Progress report – Miombo project

Compilation of Remote sensing and GIS data

The following free or cheap data sets were compiled for Nhambita and Gorongosa National Park:

(a) Roads, rivers, and major towns (from the the Digital Chart of the World)
(b) Boundary of Gorongosa national park (from the World Conservation Monitoring Centre)
(c) Boundaries for Sofala province and its districts (from the National Council for Geographic Information and Analysis)
(d) Landsat TM and ETM+ imagery for 1st January, 1991 and 31st December, 2000 (from University of Maryland).

Most of these map layers are at rather coarse spatial scales, so the digitised positions of boundaries, roads, and rivers, may differ by several kilometres from their true locations.

These data were combined with the GPS readings taken in the field to date. These field measurements comprise:

(a) Piet's baseline survey of land holdings of approximately 60 farmers in Nhambita, all of whom have signed Plan Vivo agreements.
(b) Patrick Mushove's forest sample plots within Nhambita.
(c) Mat Williams' GPS readings for key road junctions and locations within Nhambita.

Several further data sets are still being compiled for the study area. These are as follows:

(e) 10-daily rainfall summaries over an 8km grid from 1995 onwards (derived by the USAID Africa Data Dissemination Service from meteorological station records and cold cloud tops detected by the NOAA-AVHRR sensor)
(f) 1:200,000 Soviet-produced topographic maps for Gorongosa, dating from 1981
(g) Landsat MSS imagery from 1980 (from University of Maryland)

As a preliminary exploration of the available data, three analyses were undertaken using the Landsat imagery from both years:

1. Normalised Difference Vegetation Indices were created for both
2. False and true colour composites were created from the visible and near infra-red bands.
3. A simple unsupervised classification was conducted, which identifies grid squares that have similar patterns of reflected light. This represents a 'first cut' at identifying different types of land cover. A more sophisticated attempt at classification will be necessary subsequently.

No image rectification or enhancement was attempted before these calculations and this is likely to prove necessary in future work.

Preliminary findings:

The agricultural plots surveyed by Piet and his team are clearly visible on the Landsat image for 2,000. Figure 1 shows the Normalised Difference Vegetation Index (NDVI) derived from the Landsat image for the year 2,000, a measure based on the amount of red and near-infra red light detected by the satellite sensor. Figure 1 suggested that the ratio of near infra-red to red light from the surrounding forested areas is much higher than for the cleared agricultural plots. The size of the plots is consistent with the patches visible on the Landsat image. Landsat imagery is comprised of 30m pixels, whilst the agricultural plots registered in Nhambita are typically 1-2 Ha in size. In broad terms, this means that a typical plot would appear as between around 10 and 25 pixels on the Landsat image and this seems to be the case.

