

REFORESTATION IN GRASSLAND AREAS OF UCHINDILE, KILOMBERO, TANZANIA & MAPANDA, MUFINDI, TANZANIA



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1 PROJECT DETAILS

1.1 Summary Description of Project

The project is reforesting degraded grasslands in the Southern Highlands of Tanzania using the Verified Carbon Standard (VCS) for the Afforestation, Reforestation and Revegetation (ARR) project type that falls under the AFOLU (Agriculture, Forestry and Other Land Uses) category of eligible project activities. The project applies a methodology of the Clean Development Mechanism (CDM) for afforestation/reforestation – AR-AM0005, version 3. The project is located in two separate areas: Uchindile Forest Project (UFP) and Mapanda Forest Project (MFP), where reforestation takes place on many discrete small parcels of land at the two locations.

Green Resources Limited (GRL) has been granted title to a total of 18,379 ha of land split between Uchindile Forest Project (UFP) of 12,121 ha and Mapanda Forest Project (MFP) of 6,258 ha. Due to a land dispute (see section 2.1 of this report) Uchindile's total area is now 6,647ha (see figure 1.7.2). At the end of the current monitoring period, 3,231 ha and 3,012 ha had been planted at UFP and MFP, respectively. The land is held on a 99 year lease title that has been issued to the company by the Ministry of Lands and Human Settlements of Tanzania. The land acquisition in Tanzania is a bottom-up process that starts at village level and proceeds through district to national level where issuance of title deed is made – see the VCS PD for a detailed description of this process.

The project started in 1997 when the company set out to develop a commercially viable reforestation project that combined revenues from carbon and timber. The project was initiated based on CDM rules, but when the rules for the CDM AR methodology were finalised the project was ineligible due to its early start date of 1997 – no project that started pre-2000 is eligible under the CDM. However the project was eligible under the VCS ARR rules and achieved validation on the 17th July 2009. In accordance with the VCS AFOLU rules, the earliest date that carbon crediting can begin is from 2002. Therefore the first monitoring was done for the period between 1st January 2002 and 30th November 2008. The current monitoring report therefore covers the period between 1st December 2008 and 1st September 2012. The species that have been planted are various genera of pine and eucalyptus (see Table 1) where *Pinus patula* and *Eucalyptus saligna* make up the dominant species.

In the baseline scenario, the land would remain as degraded grassland, which has over a period of many years been degraded as a result of regular frequent fire regimes forcing the original natural miombo woodland back to the more moist gullies and valley bottoms. The grasslands have remained in a steady state for several decades. Areas where the natural woodland remains are kept as natural woodland with buffer zones between them and the reforestation activity to ensure biodiversity protection. The conservation areas will help to preserve the natural hydrology and promote the protection of biodiversity and wildlife in the area. No carbon benefits are being sought by the company for the protection of these

areas. The exotic species being grown in the plantation areas are on a rotation that creates a permanent carbon sink, which is established with sustainable harvesting. GRL plans on maintaining such sustainable forestry and harvesting activities at the project sites on a long-term basis – beyond the 99 year crediting period. The harvested wood will be used to provide high-quality value-added products to local markets such as utility poles, furniture and sawn timber. An added benefit of this is that it will reduce deforestation pressure for timber from native forest as it provides an alternative, sustainable source of timber.

The plantation follows best practice in forest establishment, management techniques, stakeholder consultation and environmental protection; and received FSCTM certification on the 8th of August 2008. This has been successfully retained since through surveillance audits in 2009, 2010 and 2011.

Table 1: List of Genera and Species planted

Genera	Species
Eucalyptus	<i>Eucalyptus camadulensis</i>
Eucalyptus	<i>Eucalyptus cloeziana</i>
Eucalyptus	<i>Eucalyptus globulus</i>
Eucalyptus	<i>Eucalyptus grandis</i>
Eucalyptus	<i>Eucalyptus maidenii</i>
Eucalyptus	<i>Eucalyptus saligna</i>
Eucalyptus	<i>Eucalyptus tereticornis</i>
Eucalyptus	<i>Eucalyptus urograndis</i>
Eucalyptus	<i>Eucalyptus urophylla</i>
Pine	<i>Pinus caribaea</i>
Pine	<i>Pinus elliotti</i>
Pine	<i>Pinus oocarpa</i>
Pine	<i>Pinus patula</i>
Pine	<i>Pinus taeda</i>

1.2 Sectoral Scope and Project Type

Sectoral scope: 14. Agriculture, Forestry and Other Land Use.

AFOLU Project Category: Afforestation, Reforestation and Revegetation (ARR).

The project is not a grouped project.

1.3 Project Proponent

Entity	Function	Contact
Green Resources Ltd (GRL)	Locally registered subsidiary of Green Resources AS (GRAS) Company. A tree planting and carbon offset company in Tanzania. GRL is the implementer of the project.	Sangito Sumari, General Manager, Green Resources Limited, Plot No. 446, Mikocheni P.O Box 4730, Dar es Salaam, Tanzania Tel: +255 22 260 2794 Email: sangito.sumari@greenresources.no
Green Resources AS (GRAS)	Mother company of GRL; Forest industry, renewable energy and carbon offset company. GRAS provides financing to GRL as well as management services.	Nicholas Embden, Green Resources, 8/11 St. John Lane, London EC1M 4BF, UK Tel: +44 207 250 1418 Email: nicholas.embden@greenresources.no

1.4 Other Entities Involved in the Project

The village governments of Uchindile, Kitete, Mapanda and Chogo are also entities involved in the project. The project land has been given to GRL from these villages. These villages receive 10% of the carbon revenues generated from the sale of the VCUs from the project – the community carbon revenues are used for additional community development projects.

1.5 Project Start Date

1st January 1997

1.6 Project Crediting Period

The project crediting period is 99 years.

Crediting period start date: 1st January 2002.

Crediting period end date: 31st December 2101.

This monitoring period is the second monitoring period and started on 1st December 2008 and ends on 1st September 2012.

1.7 Project Location

The ARR VCS project activity is located in East Africa, in the United Republic of Tanzania. The discrete project areas of land are found in the southern highlands of the country (see figure 1 and 2). UFP lies in Kilombero district, Morogoro Region and Mapanda is in Mufindi district, Iringa Region. UFP is found at longitude 35°28'13"E and latitude 8°42'11"S, whilst Mapanda Forest Project is found at Longitudes 35°39'49"E to 35°44'52"E and Latitudes 8°24'30"S to 8°33'19"S.

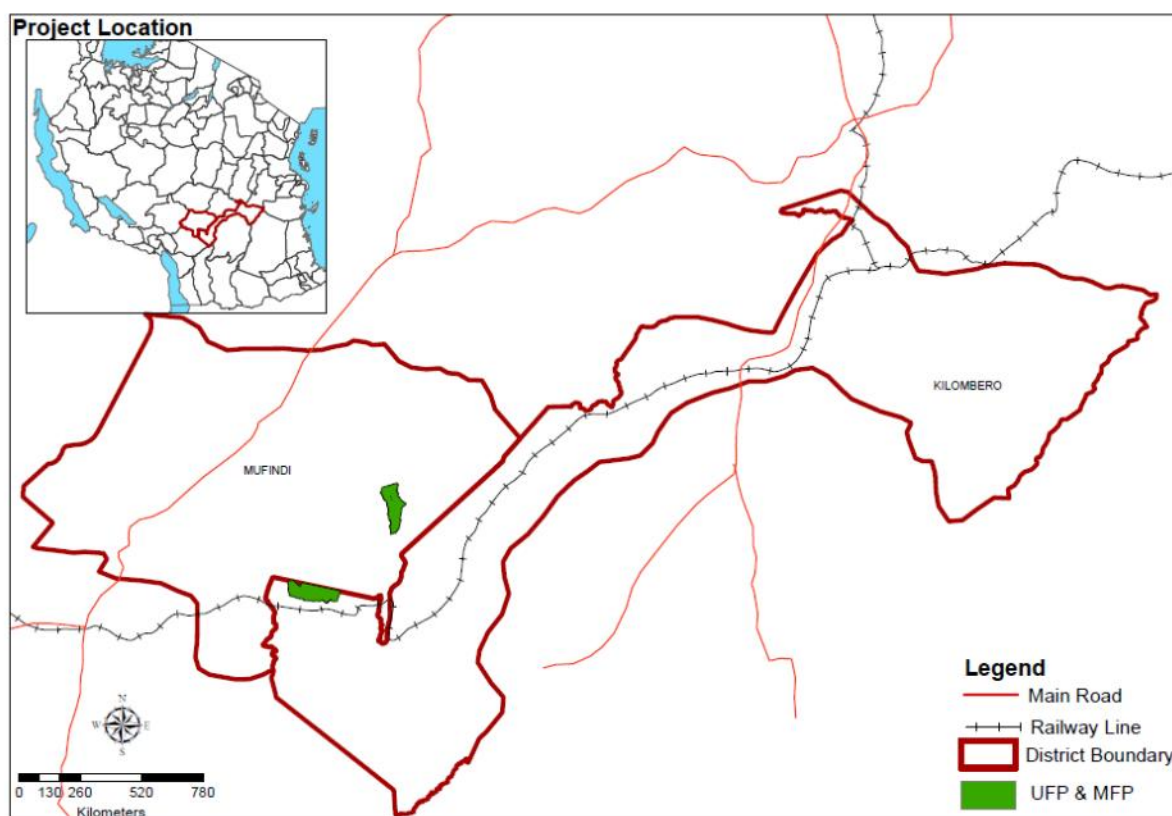


Figure 1.7.1: Location of ARR VCS project activity

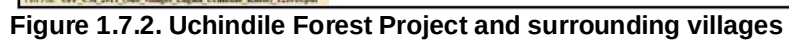


Figure 1.7.2. Uchindile Forest Project and surrounding villages

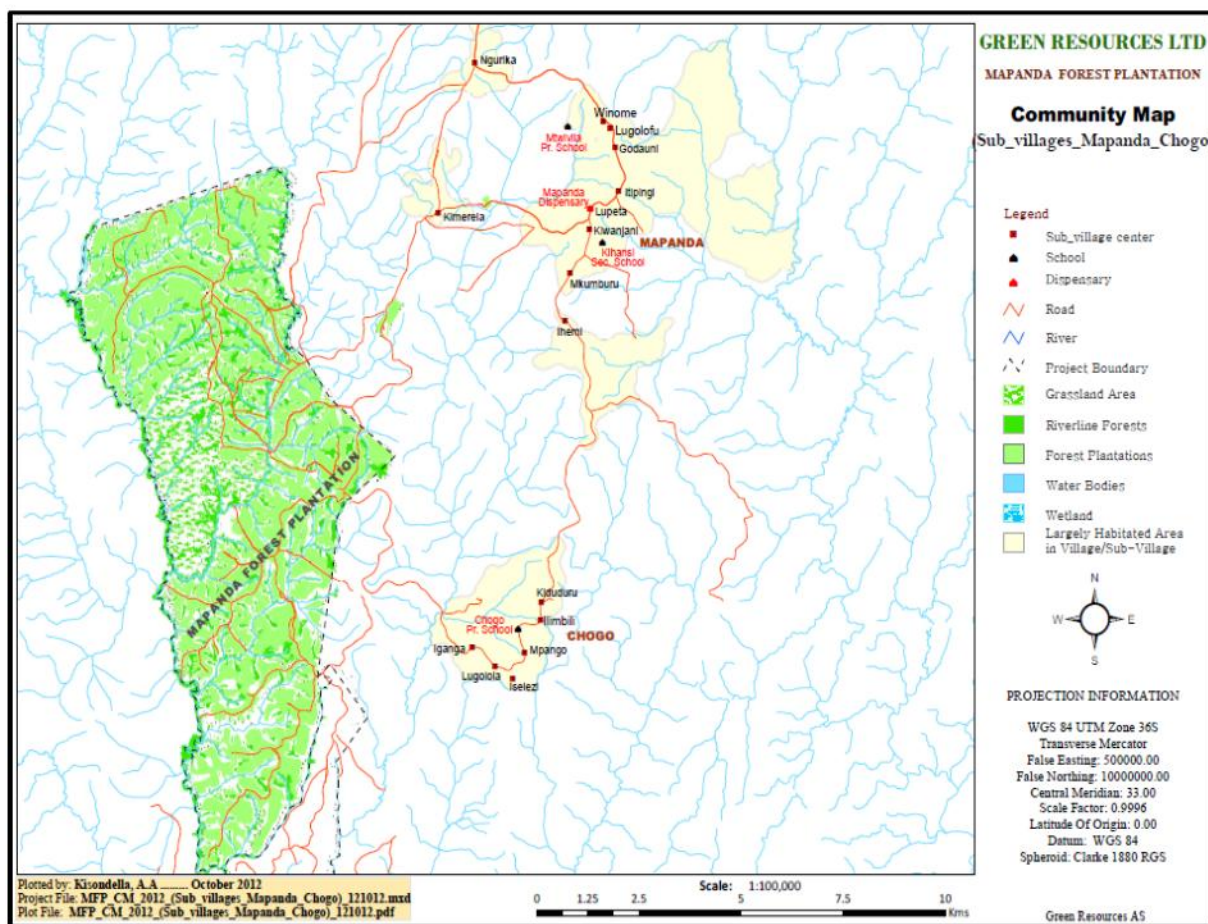


Figure 1.7.3. Mapanda Forest Project and surrounding villages

1.8 Title and Reference of Methodology

The selected approved baseline and monitoring methodology is the CDM's AR-AM0005: "Afforestation and Reforestation project activities implemented for industrial and/or commercial use" - Version 03.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

At the end of the last monitoring period that covered the monitoring period from the 1st January 2002 to the 30th November 2008¹, a total of 2,325 ha at Uchindile and 1,764 ha at Mapanda had been planted. At the end of the second monitoring period covered by this monitoring report, 2870 ha at Uchindile and 2939 ha at Mapanda had been planted, as shown in Figure 2.1.1 and Figure 2.1.2 below. Of these, 1752 ha were planted with Eucalyptus, 4028 ha of Pine. In addition, 29 ha were planted as trial plantings; however, these are not included in the calculation of carbon stocks to claim GHG benefits under the VCS.

