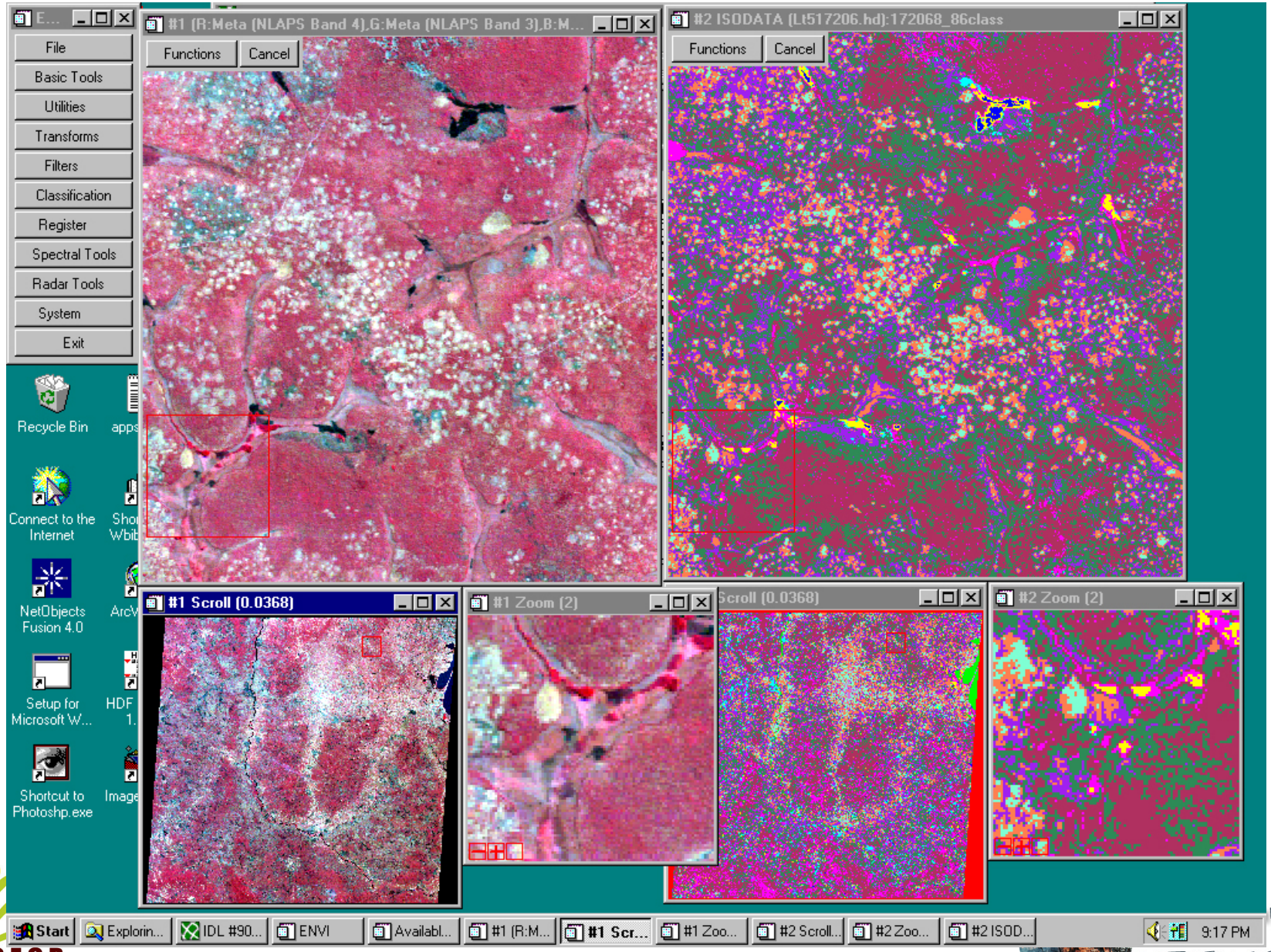
MIOMBO NETWORK

Stepwise Thematic Classification



GECP

MIOMBO NETWORK



GECP

NETWORK

Data Plan

- Miombo IMS – distribution of RS data to regional partners – web based and manual/distributed system joint with ESIPS

- Data bundles for modeling and characterization (CD product planned with data windows for Africa, Miombo Region, Mozambique, Limpopo River Basin emphasis

- Forest biomass data (historical) from miombo country data records for full carbon accounting: forest plantations and community-managed woodlands – archival on miombo home page

GECP

MIOMBO NETWORK

Questions to be Addressed by Research

1. Soil Carbon

- What is equilibrium soil carbon amounts in soils of miombo region (undisturbed systems)? <*GIS analysis jointly with USDA Soils Group*>
- What is the spatial pattern of land use – current and over the last few decades in relation to soil types? <*Soils are important determinants of soil carbon*>
- What are soil carbon recovery rates under common land use change trajectories? <*Broaden database in miombo region to cover different soil-climate-landuse regimes*>
- Where are (soil) carbon projects likely to succeed? <*where is greatest potential among existing community-managed forests/woodlands*>
- What is a cost-effective strategy for assessing and monitoring carbon at the landscape level under a carbon project setting – area distribution of carbon densities, or carbon density of land cover/soil types? <*evaluate in light of ongoing C projects in Africa – FAO/USAID/IFAD/IUCN*>

Questions to be Addressed by Research

2. Aboveground Biomass/Carbon (AGB)

- How does asymptotic AGB vary with site (soils, climate, landform) in intact miombo systems? <*site characterization then sampling*>
- What is the spatial pattern of land use/land cover change – current and over the last few decades?
- How adequate are standard allometric functions used in carbon studies? <*validation and localization methods*>
- What is impact of coppicing on above-ground biomass? <*comparative plot assessments*>

Coppicing likely increases above ground biomass, below-ground components likely significant stores of biomass - regional impacts wrt Carbon stocks largely unknown

3. Questions Related to Forest Biometrics

Are Soil and Land Cover Maps necessary for operational assessment of landscape carbon such as in a carbon trading project?

What is the optimal use of remote sensing data (Landsat mostly) in regional biomass measurement? <*delineation of stands or more*>

What is spatial distribution of site quality from characterization activity?

What is an optimal sampling strategy for the miombo region after a regional characterization in soil-climate-landform space?

Schedule/Critical Path

Year I

Landsat Data Acquisition and preprocessing

Regional Coordination Workshop and Special Issue

Data Bundle and Regional Characterization

Setup Field Sites in Mozambique

Year II

Continue Landsat Data Processing and produce updated LC Map for Mozambique

Regional workshop with country partners

Biomass allometries and growth/yield models

Preliminary Carbon budget

Year III

Full carbon accounting for miombo region

Sampling and mapping strategy for miombo region – transition into operational mode

GECP

MIOMBO NETWORK

Progress to date

- START Fellow, Steve Makungwa, Forest Inventory and PSP data rescue *(digital database)*
- START Fellow, Leo Zulu, RS analysis, Miombo GOFC GIS data bundle *(Data CD planned)*
- Maputo Regional Coordination Workshop; Special Issue publication in progress.
- Data Acquisition and Distribution to regional partners
- Field Work – northern Mozambique

GECP