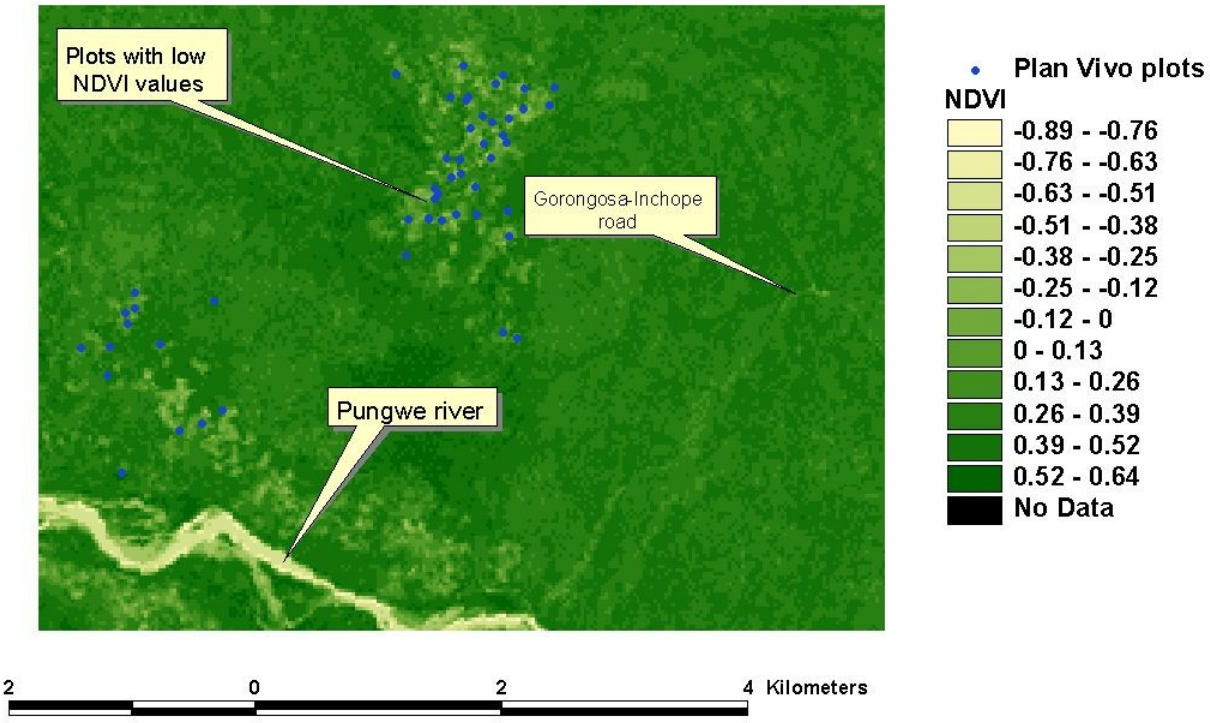

Figure 1: an NDVI vegetation index derived from a Landsat ETM+ image for 30th December, 2000 (registered Plan Vivo farmers' plots are shown in blue)

The Landsat image for 2,000 also suggests that agriculture may be encroaching into Gorongosa National Park near Gorongosa town. In 2,000, very similar patches to those observed for the Nhambita agricultural plots can be seen extending from Gorongosa town to within the park boundary. These apparent areas of agricultural activity are shown in Figure 2. There are no other areas within the WCMC park boundary that show such widespread evidence of apparent agricultural encroachment.