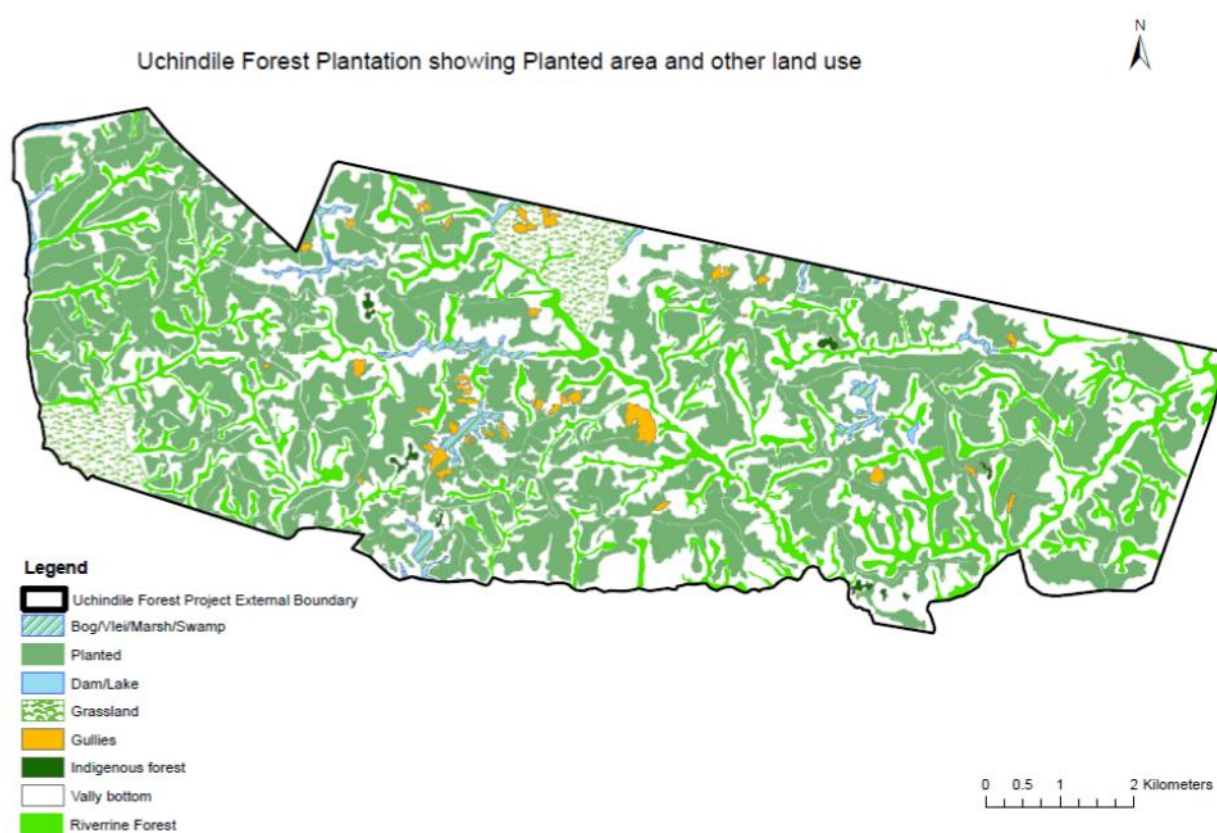


Figure 2.1.1. Uchindile Forest Project – Land-use Classification Map 2012

¹ See Reforestation in grassland areas of Uchindile, Kilombero, Tanzania & Mapanda, Mufindi, Tanzani, VCS Monitoring Report, 1st January 2002 to November 30th 2008, Version 7, May 25th 2010

Mapanda Forest Plantation showing Planted area and Other Land use

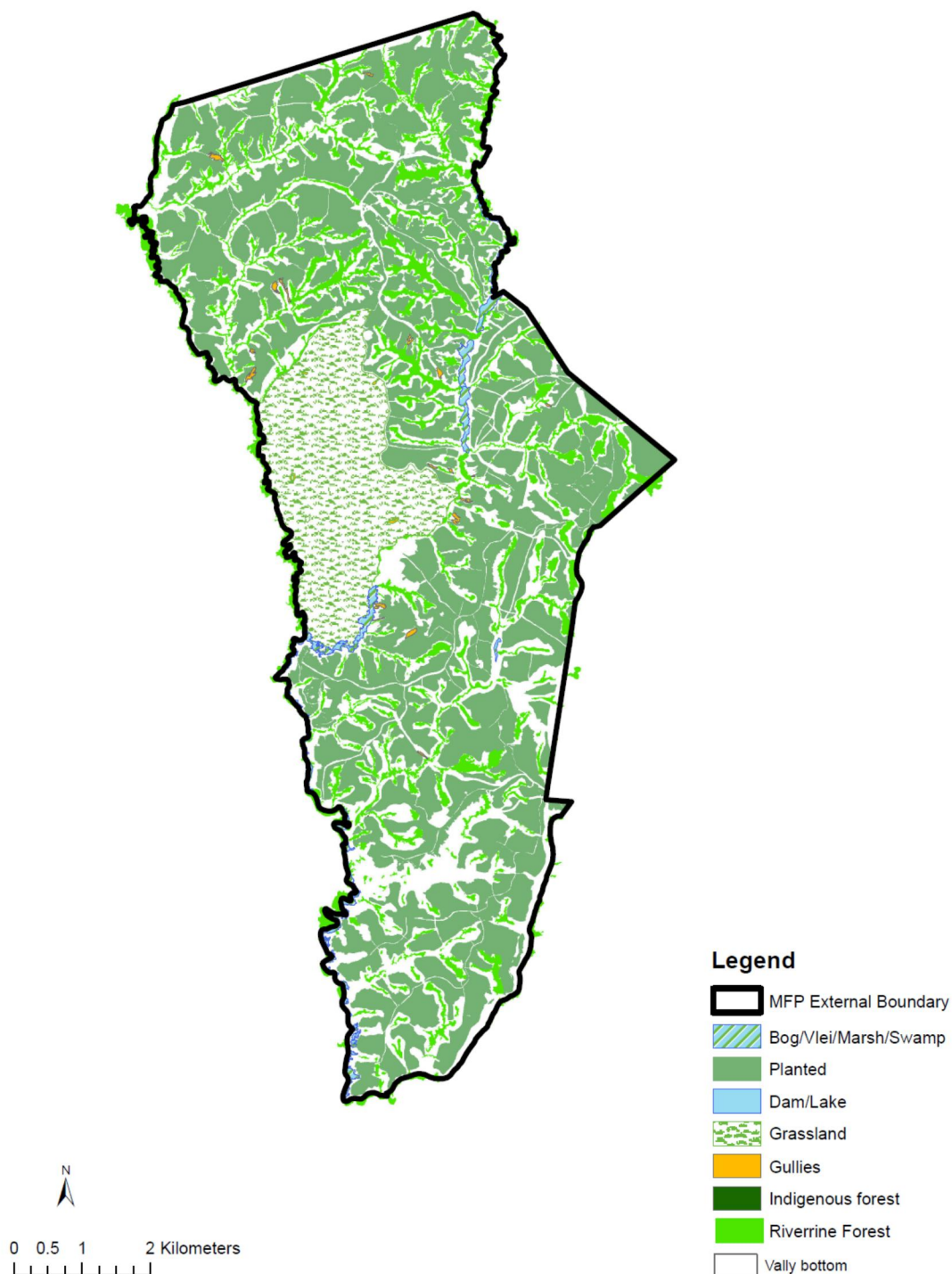
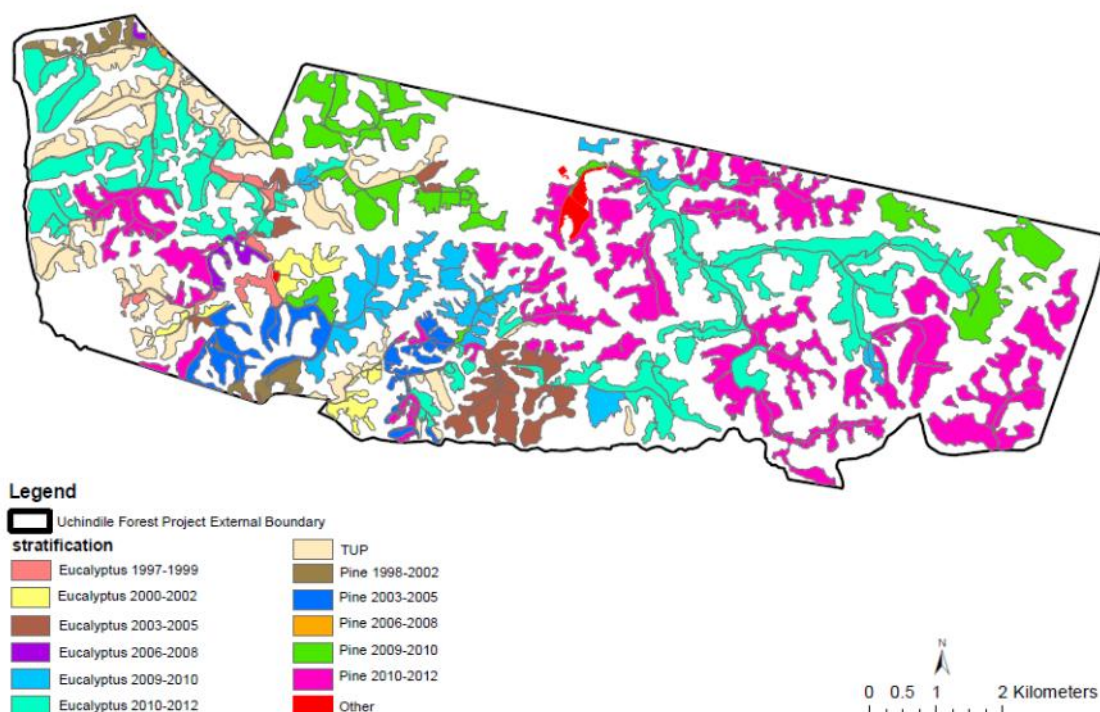


Figure 2.1.2. Mapanda Forest Project – Land-use Classification Map 2012

The project boundary of the Uchindile area has been monitored through application of the monitoring plan and reduced in size due to a land dispute in the northern half of the initial project boundary. The dispute was between the Tanzanian Government's Ministry of Natural Resources and Tourism and GRL. The dispute was raised by the government owned Sao Hill Forest Plantation in Mgololo, which claims that the northern part of GRL's Uchindile Forest Plantation is within the Mgololo Forest Reserve, Mufindi District. The disputed area is approximately 5,474 hectares³. GRL has the title deed for the whole area of land and it has held, since 1999, a Certificate of Acceptance of Boundary Beacons from the then Tanganyika Ministry of Lands, Forests and Wildlife, Survey Division approving the corner beacons of the Uchindile land. In addition, GRL has received a letter from the Director of Forestry and Beekeeping in 1996 declaring that the Ministry of Natural Resources and Tourism categorically declared that it had no objections to GRL being granted the area. The company has had several meetings with the Ministry of Natural Resources and Tourism to try and resolve the problem and has agreed to surrender the disputed land back to the government, as the alternative would be to follow the legal advice and pursue it in the courts. Green Resources had not been planting in the disputed area and no GHG benefits have been claimed from the disputed area. GRL has therefore decided to reduce the area of the project by changing the project boundary so as to exclude the disputed area.

Uchindile Forest Plantation Stratification



³ All correspondence in relation to the disputed land is documented and will be presented to the DOE

Figure 2.1.3. Stratification at Uchindile Forest Project

Mapanda Forest Project - Stratification

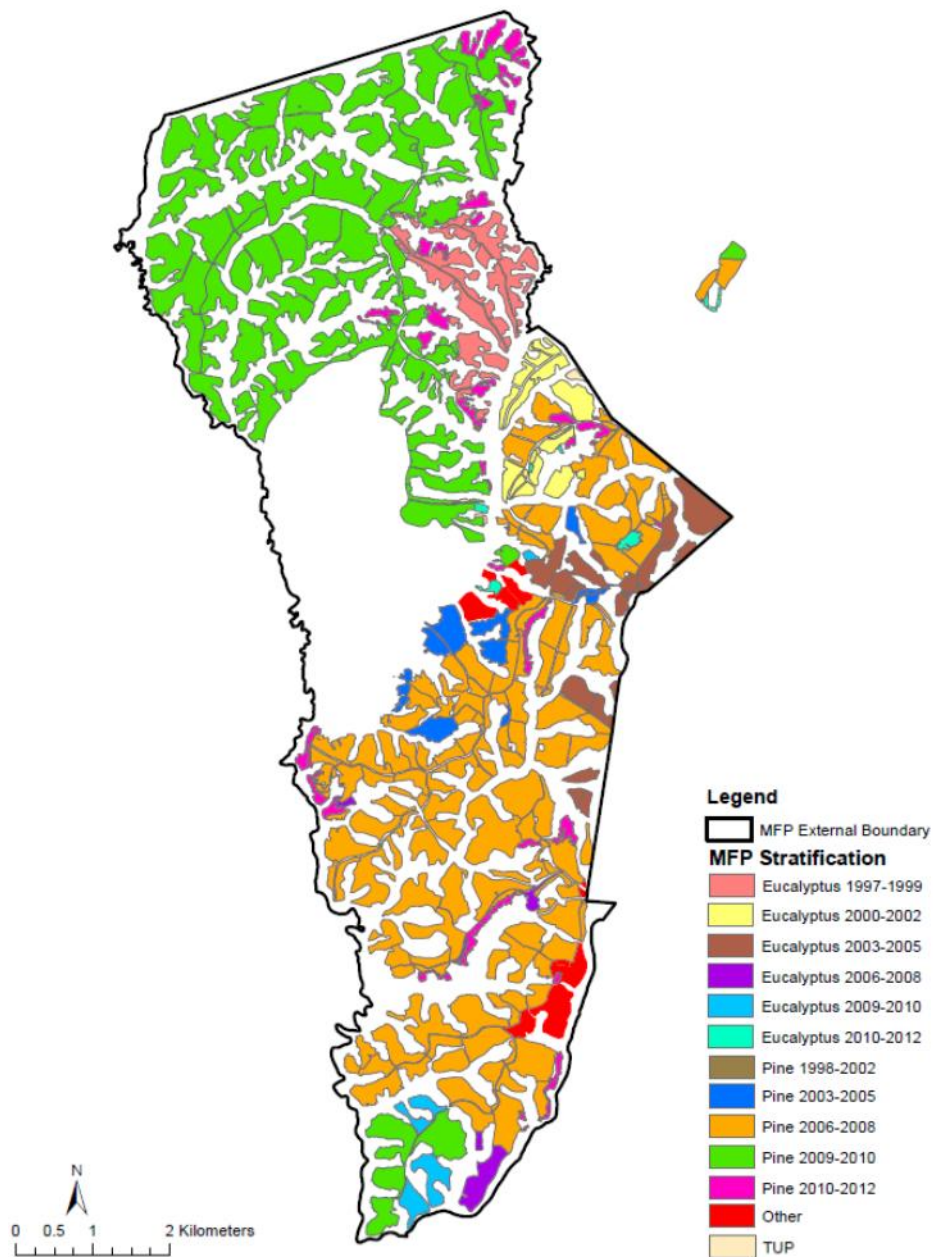


Figure 2.1.4. Stratification at Mapanda Forest Project

At the end of October 2009, GRL experienced a large fire at the Uchindile Forest Project, which affected a total of 1,857 ha of the area that was included in the previous verification covering the first monitoring period. GRL carried out a full internal assessment of the fire, covering both the causes and the impacts, and hired a South African fire expert (Dr. C. De Ronde) to assess the damage. The cause of the fire was

identified as being arson. The impact of the fire was vast due to it occurring in the dry season and there being strong winds which carried the fire.

Immediately after the fire the inventory department classified all compartments into damage classes, and this was then assessed by an external forest fire expert from South Africa to advise on the likelihood of survival and salvaging. Further assessment was done in 2010 a year after the fire.

The fire expert finished his assessment by recommending an Integrated Fire Management strategy. This involves prescribed burning and grazing in buffer zones and underneath the canopy prior to the fire season to reduce the fuel load, as well as zoning of the plantations into blocks with wider fire breaks, using more fire resistant species in the most exposed areas, and further investment in training, firefighting equipment and management capacity. Instrumental to reduce the fire risk is also strengthening relationships with the local community including the establishment of village brigades. Green Resources is now implementing this advice and believe the risk and impact of future fires can be reduced accordingly.

A loss report was submitted to the VCS Secretariat with an estimate of the loss of carbon stocks related to the 2009 fire event⁵. The net loss of carbon stock was estimated to be 76,121 tCO₂e, which was fully covered by the number of GHG removals added to the pooled buffer through the 40% risk rating applied to the 232,264 tCO₂e verified amount of net anthropogenic GHG removals – equivalent to 92,906 tCO₂e.

Following the fire, GRL harvested all compartments which were completely burnt and had no surviving trees. A total of 393 ha were harvested early due to the fire and 2371 ha were replanted. The loss of carbon stocks due to the fire has significantly impacted the GHG emissions reductions from the project; however, with the quick replanting and improved growth from better silvicultural management from the start, this loss in emission reductions has been regained. The non-CO₂ emissions from the 2009 fire have been calculated in this monitoring report – see section 4.2.

Since no leakage was anticipated at the project in the PD (section E.5), monitoring of leakage parameters is not required in the monitoring plan. Non-permanence risk factors are monitored and managed by the appropriate teams within GRL. For example, GRL's meteorologist ensures that monitoring of weather is carried out continuously at the project sites and this data feeds in to the monitoring of extreme weather, one of the non-permanence risk factors. Fires, pest outbreaks and diseases are all monitored by the GRL inventory team in cooperation with the patrol teams, which are the teams continuously monitoring on the ground and usually the first personnel to alert management of any such issues. Other non-permanence risk factors, such as community engagement, are monitored and managed through GRL's community development team, which consists of a Community Manager and a Community Officer. Their roles are to

⁵ Loss event report, Reforestation in grassland areas of Uchindile, Kilombero, Tanzania & Mapanda, Mufindi, Tanzania, Version 01, 20th October 2011

sensitize the communities on GRL activities as well as provide an easy way for the communities to approach the company and provide their feedback or suggestion. They also follow up with the communities regarding development projects that GRL is implementing.

2.2 Deviations from the Monitoring Plan

Table 2.2.1 below shows a number of parameters that have not been monitored in this monitoring period. These parameters along with the deviations described below are in line with the VCS Standard v.3.3, section 3.5 and do not affect the conservativeness of the quantification of GHG emission reductions or removals. These deviations are therefore considered acceptable.

Table 2.2.1. Parameters not monitored.

ID number (PDD)	Name of parameter	Comment
E.1.02.04	Compartment composition	not monitored
E.1.2.05	Marking of planting spots	not monitored
E.1.2.07	Volume of pit	not monitored
E.1.2.08	Height of seedlings	not monitored
E.1.2.12	Number of trees survived	not monitored
E.1.2.17	Biomass stock before slash and burn	not monitored
E.1.3.03	Biomass stock lost per ha during thinning	not monitored
E.1.3.08	Area allowed to regenerate/ resprout	not monitored
E.1.3.13	Area re-growth by fire	not monitored

Another deviation is the measurement of only four tree heights in each permanent sample plot. In the PD, it is stated that all tree heights will be measured; however, following the methods used in the studies to determine the volume equations, which the project is using, only the dominant height needs to be measured. This is done by measuring the four largest trees within each plot. This same deviation was requested and accepted at the first verification.

The final deviation is the maximum permissible error level and confidence level. In AR-AM0005 Version 3, the maximum permissible error level is $\pm 10\%$ at the 95% confidence level. However, the VCS Version 3 allows for projects to adopt a maximum permissible error level of $\pm 10\%$ at the 90% confidence level, and as such, this has been applied in this monitoring report. In addition, for some of the strata, this precision level could not be met. Instead, a conservative adjustment was made to the mean carbon stock following the guidance from the CDM A/R Working Group, 28th meeting – see paragraph 11.

2.3 Grouped Project

The project is not a grouped project; therefore this section is not applicable.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Some parameters have been reviewed to ensure better estimates for tree biomass and as such are described in the next section (monitored parameters); these were basic wood density (D), biomass expansion factor (BEF) and root-to-shoot ratio (R).

According to the methodology default values should preferably be from locally-derived species-specific information or if not available should give preference to species-specific regional or national datasets with similar soil and climatic conditions. Alternatively, information for similar species or default values from the IPCC Good Practice Guidelines can be used. The wood density values are species-specific mean values (*Pinus patula* and *Eucalyptus saligna*) from a Tanzanian study representing similar climatic conditions.

For the BEF, since values for the same species / genus and project site or region were not found, data from the IPCC Guidelines was used (see table 3.1.1 below). For the eucalyptus, the range of values is not for the same genus, therefore, it was deemed conservative to take a value half way between the lower limit of the range and the mean. For pine, since there is a BEF for tropical pine forest, the average was taken and applied without any adjustment. The root-to-shoot ratio for both species was taken from the IPCC Guidelines, which has genus specific values. Since the different strata in the project have significant differences in mean above ground biomass (t/ha), R values were taken considering the three ranges of above ground biomass values in the IPCC Guidelines (<50, 50-150 and >50 t/ha).

Table 3.1.1. BEF, W and R values for pine and eucalyptus.

Specie	PD values			Updated values				
	BEF	D	R	BEF	D	R		
						< 50	50 - 150	> 150
Pine	1.30 ⁶	0.45 ⁷	0.32 ⁸	1.30 ⁶	0.44	0.46	0.32	-
Eucalyptus	2.00	0.80 ⁹	0.35 ¹⁰	2.70 ⁶	0.46	0.45	0.35	0.2

⁶ Taken from table 3A.1.10 of the GPG LULUCF 2003.

⁷ Taken from table 3A.1.9 of the GPG LULUCF 2003

⁸ Taken from table 3A.1.8 of the GPG LULUCF 2003 – mean value taken from the conifer forest/ plantation category with aboveground biomass (t/ha) of 50 - 150

⁹ Taken from the book "The Commercial Timbers of Tanzania", J.M. Bryce, revised edition of 1999. Although this is the maximum value for the wood density for this species, so a more accurate value is presented.

¹⁰ Taken from table 3A.1.8 of the GPG LULUCF 2003 – mean value for eucalypt plantation taken for biomass of 50 – 150 t/ha

Data Unit / Parameter:	Carbon Fraction
Data unit:	tC / t d.m
Description:	It is used to convert biomass to carbon
Source of data:	IPCC default value
Value applied:	0.5
Purpose of the data:	Used in the calculation of project emission removal
Any comment:	

Data Unit / Parameter:	CO ₂ / C
Data unit:	Dimensionless
Description:	Ratio of molecular weights of CO ₂ and carbon
Source of data:	IPCC default value
Value applied:	44/ 12
Purpose of the data:	Used in the calculation of project emission removal
Any comment:	

Data Unit / Parameter:	Confidence level
Data unit:	%
Description:	The required confidence level at which the error level between samples must meet.
Source of data:	VCS Version 3
Value applied:	90%
Purpose of the data:	Used in the calculation of project emission removal
Any comment:	See the Deviations from the Monitoring Plan section for justification

Data Unit / Parameter:	Error level
Data unit:	t d.m (or t d.m. ha ⁻¹)
Description:	Acceptable margin of error in estimation of biomass stock within the project boundary
Source of data:	VCS Version 3
Value applied:	10%
Purpose of the data:	Used in the calculation of project emission removal
Any comment:	See the Deviations from the Monitoring Plan section for justification

3.2 Data and Parameters Monitored

The following are the parameters used to monitor project boundary:

Data Unit / Parameter:	Compartment ID
Data unit:	Alpha numeric
Description:	Each compartment has a particular combination of tree species and year planted. Numeric series ID is assigned to each compartment.
Source of data:	Assigned in Microforest
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Annually
Value monitored:	See table of compartment IDs presented in Section 5, Additional Information, of this Monitoring Report.
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

The following are the parameters used to monitor forest establishment:

Data Unit / Parameter:	Compartment location
Data unit:	Geographical units
Description:	The geographical coordinates of the compartment boundary.
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Global Positioning Systems (GPS) is used to locate geographical coordinates of the compartment boundary before start of planting.
Frequency of monitoring/recording:	Before planting
Value monitored:	Not applicable
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	Verification is carried out through the analysis of high resolution satellite images
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Compartment size
Data unit:	ha
Description:	Calculated from the geographical points collected by GPS
Source of data:	Calculated
Description of measurement methods and procedures to be applied:	Calculated from the geographical points collected by GPS
Frequency of monitoring/recording:	Before planting
Value monitored:	
Monitoring equipment:	GPS
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Areas cleaned (screefed)
Data unit:	m ²
Description:	
Source of data:	Calculated
Description of measurement methods and procedures to be applied:	Supervisors and plantation managers use GPS to control area cleaned
Frequency of monitoring/recording:	Operation is recorded in Microforest every time it is performed.
Value monitored:	See compartment information file
Monitoring equipment:	GPS
QA/QC procedures to be applied:	N/A
Calculation method:	N/A
Any comment:	