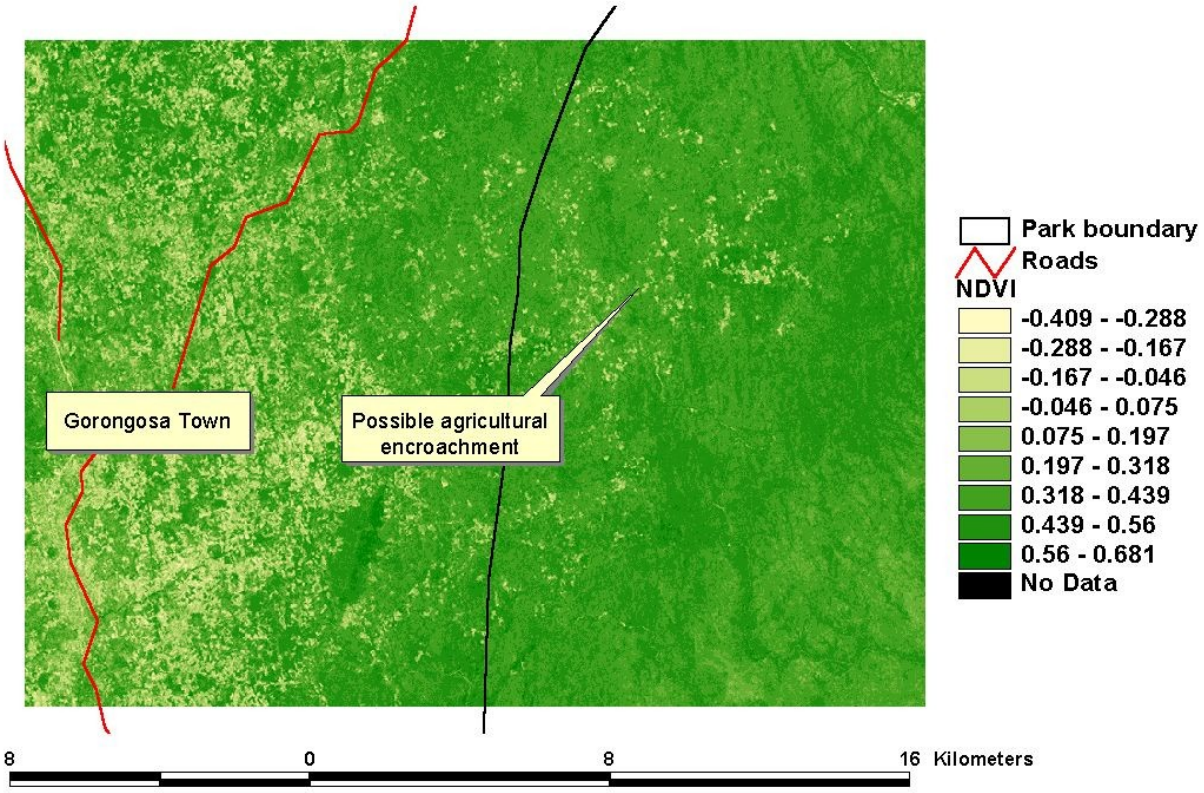

Figure 2: an NDVI vegetation index derived from a Landsat ETM+ image for 30th December, 2000 (the area shown is the park boundary to the east of Gorongosa town)

Sample plot observations about topography and agricultural activity recorded by Patrick and his team are also corroborated by the Landsat image for the year 2,000. When the plot locations were superimposed on the Landsat image, the comments made in the field about topography and agricultural activity were generally consistent with the features visible on the image. Some, though not all, of the roads surveyed by Mat are visible on a colour composite image created from the Landsat imagery. The main road from Inchope to Gorongosa, the road into the park and the track to Boa Morte are all visible on the colour composite image. The other minor tracks are not visible.

The 1991 Landsat image suggests a very different pattern of agricultural land use. The current Plan Vivo plots within Nhambita are not visible on an NDVI image of the area for 1991 (Figure 3). Similarly, the apparent agricultural activity near Gorongosa town appears much more restricted. Unlike the Landsat image from the year 2,000, there is no evidence of agricultural activity within the park boundary (Figure 4).