Data Unit / Parameter:	Area weeded
Data unit:	ha
Description:	Weeding is conducted to minimize competition from grass three months after planting. Completion of weeding is recorded in Microforest.
Source of data:	Calculated
Description of measurement methods and procedures to be applied:	Supervisors and plantation managers use GPS to control area weeded

Frequency of monitoring/recording:	Operation is recorded in Microforest every time it is performed.
Value monitored:	See compartment information file
Monitoring equipment:	GPS
QA/QC procedures to be applied:	N/A
Calculation method:	N/A
Any comment:	

Data Unit / Parameter:	Area slashed
Data unit:	ha
Description:	Slashing is conducted mainly in Eucalyptus stands preferably in the second and third years after planting
Source of data:	Calculated
Description of measurement methods and procedures to be applied:	Supervisors and plantation managers use GPS to control area slashed
Frequency of monitoring/recording:	Recorded in Microforest every time the activity is carried out
Value monitored:	
Monitoring equipment:	GPS
QA/QC procedures to be applied:	N/A
Calculation method:	N/A
Any comment:	

Data Unit / Parameter:	Survival rate
Data unit:	%
Description:	A sample survey for each compartment is performed after the planting season and the calculated figure is recorded in Microforest.
Source of data:	Measured
Description of measurement methods and procedures to be applied:	See SOP 21 Survival assessment 120522
Frequency of monitoring/recording:	After each planting season for newly planted compartments.
Value monitored:	See compartment information file
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	Not applicable

Calculation method:	Not applicable
Any comment:	Not applicable

Data Unit / Parameter:	Area of fire lines and fire breaks
Data unit:	ha
Description:	Each year before the fire season, fire lines and fire breaks are created at the project sites to reduce the risk from fire.
Source of data:	The mapping and inventory team carry out an internal audit each year prior to the fire season to check that the project's risk mitigation measures are in place.
Description of measurement methods and procedures to be applied:	A combination of visual assessments
Frequency of monitoring/recording:	Every year prior to the fire season.
Value monitored:	
Monitoring equipment:	GPS
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	A map of fire lines is presented in Section 5, Additional Information, of this Monitoring Report.

The following are the parameters used to monitor forest management:

Data Unit / Parameter:	Area of thinning
Data unit:	Dimensionless
Description:	Area thinned per year
Source of data:	The data is recorded and archived on a compartment level in Microforest.
Description of measurement methods and procedures to be applied:	Thinning is planned through Microforest, with the plantation managers selecting which compartments will be thinned.
Frequency of monitoring/recording:	This occurs each time a compartment is thinned.
Value monitored:	See document with thinning carried out during this monitoring period
Monitoring equipment:	No monitoring equipment is required.
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable

Any comment:	
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Data Unit / Parameter:	Harvesting location
Data unit:	Alpha numeric
Description:	Harvesting is carried out at the compartment level so the compartment IDs are used for harvesting location
Source of data:	The data is recorded and stored in Microforest.
Description of measurement methods and procedures to be applied:	Harvesting is planned through Microforest, with the plantation managers selecting which compartments will be harvested
Frequency of monitoring/recording:	This occurs each time a compartment is harvested.
Value monitored:	See document with harvest and thinning during this monitoring period
Monitoring equipment:	No monitoring equipment is required.
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Area of harvest
Data unit:	Ha
Description:	Harvesting is planned through Microforest, with the plantation managers selecting which compartments will be harvested.
Source of data:	The data is recorded and stored in Microforest.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	This occurs each time a compartment is harvested.
Value monitored:	
Monitoring equipment:	No monitoring equipment is required.
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Volume harvested
Data unit:	m ³

Description:	
Source of data:	The data is recorded and stored in Microforest.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Following harvest
Value monitored:	
Monitoring equipment:	No monitoring equipment is required.
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Area replanted
Data unit:	ha
Description:	Area replanted following harvesting, fire etc.
Source of data:	The data is recorded and stored in Microforest.
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	Every time a compartment is replanted
Value monitored:	See Microforest for list of compartments and areas
Monitoring equipment:	No monitoring equipment is required.
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Area affected by pests and/ or diseases
Data unit:	ha
Description:	
Source of data:	The data is recorded and stored in Microforest
Description of measurement methods and procedures to be applied:	The company's SOP 12: "Pests and diseases monitoring procedure" is applied.
Frequency of monitoring/recording:	
Value monitored:	
Monitoring equipment:	No monitoring equipment is required.
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable

Any comment:	
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Data Unit / Parameter:	Area burnt by fire		
Data unit:	Ha		
Description:	Area burnt by fire		
Source of data:	The data is recorded and stored in Microforest.		
Description of measurement methods and procedures to be applied:	Measured following GRAS' Inventory Guidelines – see "Fire Damage Assessment"		
Frequency of monitoring/recording:	Measured after any forest fire		
Value monitored:		Uchindile	Mapanda
	2009	2,372	-
	2010	-	12.44
	2011	-	23.14
Monitoring equipment:	No monitoring equipment is required.		
QA/QC procedures to be applied:	Not applicable		
Calculation method:	The area burnt from all forest fires in each particular year is summed		
Any comment:			

Data Unit / Parameter:	Location burnt		
Data unit:	Geographical units		
Description:	Location of burnt areas		
Source of data:	The data is recorded and stored in Microforest.		
Description of measurement methods and procedures to be applied:	The area is recorded with GPS in the field after each occurrence		
Frequency of monitoring/recording:	Each time there is a fire		
Value monitored:	A map of fire locations is presented in Section 5, Additional Information, of this Monitoring Report.		
Monitoring equipment:	GPS		
QA/QC procedures to be applied:	Not applicable		
Calculation method:	Not applicable		
Any comment:			

Data Unit / Parameter:	Volume of biomass lost due to fire		
Data unit:	m ³		

Description:	
Source of data:	Calculated based on inventory data
Description of measurement methods and procedures to be applied:	
Frequency of monitoring/recording:	
Value monitored:	
Monitoring equipment:	No monitoring equipment is required.
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

The following are the parameters used to monitor the actual net GHG removals by sinks:

Data Unit / Parameter:	Stratum ID																
Data unit:	Alpha numeric																
Description:	Each compartment has been given a different alpha numeric ID. Compartments are grouped together to form strata, which are given an alpha numeric name.																
Source of data:	Determined through the assessment of PSP data which is measured in each compartment – see DBH and Height measurement parameters.																
Description of measurement methods and procedures to be applied:	Each compartment has been given a different alpha numeric identity. Compartments are grouped together to form stratum, which are given an alpha numeric label. GPS is used to identify boundary coordinates.																
Frequency of monitoring/recording:	Restratification is carried out at each verification and so the areas of each stratum are calculated at this point. There will be a verification at the project at least every 5 years.																
Value monitored:	<table border="1"> <thead> <tr> <th>Stratum ID</th><th>Alphanumeric</th></tr> </thead> <tbody> <tr> <td>Pine 98-02</td><td>P98-02</td></tr> <tr> <td>Pine 03-05</td><td>P03-05</td></tr> <tr> <td>Pine 06-08</td><td>P06-08</td></tr> <tr> <td>Pine 09-10</td><td>P09-10</td></tr> <tr> <td>Euc 97-99</td><td>E97-99</td></tr> <tr> <td>Euc 00-02</td><td>E00-02</td></tr> <tr> <td>Euc 03-05</td><td>E03-05</td></tr> </tbody> </table>	Stratum ID	Alphanumeric	Pine 98-02	P98-02	Pine 03-05	P03-05	Pine 06-08	P06-08	Pine 09-10	P09-10	Euc 97-99	E97-99	Euc 00-02	E00-02	Euc 03-05	E03-05
Stratum ID	Alphanumeric																
Pine 98-02	P98-02																
Pine 03-05	P03-05																
Pine 06-08	P06-08																
Pine 09-10	P09-10																
Euc 97-99	E97-99																
Euc 00-02	E00-02																
Euc 03-05	E03-05																

	<table border="1"> <tr> <td>Euc 06-08</td><td>E06-08</td></tr> <tr> <td>Euc 09-10</td><td>E09-10</td></tr> </table>	Euc 06-08	E06-08	Euc 09-10	E09-10
Euc 06-08	E06-08				
Euc 09-10	E09-10				
Monitoring equipment:	Microforest, ArcGis				
QA/QC procedures to be applied:	Not applicable				
Calculation method:	Not applicable				
Any comment:	These strata are not including young stands from 2010 to 2012.				

Data Unit / Parameter:	Sub-stratum ID
Data unit:	Alpha numeric
Description:	Each compartment has been given a different alpha numeric ID. Compartments are grouped together to form strata, which are given an alpha numeric name.
Source of data:	Determined through the assessment of PSP data which is measured in each compartment – see DBH and Height measurement parameters.
Description of measurement methods and procedures to be applied:	Each sub-stratum is given a different alpha numeric identity. GPS is used to identify boundary coordinates of the sub-stratum.
Frequency of monitoring/recording:	Restratification is carried out at each verification and so the areas of each stratum are calculated at this point. There will be a verification at the project at least every 5 years.
Value monitored:	
Monitoring equipment:	Microforest, ArcGis
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Area planted per stratum
Data unit:	ha
Description:	The hectares of a certain stratum or sub-stratum
Source of data:	Calculated from data stored in Microforest
Description of measurement methods and procedures to be applied:	The geographical coordinates of each parcel of project area that mark the corners of the polygon are used to calculate the area
Frequency of monitoring/recording:	Re-stratification is carried out at each verification

	and so the areas of each stratum are calculated at this point. There will be a verification at the project at least every 5 years.																				
Value monitored:	<table border="1"> <thead> <tr> <th>Stratum</th><th>Area, ha</th></tr> </thead> <tbody> <tr> <td>Pine 98-02</td><td>58</td></tr> <tr> <td>Pine 03-05</td><td>208</td></tr> <tr> <td>Pine 06-08</td><td>1,180</td></tr> <tr> <td>Pine 09-10</td><td>1,498</td></tr> <tr> <td>Euc 97-99</td><td>186</td></tr> <tr> <td>Euc 00-02</td><td>155</td></tr> <tr> <td>Euc 03-05</td><td>318</td></tr> <tr> <td>Euc 06-08</td><td>96</td></tr> <tr> <td>Euc 09-10</td><td>267</td></tr> </tbody> </table>	Stratum	Area, ha	Pine 98-02	58	Pine 03-05	208	Pine 06-08	1,180	Pine 09-10	1,498	Euc 97-99	186	Euc 00-02	155	Euc 03-05	318	Euc 06-08	96	Euc 09-10	267
Stratum	Area, ha																				
Pine 98-02	58																				
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Euc 97-99	186																				
Euc 00-02	155																				
Euc 03-05	318																				
Euc 06-08	96																				
Euc 09-10	267																				
Monitoring equipment:	GPS, Arc GIS, Microforest, high resolution satellite imagery																				
QA/QC procedures to be applied:	When high resolution satellite imagery is available, further analysis of the compartments is carried out to ensure that the compartment boundaries are consistent and that the total area within the compartment is homogenous.																				
Calculation method:	The area is calculated by summing all the compartment areas that are included within the stratum. The areas are extracted from Microforest into the <i>ex-post</i> carbon model where the data at the compartment level is summed to give each of the strata/ sub-strata areas.																				
Any comment:																					

Data Unit / Parameter:	Number of sample plots
Data unit:	Numeric
Description:	The number of sample plots in each stratum is recorded.
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Field forms are filled out for each sample plot that is implemented in the field. These are the scanned and data inputted into Excel.
Frequency of monitoring/recording:	Sample plots will be measured at each verification

	event. There will be a verification at the project at least every 5 years.																				
Value monitored:	<table border="1"> <thead> <tr> <th>Stratum</th><th>Number of PSPs</th></tr> </thead> <tbody> <tr> <td>Pine 98-02</td><td>9</td></tr> <tr> <td>Pine 03-05</td><td>25</td></tr> <tr> <td>Pine 06-08</td><td>63</td></tr> <tr> <td>Pine 09-10</td><td>8</td></tr> <tr> <td>Euc 97-99</td><td>78</td></tr> <tr> <td>Euc 00-02</td><td>45</td></tr> <tr> <td>Euc 03-05</td><td>131</td></tr> <tr> <td>Euc 06-08</td><td>16</td></tr> <tr> <td>Euc 09-10</td><td>6</td></tr> </tbody> </table>	Stratum	Number of PSPs	Pine 98-02	9	Pine 03-05	25	Pine 06-08	63	Pine 09-10	8	Euc 97-99	78	Euc 00-02	45	Euc 03-05	131	Euc 06-08	16	Euc 09-10	6
Stratum	Number of PSPs																				
Pine 98-02	9																				
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Euc 97-99	78																				
Euc 00-02	45																				
Euc 03-05	131																				
Euc 06-08	16																				
Euc 09-10	6																				
Monitoring equipment:	Microforest, ArcGis, GPS																				
QA/QC procedures to be applied:	10% of the PSPs are remeasured as part of the QA/ QC process – see Section 5, Additional Information, of this Monitoring Report for the QA/ QC report.																				
Calculation method:	Not applicable																				
Any comment:																					

Data Unit / Parameter:	Sample Plot ID
Data unit:	Alphanumeric
Description:	Each sample plot has been given a different alpha numeric ID.
Source of data:	Measured
Description of measurement methods and procedures to be applied:	Each sample plot is given a different alpha numeric identity. GPS is used to identify the coordinates of the sample plot.
Frequency of monitoring/recording:	Each time there is an inventory
Value monitored:	
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Plot location
Data unit:	Coordinates
Description:	In this monitoring period, a combination of previously established permanent sample plots were measured as well as newly established plots. For both of these, plot locations were recorded using a GPS in the field and recorded in the field forms. All plots have been established systematically but with a random start.
Source of data:	Measured
Description of measurement methods and procedures to be applied:	The centre point of each permanent sample plot is recorded with a GPS
Frequency of monitoring/recording:	Sample plots will be measured at each verification event. There will be a verification at the project at least every 5 years.
Value monitored:	See Section 3.3, Description of the Monitoring Plan, of this Monitoring Report for a map of the PSP locations.
Monitoring equipment:	GPS
QA/QC procedures to be applied:	10% of the PSPs are remeasured as part of the QA/ QC process – see Section 5, Additional Information, of this Monitoring Report for the QA/ QC report.
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Age of plantation
Data unit:	years
Description:	Recorded when plantation is established
Source of data:	Recorded in Microforest
Description of measurement methods and procedures to be applied:	Recorded since planting year
Frequency of monitoring/recording:	Annually
Value monitored:	This is included in the file with compartment information
Monitoring equipment:	Not applicable
QA/QC procedures to be applied:	Not applicable
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Number of trees
Data unit:	dimensionless
Description:	Number of trees in a sample plot
Source of data:	Measured
Description of measurement methods and procedures to be applied:	The company SOP for measuring PSPs was followed
Frequency of monitoring/recording:	Sample plots will be measured at each verification event. There will be a verification at the project at least every 5 years.
Value monitored:	See <i>ex-post</i> carbon model for all raw data and carbon calculations.
Monitoring equipment:	
QA/QC procedures to be applied:	10% of the PSPs are remeasured as part of the QA/ QC process – see Section 5, Additional Information, of this Monitoring Report for the QA/ QC report.
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Diameter at Breast Height (DBH)
Data unit:	Cm
Description:	DBH of each tree in with DBH > 2cm located in each permanent sample plot measured to calculate accumulated biomass
Source of data:	Measured
Description of measurement methods and procedures to be applied:	The company SOP for measuring PSPs was followed
Frequency of monitoring/recording:	Sample plots will be measured at each verification event. There will be a verification at the project at least every 5 years.
Value monitored:	See <i>ex-post</i> carbon model for all raw data and carbon calculations.
Monitoring equipment:	Haglöfs calipers
QA/QC procedures to be applied:	10% of the PSPs are remeasured as part of the QA/ QC process – see Section 5, Additional Information, of this Monitoring Report for the QA/ QC report.
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Tree height
Data unit:	m
Description:	Heights of the four tallest trees in each PSP were measured to calculate the accumulated biomass
Source of data:	Measured
Description of measurement methods and procedures to be applied:	The company SOP for measuring PSPs was followed
Frequency of monitoring/recording:	Sample plots will be measured at each verification event. There will be a verification at the project at least every 5 years.
Value monitored:	See <i>ex-post</i> carbon model for all raw data and carbon calculations.
Monitoring equipment:	3 x Vertex: CE4-04634 CE4-04635 CE4-00639 3 x Transponder: 19085 19106 12926
QA/QC procedures to be applied:	10% of the PSPs are remeasured as part of the QA/ QC process – see Section 5, Additional Information, of this Monitoring Report for the QA/ QC report.
Calculation method:	Not applicable
Any comment:	

Data Unit / Parameter:	Merchantable (Standing) Volume
Data unit:	m ³ ha ⁻¹
Description:	Volume equations based on DBH and Height functions for eucalyptus and pine are used to calculate the standing volume
Source of data:	Indufor, May 2008
Description of measurement methods and procedures to be applied:	N/A
Frequency of monitoring/recording:	Annually
Value monitored:	Eucalyptus: $\ln(V) = -10.7304 + 1.1837 \cdot \ln(H_{dom}) + 1.0151 \cdot \ln(N) + 1.8757 \cdot \ln(D)$

	Pine: $\ln(V) = -10.6938 + 1.0579 \cdot \ln(H_{dom}) + 1.0382 \cdot \ln(N) + 1.9841 \cdot \ln(D)$ V = Mean volume, m³ha⁻¹ H_{dom} = Dominant height, m N = Stocking in terms of trees per ha D = Mean Diameter, cm
Monitoring equipment:	N/A
QA/QC procedures to be applied:	N/A
Calculation method:	N/A
Any comment:	In the previous monitoring report (2002 – 2008) and verification, the project used the Malimbwi 1998 pine and eucalyptus volume equations, which were developed based on the nearby Sao Hill Plantation stands. However, the application of these equations in the monitoring period 2008 – 2012 showed that the Malimbwi equations were overestimating the volume for this period. This was indicated by the form factor of the trees: many of the trees had a form factor >1, which clearly shows that the volume equations are not correct. Therefore alternative volume equations were sought, with the Indufor study and volume equations being deemed suitable. The Indufor volume equations were developed from data from temporal sample plot measurements carried out in late 2007 and early 2008. A total of 140 plots were used for <i>Pinus patula</i> and 127 plots for <i>Eucalyptus grandis</i>. Pine plots were measured in Sao Hill, Meru and Rongai plantations, Tanzania and eucalypt plots in Sao Hill and Meru, Tanzania.

Data Unit / Parameter:	Basic wood density (D)
Data unit:	t d.m./m ³
Description:	The basic wood densities of the tree species planted for this project - <i>Pinus patula</i> and eucalyptus species were obtained from literature. These were used to convert tree volume to tree biomass.
Source of data:	Bryce J.M., <i>The Commercial Timbers of Tanzania</i> , revised edition of 1999. Species-specific from national studies

Description of measurement methods and procedures to be applied:	Literature review will be carried out at each verification						
Frequency of monitoring/recording:	At each verification event						
Value monitored:	<table border="1"> <tr> <td></td><td>D, t d.m./m3</td></tr> <tr> <td>Pine</td><td>0.444 (15y)</td></tr> <tr> <td>Eucalyptus</td><td>0.464 (14y)</td></tr> </table>		D, t d.m./m3	Pine	0.444 (15y)	Eucalyptus	0.464 (14y)
	D, t d.m./m3						
Pine	0.444 (15y)						
Eucalyptus	0.464 (14y)						
Monitoring equipment:	Not applicable						
QA/QC procedures to be applied:	Not applicable						
Calculation method:	Not applicable						
Any comment:							

Data Unit / Parameter:	Biomass Expansion Factor (BEF)						
Data unit:	Dimensionless						
Description:	The biomass expansion factor is used to calculate whole tree above ground biomass from merchantable volume						
Source of data:	In the absence of species-specific values for BEF for the project site and the region, default value from GPG LULUCF 2003 was used, as presented in table 3.1.1.						
Description of measurement methods and procedures to be applied:	Literature review will be carried out at each verification						
Frequency of monitoring/recording:	At each verification event						
Value monitored:	<table border="1"> <tr> <td></td><td>BEF</td></tr> <tr> <td>Pine</td><td>1.3</td></tr> <tr> <td>Eucalyptus</td><td>2.7</td></tr> </table>		BEF	Pine	1.3	Eucalyptus	2.7
	BEF						
Pine	1.3						
Eucalyptus	2.7						
Monitoring equipment:	Not applicable						
QA/QC procedures to be applied:	Not applicable						
Calculation method:	For Eucalyptus, since no species-specific or genus specific data was available data was taken from the IPCC GPG LULUCF 2003 literature for broadleaf forest type in the same climatic zone (tropical). Since the data available was not from the same genus, a conservative value was determined by taking the value which fell half way between the mean and the lower limit of the range. Since for Pine there is IPCC GPG LULUCF 2003 data available for the same genus (tropical pines), the average was taken.						
Any comment:							

Data Unit / Parameter:	Root-Shoot Ratio																
Data unit:	Dimensionless																
Description:	It is used to calculate below ground biomass of tree from the aboveground biomass of standing tree.																
Source of data:	IPCC GPG LULUCF 2003																
Description of measurement methods and procedures to be applied:	Literature review will be carried out at each verification																
Frequency of monitoring/recording:	At each verification event																
Value applied:	<table><tr><td></td><td colspan="3">R</td></tr><tr><td>Above ground biomass t/ha</td><td>< 50</td><td>50 - 150</td><td>> 150</td></tr><tr><td>Pine</td><td>0.46</td><td>0.32</td><td>-</td></tr><tr><td>Eucalyptus</td><td>0.45</td><td>0.35</td><td>0.2</td></tr></table>		R			Above ground biomass t/ha	< 50	50 - 150	> 150	Pine	0.46	0.32	-	Eucalyptus	0.45	0.35	0.2
	R																
Above ground biomass t/ha	< 50	50 - 150	> 150														
Pine	0.46	0.32	-														
Eucalyptus	0.45	0.35	0.2														
Monitoring equipment:	Not applicable																
QA/QC procedures to be applied:	Not applicable																
Calculation method:	Values taken from table 3A.18 of the IPCC Guidelines, which are genus specific for both species. Different R values were taken considering significant different mean above ground biomass (t/ha) per strata in the project; according to IPCC Guidelines the three ranges of above ground biomass values are <50, 50-150 and >50 t/ha.																
Any comment:																	

3.3 Description of the Monitoring Plan

Organizational structure and responsibilities

Green Resources Ltd has a main administrative structure with the Managing Director that over sees the planning and management of forest resources. It is supported by a Resource Division which comprises of research, mapping and GIS, inventory and carbon certification and FSC departments. The monitoring activities are planned and implemented by these departments assisted in the field by the forest management team. For this monitoring report, the main teams involved have been the Carbon Certification Team, managed by Nicholas Embden, the Mapping and Inventory Team, managed by Jakob Sandven and the Community Development Team, managed by Hamisi Malinga.

The full main team involved in the mapping, monitoring and reporting is as follows:

- Nicholas Embden, Carbon Manager, GRAS
- Jakob Sandven, Mapping and Inventory, GRAS
- Ana Meyer, Carbon Associate, GRAS

- Eliya Mtupile, Carbon Certification Associate, GRL
- Dr Peter Mussami, Research Manager, GRL
- Jimton Titia, Forest Management Systems Specialist, GRL
- Dr Moses Negegba, Carbon Certification Manager, GRL
- Sophia Gogo, Remote Sensing Analyst
- Anthony Kisondella, Mapping and GIS Specialist
- Jacopo Parigiani, Mapping and Inventory, GRL
- Peter Nguyeje, Mapping and Inventory, GRL
- Isaac Mapunda, Mapping and Inventory, GRL
-
- Hamisi Malinga, Community Development Manager, GRL

All of this team has worked previously on successful carbon validations and verifications either on the Uchindile and Mapanda Reforestation Project or on other carbon projects within Green Resources, and has a wealth of first-hand forestry experience in Tanzania.

During data collection in the field, the team is placed into at least two groups collecting data for the same parameters at different locations. Each group will have a supervisor, and the groups would check one another's work through random sample re-measurement and checking of recorded data in the field. On returning to the office, the inventory manager and another senior staff will also do quality check on collected and entered data.

Data management system

Since the first monitoring period, Green Resources has introduced a new monitoring and inventory management system called Microforest, which is the company's principle archiving platform. Microforest is an integrated plantation and natural resource management system¹¹. It encompasses the entire life cycle of forestry operations and includes modules that manage inventory, modelling, planning, scheduling, operations, logistics and financials. An organizational diagram for project monitoring is shown at in Figure 3.3.1. This details the responsibilities, information flows and levels of control.