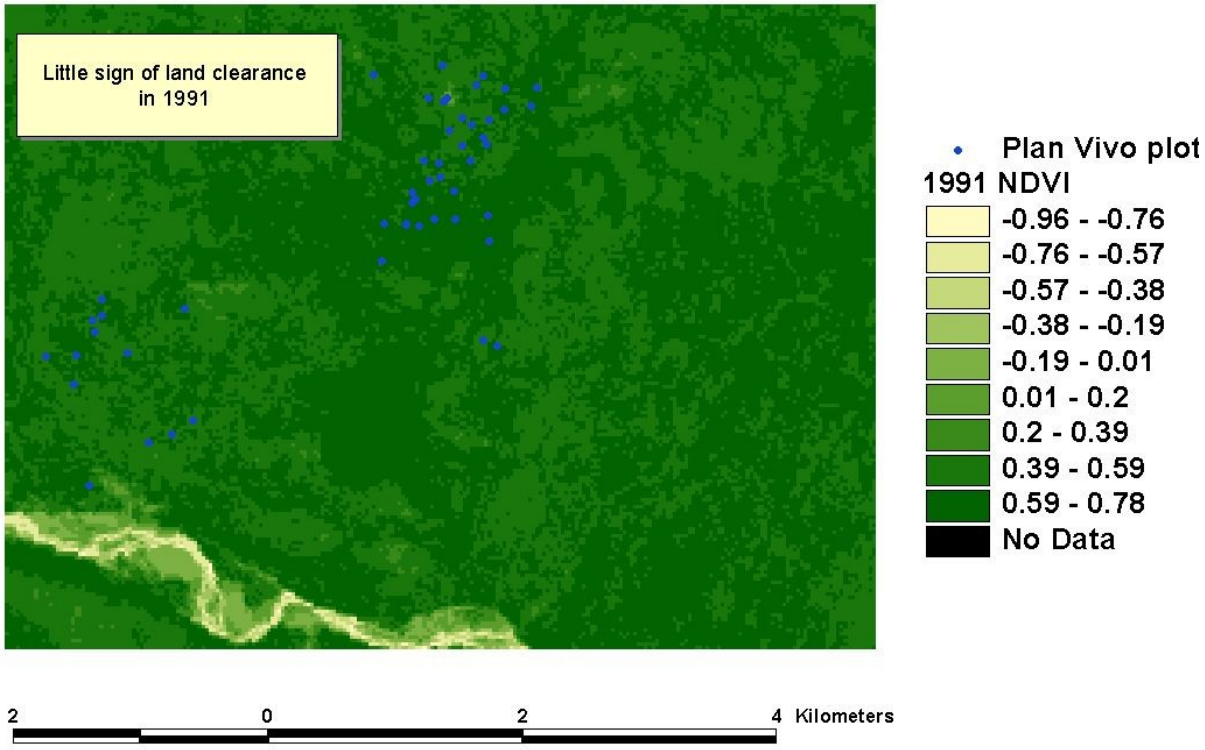

Figure 3: *an NDVI vegetation index derived from a Landsat TM image for 1st January 1991 (registered Plan Vivo farmers' plots are shown in blue)*

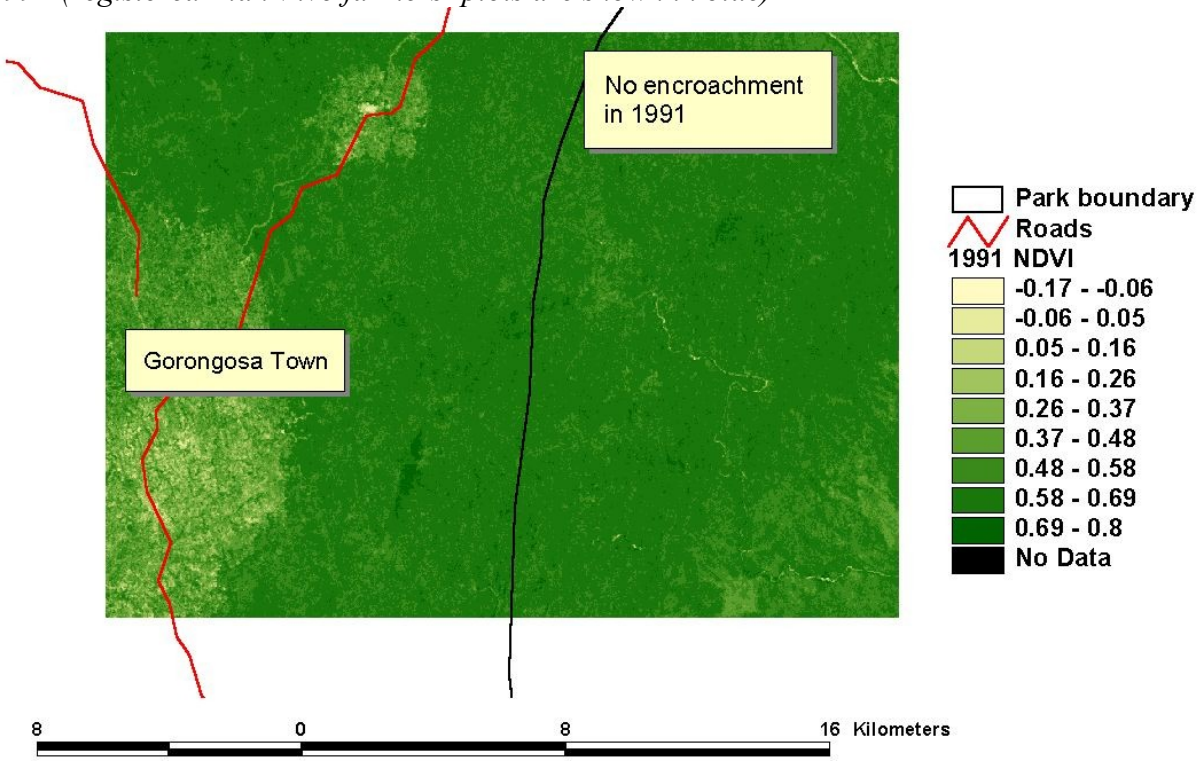

Figure 4: an NDVI vegetation index derived from a Landsat TM image for 1st January, 1991 (the area shown is the park boundary to the east of Gorongosa town)

Preliminary classification of Landsat image for 2000

Figure 5 shows the areas with similar reflected light characteristics identified by the unsupervised classification. Initially 11 land cover classes were identified by the classification routine, based on the 6 visible, near infra-red and short wave infra-red Landsat bands. Three classes that were similar and are likely to be water were then merged together to leave 8 different land cover types. Descriptions were assigned to each of these classes, based on their spectral characteristics and spatial distribution. Further refinement of this very preliminary classification will be necessary and these initial descriptions are likely to need further investigation. Table 1 summarises their characteristics, whilst Figure 6 summarises their reflectance patterns.

Possible land cover type	*Description*	*Reason for assigning land cover type*
Forest & possibly marshland?	Quite widespread and seems related to topography. The area surrounding the Lake in GNP also forms part of this land cover type	spectral data from Landsat imagery
Forest / grassland1?	Possibly grassland/forest mix, or secondary forest / areas of broken canopy. Quite widespread and seems related to topography.	spectral data from Landsat imagery
Forest / grassland2?	Possibly grassland/forest mix, or secondary forest / areas of broken canopy. Quite widespread and seems related to topography.	spectral data from Landsat imagery
Forest / grassland margins?	The edges of the Nhambita plots and the camp airstrip, as well as patches throughout GNP	spectral data from Landsat imagery
Agriculture / grassland?	Includes the centres of the Nhambita plots, the area around Gorongosa town, as well as the airstrip northeast of the park camp. A few patches occur within GNP, but generally occurs outwith the park.	Spatial distribution
Water?	Indian Ocean, lake, Pungwe and other rivers. A few patches of water & land appear misclassified in this preliminary classification, unless some seasonal flooding has occurred.	Spatial distribution; spectral data from Landsat imagery
Sand / bare earth?	Near rivers, with patches in GNP and occasionally in the Nhambita fields	Spatial distribution; spectral data from Landsat imagery
Vlei (riverine grasses?)	Near rivers	Spatial distribution

Table 1: Characteristics of land cover types identified from an unsupervised classification of Landsat ETM+ imagery for 2000