¹¹ See <http://syndicate.co.za/files/microforest.html>



In order to ensure that quality control is ensured throughout the project all Standard Operating Procedures (SOPs) that are carried out are covered by written instructions. The following SOPs have been developed and are complied with by Green Resources:

1. Stakeholder Consultation Process
2. Raising FSC Awareness
3. Complaints, Grievances Disputes and conflict resolution
4. Documents Management and Updating
5. Oil Spillage Response, cleanup and disposal (Spill Prevention control and countermeasures)
6. Control, prevention and monitoring of illegal activities
7. Employee Selection Procedure
8. Company internal audit and car system procedure
9. Waste description and management procedure
10. Specific site environmental impact assessment (form for collection of field data)
11. Chemical Screening Procedure
12. Pests and diseases monitoring procedure
13. Documentation approval procedure
14. Site Specific Environmental Impact Assessment
15. Workers Awareness
16. Inventory and Monitoring Guidelines

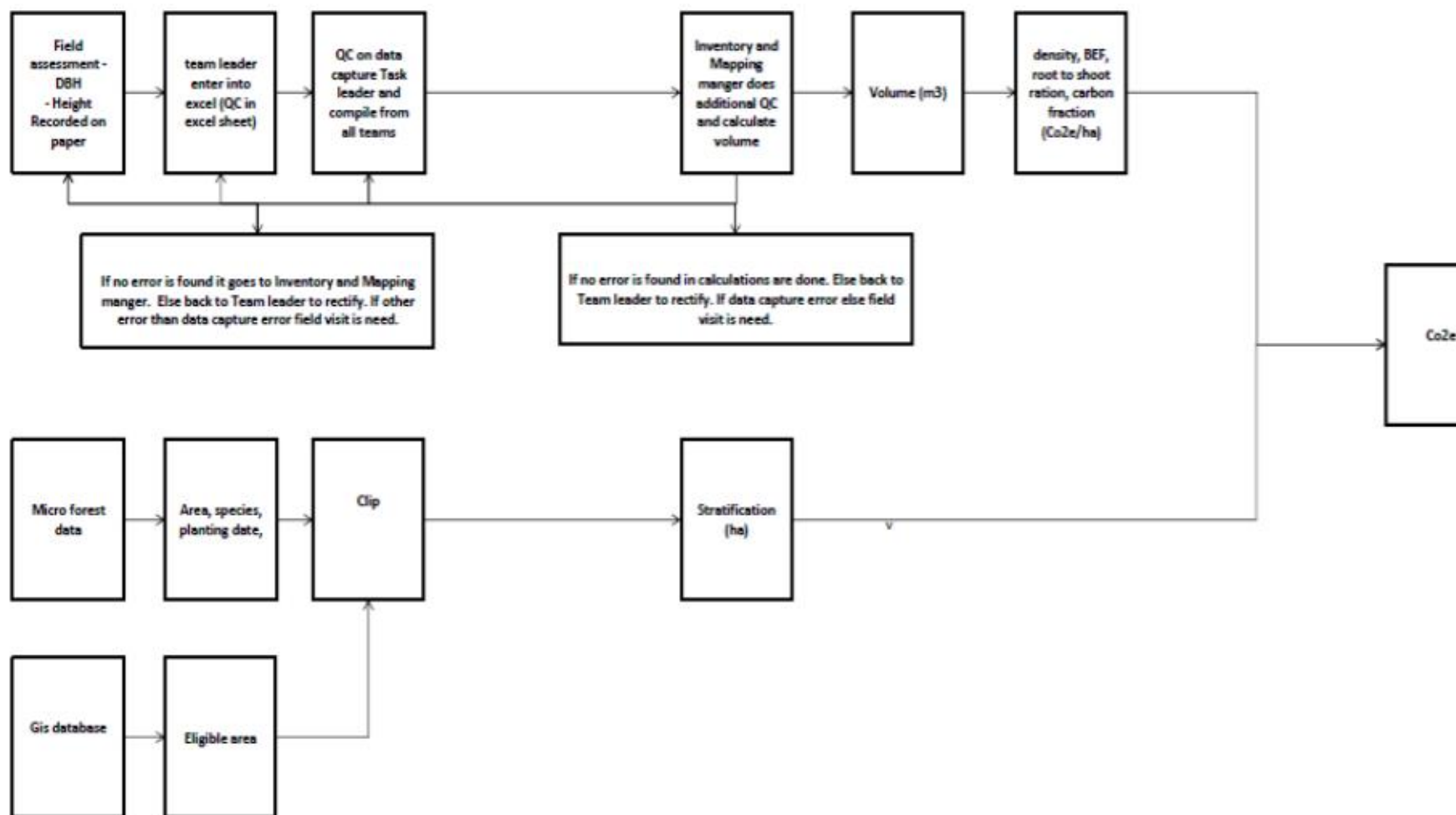


Figure 3.3.1. Overview of Green Resources monitoring system and the different levels and stages to arrive at the estimate of carbon stocks

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

As described in the PD (Section E.3), the baseline net GHG removal by sink prior to start of the proposed ARR VCS project activity are set to zero for lands without growing trees in accordance with the recommendation of the AR methodology applied. One baseline stratum was identified prior to start of the project that is grassland with few scattered trees. According to the methodology, *ex ante* baseline scenario defined prior to the start of the proposed A/R CDM project activity shall be valid for the entire crediting period. Therefore, this methodology does not require the monitoring of baseline scenario during the whole crediting period.

4.2 Project Emissions

As per AR-AM005 version 03 only non-CO2 emissions from biomass burning are considered applicable in this project. Both leakage and baseline emissions are not applicable in this project for reasons explained in the PD. Uchindile and Mapanda Forest Projects both encountered fires during the 2008 to 2012 verification period. In the case of areas that were affected by fire at UFP/MFP they were either cleared completely following fire and replanted with pine or eucalyptus, or they were left following fire and they recovered. The non-CO2 emissions resulting from incomplete combustion of biomass as a result of fire are calculated following equations M.23, M.24 and M.25.

$$E_{Non-CO2, BiomassBurn, t} = E_{BiomassBurn, CH4, t} \quad (M.23)$$

$$E_{BiomassBurn, CH4, t} = E_{BiomassBurn, C, t} * EF_{CH4} * GWP_{CH4} * 16/12 \quad (M.24)$$

Where:

$E_{Non-CO2, BiomassBurn, t}$	Non-CO2 emission as a result of biomass burning within the project boundary; tonnes CO2-e yr ⁻¹ in year <i>t</i>
$E_{BiomassBurn, CH4, t}$	CH ₄ emission from biomass burning; tonnes CO2-e yr ⁻¹ in year <i>t</i>
$E_{BiomassBurn, C, t}$	Loss of carbon stock in above-ground biomass due to burning; tonnes C yr ⁻¹ in year <i>t</i>
EF_{CH4}	IPCC default emission ratio for CH ₄ of biomass burning (IPCC default: 0.012); tC as CH ₄ (t C burned) ⁻¹
GWP_{CH4}	Global warming potential for CH ₄ (IPCC default for the first commitment period: 21); t CO2-e (t CH ₄) ⁻¹
16/12	Ratio of molecular weights of CH ₄ and carbon; dimensionless

$$E_{BiomassBurn, C, t} = \sum_{i=1}^I \sum_{j=1}^J \sum_{k=1}^K A_{burn, ijk, t} * B_{ijk, t} * PP_{ijk, t} * CE * CF \quad (M.25)$$

Where:

$E_{BiomassBurn, C, t}$	Loss of carbon stock in above-ground biomass due to burning; tonnes C yr ⁻¹ in year t
$A_{burn,ijk, t}$	Annual area affected by biomass burning in stratum i , species j , substratum k ; ha yr ⁻¹ in year t
$B_{ijk, t}$	Average above-ground biomass before burning for stratum i , species j , substratum k ; tonnes d.m. ha ⁻¹ Note: if the burning occurs during site preparation, $B_{ijk, t}$ indicates the above-ground biomass on grassland before burning. Otherwise it indicates the above-ground biomass of established forest in year t
$PP_{ijk, t}$	Proportion of biomass burned, dimensionless
CE	Combustion efficiency; dimensionless (IPCC default =0.5)
CF	Carbon fraction of dry matter; tonnes C (tonne d.m.) ⁻¹
i	Stratum i (I = total number of strata)
j	Species j (J = total number of species)
k	Substratum k (K = total number of substrata)

Project removals were calculated using the data from the 2012 inventory at UFP and MFP¹². This was first used to calculate volume of trees and carbon stocks (above and below ground) at plot level for each species. Carbon stock was then converted to stratum level and to project level.

Living biomass in the project was calculated using biomass expansion factors (BEF) and root-shoot ratios (R) following equations M.15 and M.16 in the methodology.

$$TB_{AB,ijk,tree,m} = V_{ijk,m} * D * BEF_{jk} \quad (M.15)$$

$$TB_{BB,ijk,tree,m} = TB_{AB,ijk,tree,m} * R_j \quad (M.16)$$

Where:

$TB_{AB,ijk,tree,m}$	Above-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. tree ⁻¹ at monitoring time m
$TB_{BB,ijk,tree,m}$	Below-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. tree ⁻¹ at monitoring time m
$V_{ijk,m}$	Merchantable volume in stratum i , species j , sub-stratum k (age class); m ³ ha ⁻¹ at monitoring time m

¹² UMFP carbon new model (excel file)

Note: the volume in each plot was calculated using Indufor volume equations for both species, as shown below.

Eucalyptus:

$$\ln(V) = -10.7304 + 1.1837 \cdot \ln(H_{dom}) + 1.0151 \cdot \ln(N) + 1.8757 \cdot \ln(DBH)$$

Pine:

$$\ln(V) = -10.6938 + 1.0579 \cdot \ln(H_{dom}) + 1.0382 \cdot \ln(N) + 1.9841 \cdot \ln(DBH)$$

H_{dom} = Dominant height, m

N = Stocking in terms of trees per ha

DBH = Mean Diameter, cm

D_j	Basic wood density for species j ; tonnes d.m. m^{-3} merchantable volume
BEF_{jk}	Biomass expansion factor for conversion of merchantable volume to aboveground tree biomass for species j , sub-stratum k ; dimensionless
R_j	Root-to-shoot ratio appropriate for species j ; dimensionless

Carbon stocks were estimated using equations M.17 and M.18 of the methodology, which give plot level above and below ground carbon stock, respectively.

$$PC_{AB,ijk,plot,m} = \sum_{t=1}^T TB_{AB,ijk,tree,m} * CF_j \quad (M.17)$$

$$PC_{BB,ijk,plot,m} = \sum_{t=1}^T TB_{BB,ijk,tree,m} * CF_j \quad (M.18)$$

Where:

$PC_{AB,ijk,plot,m}$	Plot level carbon stock in above-ground biomass for stratum i , species j , substratum k ; tonnes C ha^{-1} at monitoring time m
$PC_{BB,ijk,plot,m}$	Plot level carbon stock in below-ground biomass for stratum i , species j , substratum k ; tonnes C ha^{-1} at monitoring time m
$TB_{AB,ijk,tree,m}$	Above-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. $tree^{-1}$ at monitoring time m
$TB_{BB,ijk,tree,m}$	Below-ground biomass per tree of stratum i , species j , sub-stratum k ; tonnes d.m. $tree^{-1}$ at monitoring time m

Mean carbon stock in each stratum was calculated with equations M.11 (above ground) and M.12 (below ground) of the methodology.

$$MC_{AB,ijk,m} = \frac{\sum_{p=1}^{P_{ijk}} PC_{AB,ijk,plot,m}}{P_{ijk}} \quad (M.11)$$

$$MC_{BB,ijk,m} = \frac{\sum_{p_{ijk}=1}^{P_{ijk}} PC_{BB,ijk,plot,m}}{P_{ijk}} \quad (M.12)$$

Where:

$MC_{AB,ijk,m}$	Mean carbon stock in above-ground biomass for stratum i, species j, substratum k; tonnes C ha ⁻¹ at monitoring time m
$MC_{BB,ijk,m}$	Mean carbon stock in below-ground biomass for stratum i, species j, substratum k; tonnes C ha ⁻¹ at monitoring time m
$PC_{AB,ijk,plot,m}$	Plot level carbon stock in above-ground biomass for stratum i, species j, substratum k; tonnes C ha ⁻¹ at monitoring time m
$PC_{BB,ijk,plot,m}$	Plot level carbon stock in below-ground biomass for stratum i, species j, substratum k; tonnes C ha ⁻¹ at monitoring time m
P_{ijk}	Plot in stratum i, species j, sub-stratum k (P_{ijk} = total number of plots in stratum i, species j, sub-stratum k); dimensionless

Carbon stock in each stratum is then calculated taking the mean carbon stock and the area of each stratum (equations M.13 and M.14 of methodology). Table 4.3.2 below summarizes the steps and values obtained for this monitoring period.

$$C_{AB,ijk,m} = A_{ijk,m} * MC_{AB,ijk,m}$$

$$C_{BB,ijk,m} = A_{ijk,m} * MC_{BB,ijk,m}$$

Where:

$C_{AB,ijk,m}$	Changes in carbon stock in above-ground biomass for stratum i, species j, substratum k; tonnes C at monitoring time m
$C_{BB,ijk,m}$	Changes in carbon stock in below-ground biomass for stratum i, species j, substratum k; tonnes C at monitoring time m
$A_{ijk,m}$	Area of stratum i, species j, sub-stratum k; hectare (ha) at monitoring time m
$MC_{AB,ijk,m}$	Mean carbon stock in above-ground biomass for stratum i, species j, substratum k; tonnes C ha ⁻¹ at monitoring time m
$MC_{BB,ijk,m}$	Mean carbon stock in above-ground biomass for stratum i, species j, substratum k; tonnes C ha ⁻¹ at monitoring time m

Carbon stock changes are given by equations M.3, M.4 and M.5:

$$\Delta C_{ijk,t} = (\Delta C_{AB,ijk,t} + \Delta C_{BB,ijk,t}) * \frac{44}{12} \quad (M.3)$$

$$\Delta C_{AB,ijk,t} = \frac{C_{AB,ijk,m2} - C_{AB,ijk,m1}}{T} \quad (M.4)$$

$$\Delta C_{BB,ijk,t} = \frac{C_{BB,ijk,m2} - C_{BB,ijk,m1}}{T} \quad (M.5)$$

Where:

$\Delta C_{ijk,t}$	Verifiable changes in carbon stock in living biomass of trees for stratum i , species j , substratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{AB,ijk,t}$	Changes in carbon stock in above-ground biomass of trees for stratum i , species j , substratum k ; tonnes CO ₂ yr ⁻¹ in year t
$\Delta C_{BB,ijk,t}$	Changes in carbon stock in below-ground biomass of trees for stratum i , species j , substratum k ; tonnes CO ₂ yr ⁻¹ in year t
$C_{AB,ijk,m2}$	Carbon stock in above-ground biomass of trees for stratum i , species j , substratum k calculated at monitoring point m_2 ; tonnes C
$C_{AB,ijk,m1}$	Carbon stock in above-ground biomass of trees for stratum i , species j , substratum k calculated at monitoring point m_1 ; tonnes C
$C_{BB,ijk,m2}$	Carbon stock in below-ground biomass of trees for stratum i , species j , substratum k calculated at monitoring point m_2 ; tonnes C
$C_{BB,ijk,m1}$	Carbon stock in below-ground biomass of trees for stratum i , species j , substratum k calculated at monitoring point m_1 ; tonnes C
T	Number of years between monitoring point m_2 and m_1
$\frac{44}{12}$	Ratio of molecular weights of CO ₂ and carbon; dimensionless

Actual net GHG emission removals by sinks represent the sum of changes in carbon stocks for this monitoring period minus the non-CO₂ emissions from biomass burning and are given by equation M.26:

$$\Delta C_{ACTUAL,t} = \sum_{i=1}^I \sum_{j=1}^J \sum_{k=1}^K \Delta C_{ijk,t} - E_{Non-CO_2, BiomassBurn,t}$$

Where:

$\Delta C_{ACTUAL,t}$	Actual net greenhouse gas removals by sinks; tonnes CO ₂ -e yr ⁻¹ for year t
i	Stratum i (I = total number of strata)
j	Stratum j (J = total number of strata)
k	Stratum k (K = total number of strata)

Table 4.3.2 Values obtained for this monitoring period by applying the methodology.

Strata	Mean above ground carbon stock	Mean below ground carbon stock	Area of stratum	Above ground carbon stock per stratum	Below ground carbon stock per stratum	Total carbon stock	Adjusted Total carbon stock	Emissions	2012 Total carbon stock
	tC/ha		ha	tC				tCO ₂ e	tCO ₂ e
P98-02	32.9	10.5	58	1,905	610	2,514	2,371	3,296	2,371
P03-05	24.5	11.3	208	5,088	2,340	7,429	6,942	9	6,942
P06-08	20.8	9.6	1,180	24,581	11,307	35,889	35,233	0	35,233
P09-10	0.7	0.3	1,498	979	451	1,430	453	38	453
E97-99	79.1	15.8	186	14,674	2,935	17,608	16,738	2007	16,738
E00-02	47.0	16.5	155	7,300	2,555	9,855	8,803	423	8,803
E03-05	30.2	10.6	318	9,605	3,362	12,966	12,758	76	12,758
E06-08	12.9	5.8	96	1,235	556	1,790	1,192	0	1,192
E09-10	7.0	3.1	267	1,856	835	2,692	1,362	27	1,362
Total			3,985			92,173	85,852	5,877	314,790

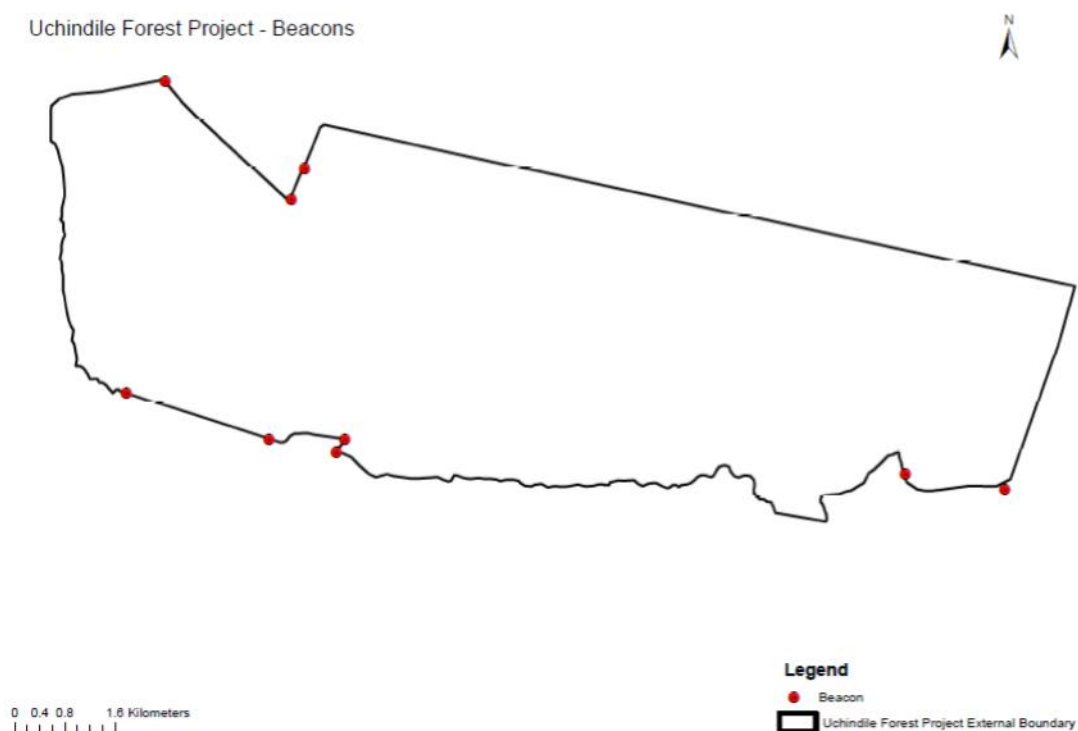
4.3 Leakage

No leakage was anticipated at the PD stage and was thus not monitored.

4.4 Summary of GHG Emission Reductions and Removals

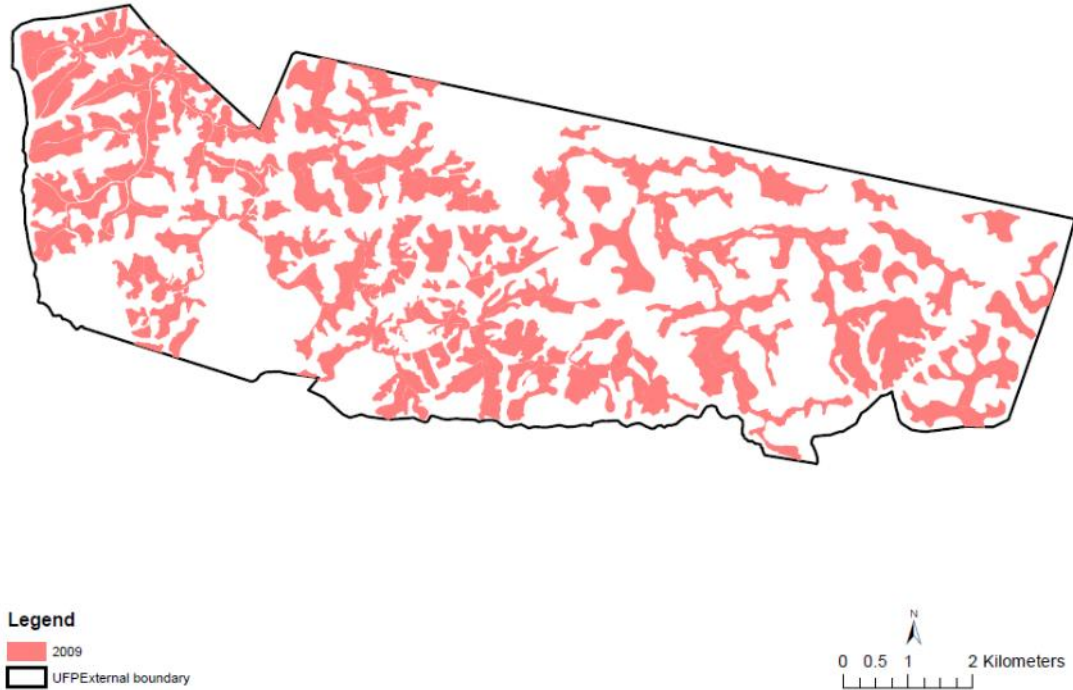
No.	Description	tCO ₂ e
1	Total project emission removals by sink (Carbon stock changes 2008-2012)	38,935
2	Baseline emissions	0
3	Emissions from leakage	0
4	Project emissions	5,877
5	Net emission reductions	33,058
6	Net emission reductions to buffer pool (10%)	- 63,348
7	Net emission removals	96,406