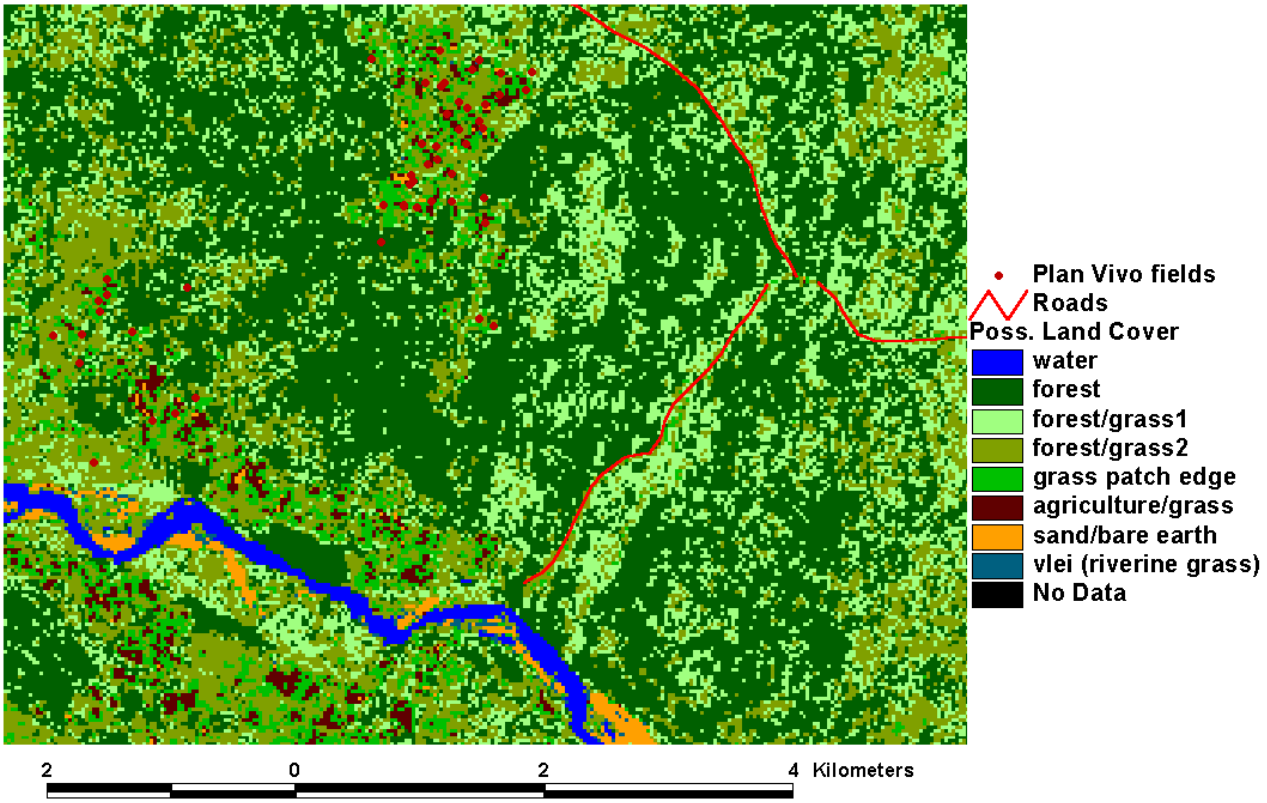

Figure 5: Preliminary land cover classes derived from an unsupervised classification of Landsat ETM+ imagery for 2000 (Nhambita area)

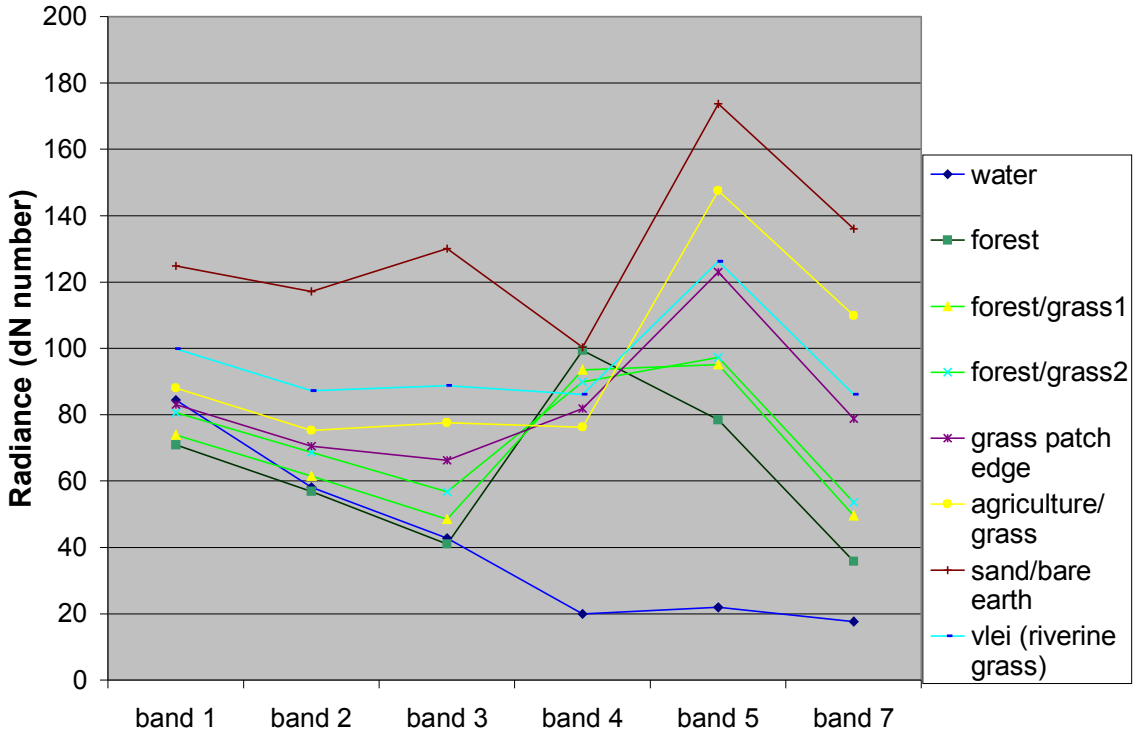

Figure 6: spectral characteristics of 8 land cover classes identified through an unsupervised classification of Landsat ETM+ scene for 2000 (band 1: blue (0.45-0.52um); band 2: green (0.53-0.61um); band 3: red (0.63-0.69um); band 4: near infra-red (0.76-0.9um); band 5: short wave infra-red (1.55-1.75um); band 7: short wave infra-red (2.08-2.35um)

Tentative conclusions:

Subject to a more thorough investigation on the ground, we can draw several tentative conclusions about land cover change in Nhambita and Gorongosa:

1. Apparent agricultural encroachment into the park has been occurring near Gorongosa town, but not on a large scale elsewhere.
2. Mashambas do seem to be visible on Landsat imagery, which suggests that we may be able to derive baseline maps for the project using Landsat.
3. The Plan Vivo plots at Nhambita are relatively recent, having been cleared within the last 13 years. The apparent encroachment near Gorongosa town also seems relatively recent.

Future directions:

These very preliminary findings could be taken forward in several ways:

(a) We could acquire more recent Landsat imagery, as well as imagery for intermediate years between 1991 and 2000 to provide a more detailed picture of land cover change within the area. Both cost and the availability of cloud free imagery around 1st

January may limit this analysis. Landsat imagery from earlier or later in the growing season is likely to show different reflectance patterns and thus make inter-year comparisons more difficult.

(b) We could use RadarSat imagery to gain a better understanding of canopy structure and thereby carbon dynamics across broad areas.

(c) The MODIS fire products could be added to the existing spatial database.

(d) Some key data sets necessary to model land cover change have not yet been collated. Such data include demographic and (if available) agricultural census results for Sofala, details of mine-clearing operations, topography, the transport network (and the timetable of any upgrading of roads to this), and details of any quantities of charcoal taxed.

(e) The unsupervised classification technique used with the 2,000 LandSat image was very rudimentary. More sophisticated unsupervised techniques may produce a more accurate depiction of land cover.

(f) More detailed data for subsets of the Landsat imagery could be used to undertake a supervised classification. There are three potential sources for this. Firstly, historical aerial photography may be available (e.g. as the basis of the 1981 topographic maps), which could be used for performing supervised classification of some of the older Landsat images. Secondly, we may be able to use Ikonos imagery (e.g. for Nhambita) to identify training sites and so classify the Landsat imagery. The third option would be to use Piet's contact with the microlite to survey an area of the park, thus providing training sites for classification.

Possible fieldwork options might include:

(a) Ground-truthing of any current land cover maps produced will be necessary. Potentially, we could use the existing plot data and Plan Vivo database for 'ground-truthing' but ideally we should undertake a survey explicitly for this purpose, based on

(b) At the end of the dry season, a very useful exercise might be to survey the boundaries of burnt areas as a means of checking the quality of the MODIS fire products.

(c) Surveying of the Plan Vivo plots using multiple GPS readings for each plot.

Actions:

(a) Contact Catholic University in Beira

(b) Identify cloud-free imagery and costs of using Landsat year-on-year, as well as cost of latest imagery

(c) Refine classification methods used

(d) Continue compiling data for project spatial database (e.g. rainfall imagery, digital elevation model, MSS image from 1980, etc.)

(e) Contact Ian Woodhouse regarding sources and possible use of radar data