5 ADDITIONAL INFORMATION



Figures 5.1. Uchindile Forest Project beacons

Uchindile Forest Plantation Showing Fire History



Figures 5.2 Uchindile Forest Project history

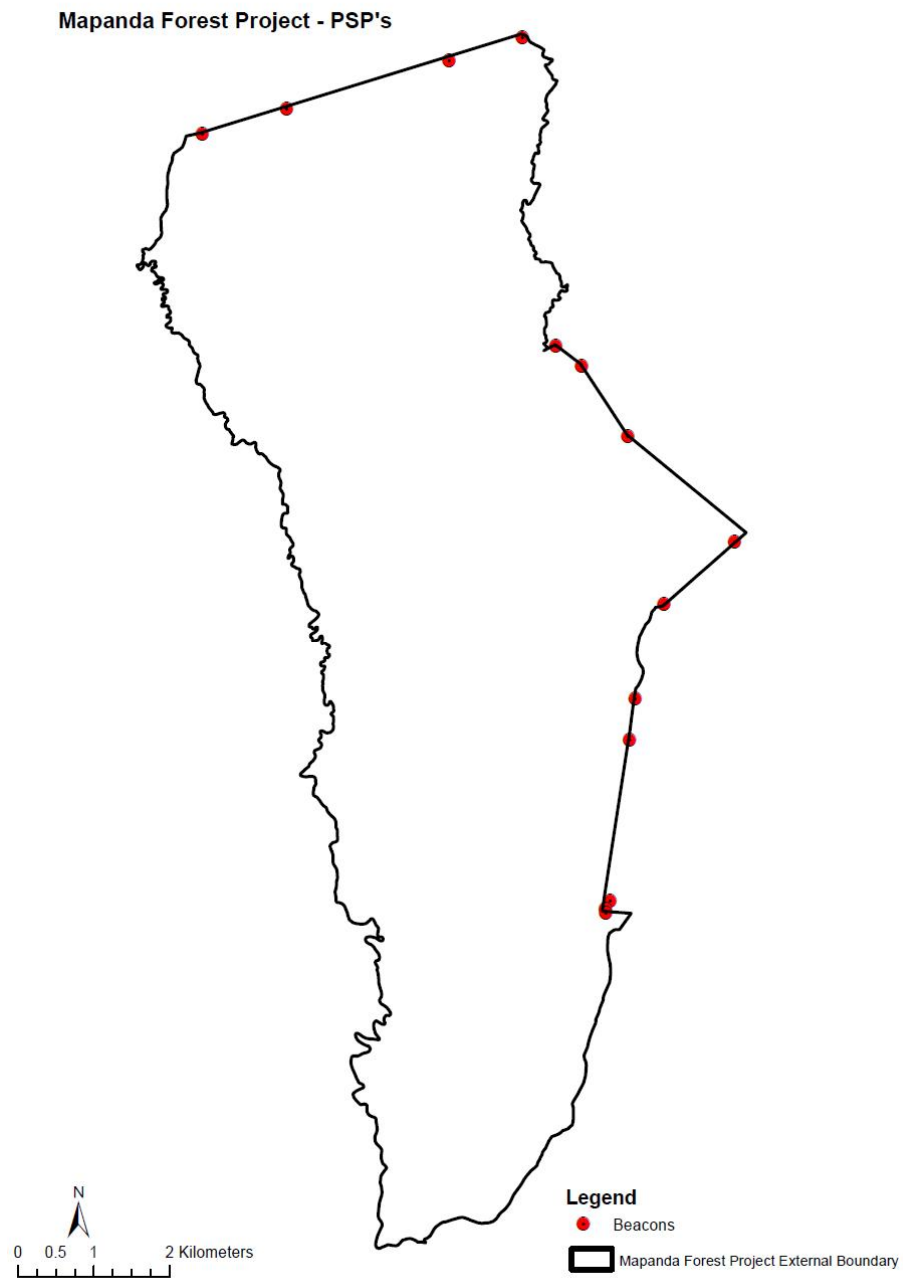


Figure 5.3. Mapanda Forest Project Beacons

Mapanda Forest Plantation Showing Fire History

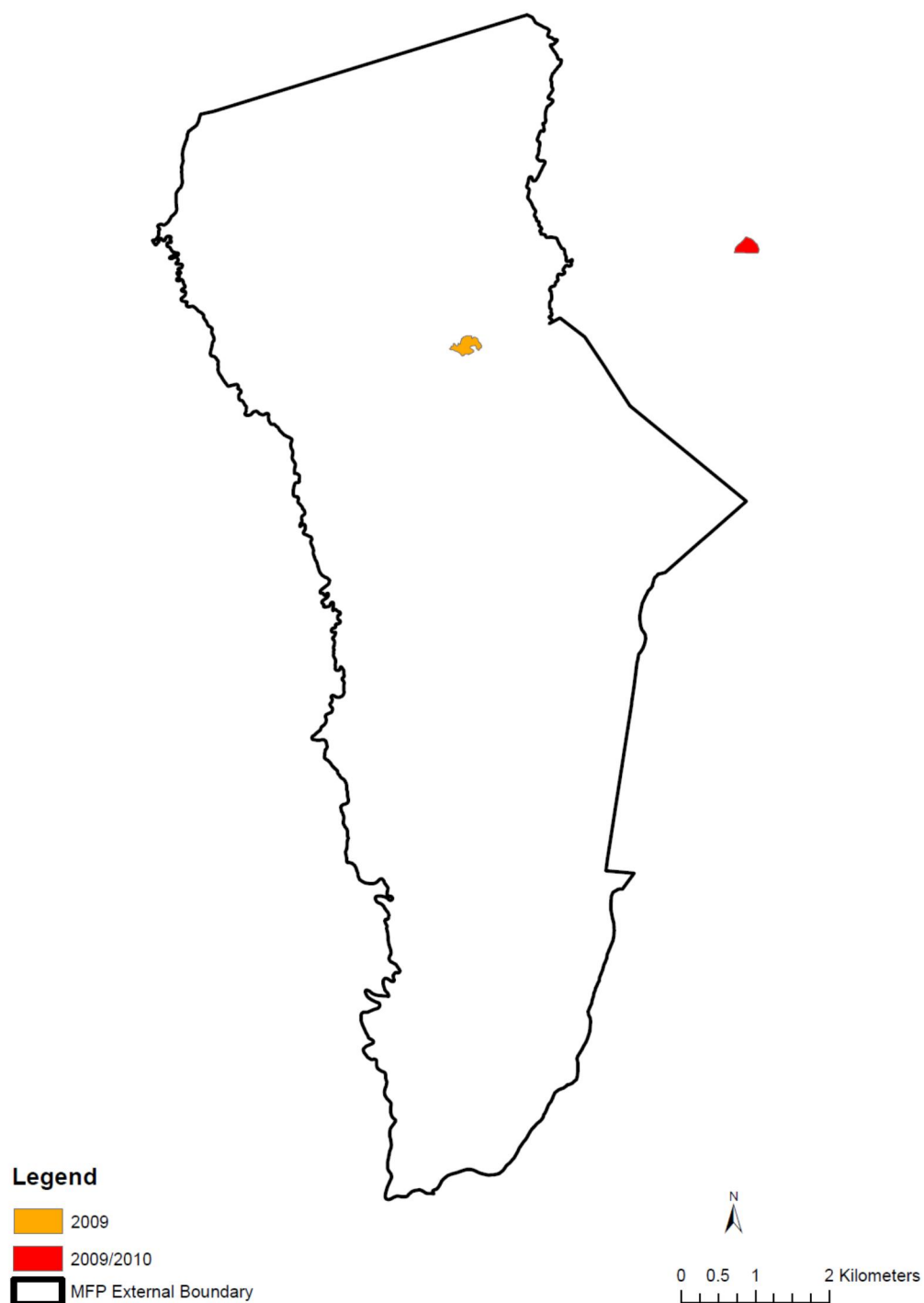


Figure 5.4. Fire history at Mapanda Forest Project

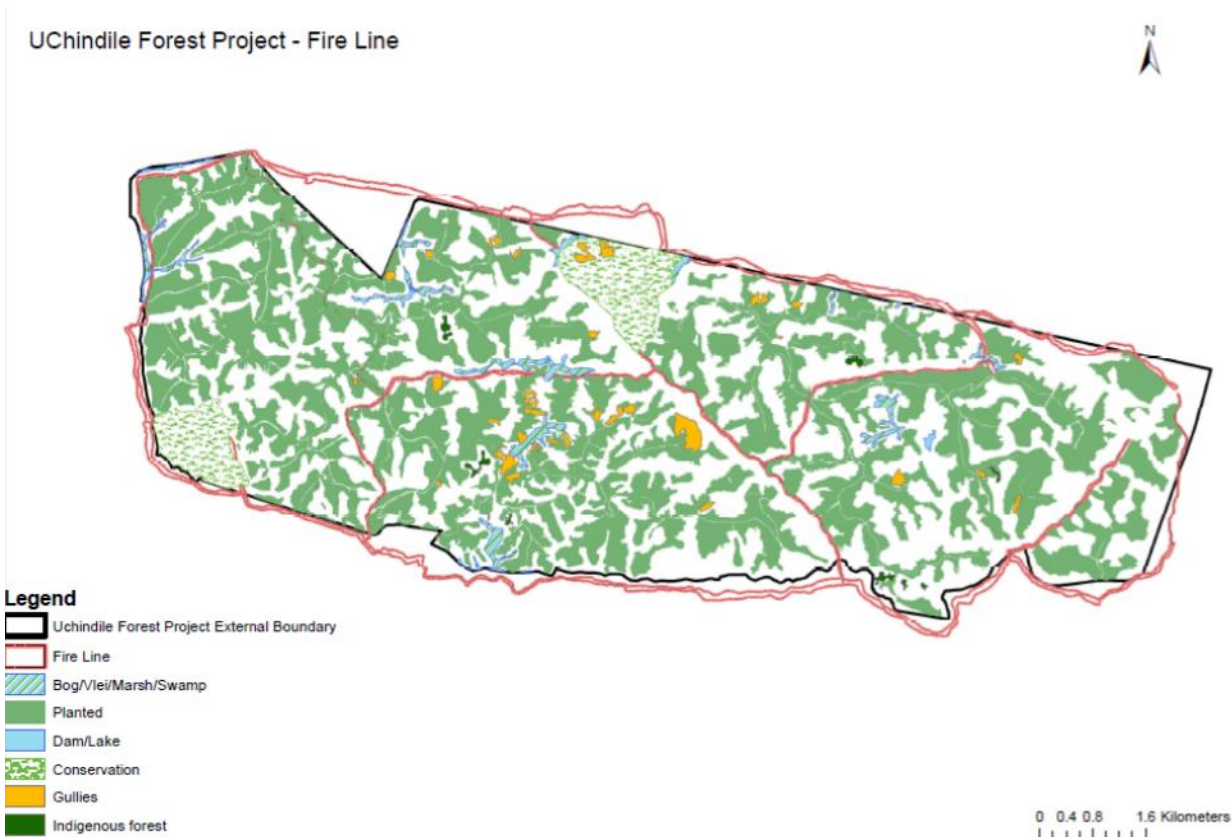


Figure 5.5. Uchindile Forest Project fire lines

Mapanda Forest Project - Fire Line

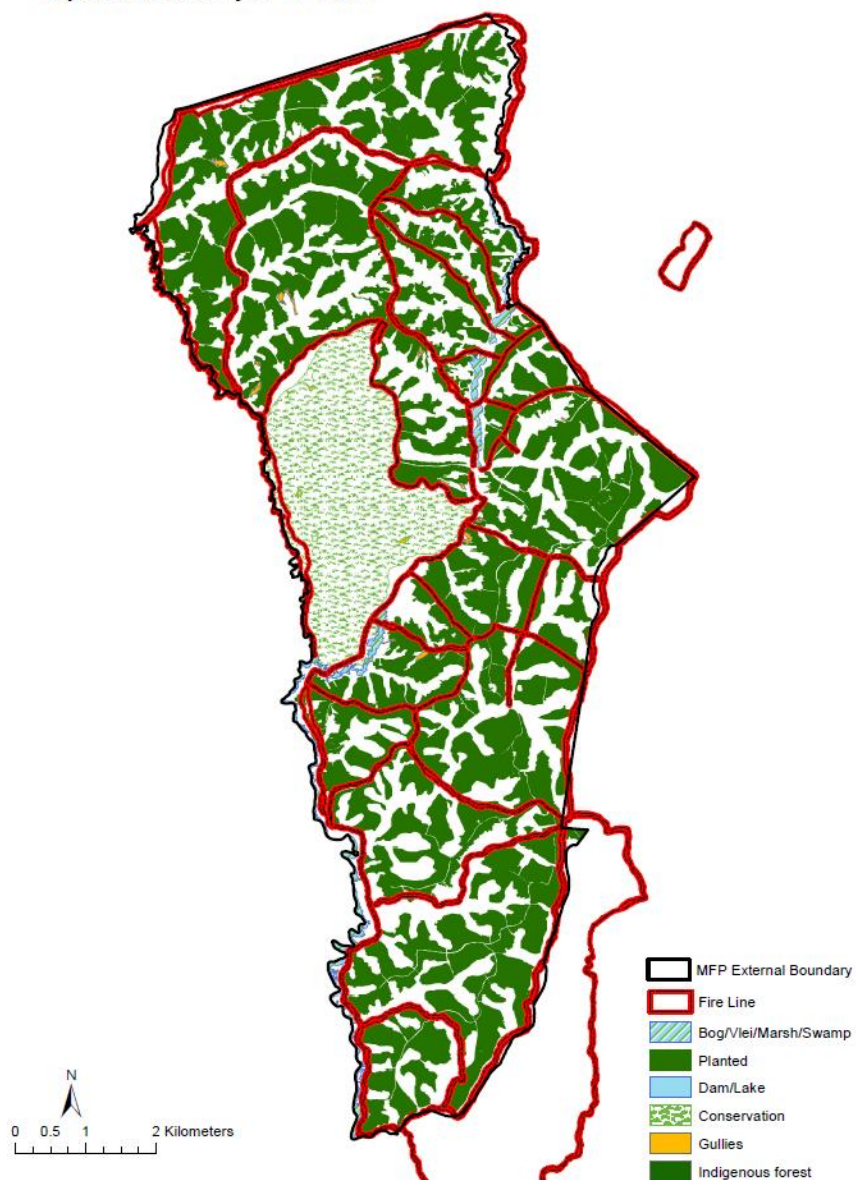


Figure 5.6. Mapanda Forest Project fire lines

Uchindile Forest Plantation Stratification and PSP's

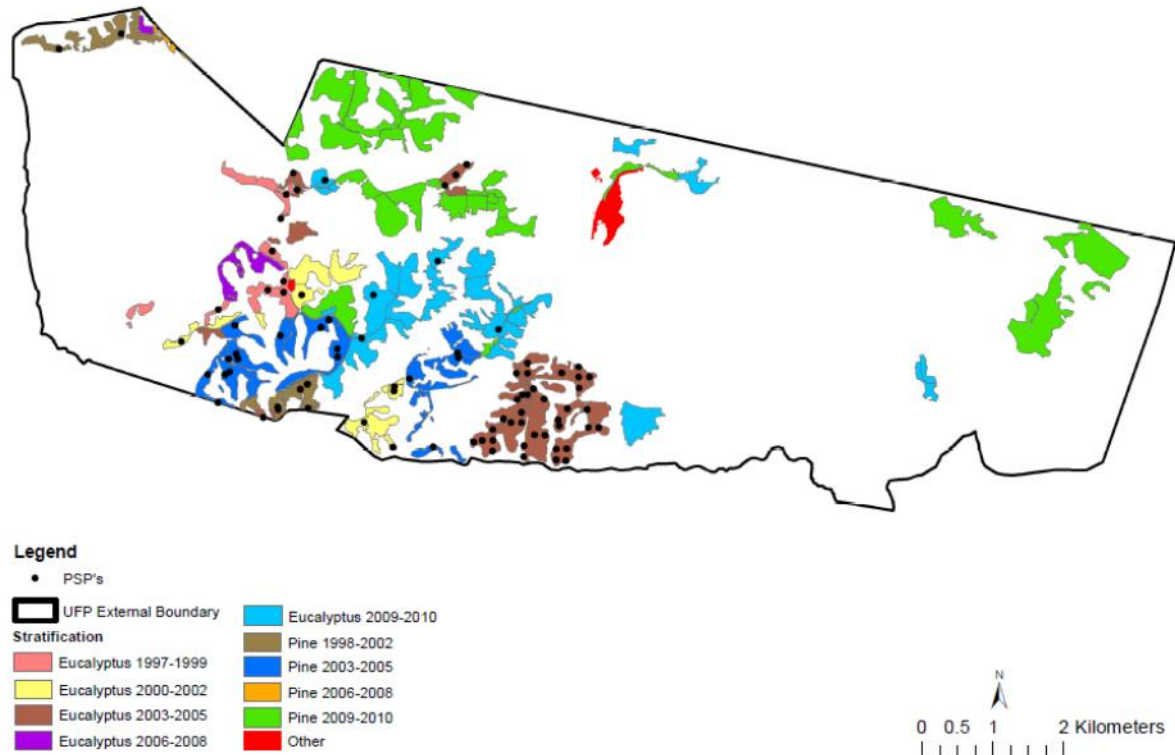


Figure 5.7. Strata and PSPs used for carbon calculations at Uchindile Forest Project

Mapanda Forest Plantation Stratification and PSP's

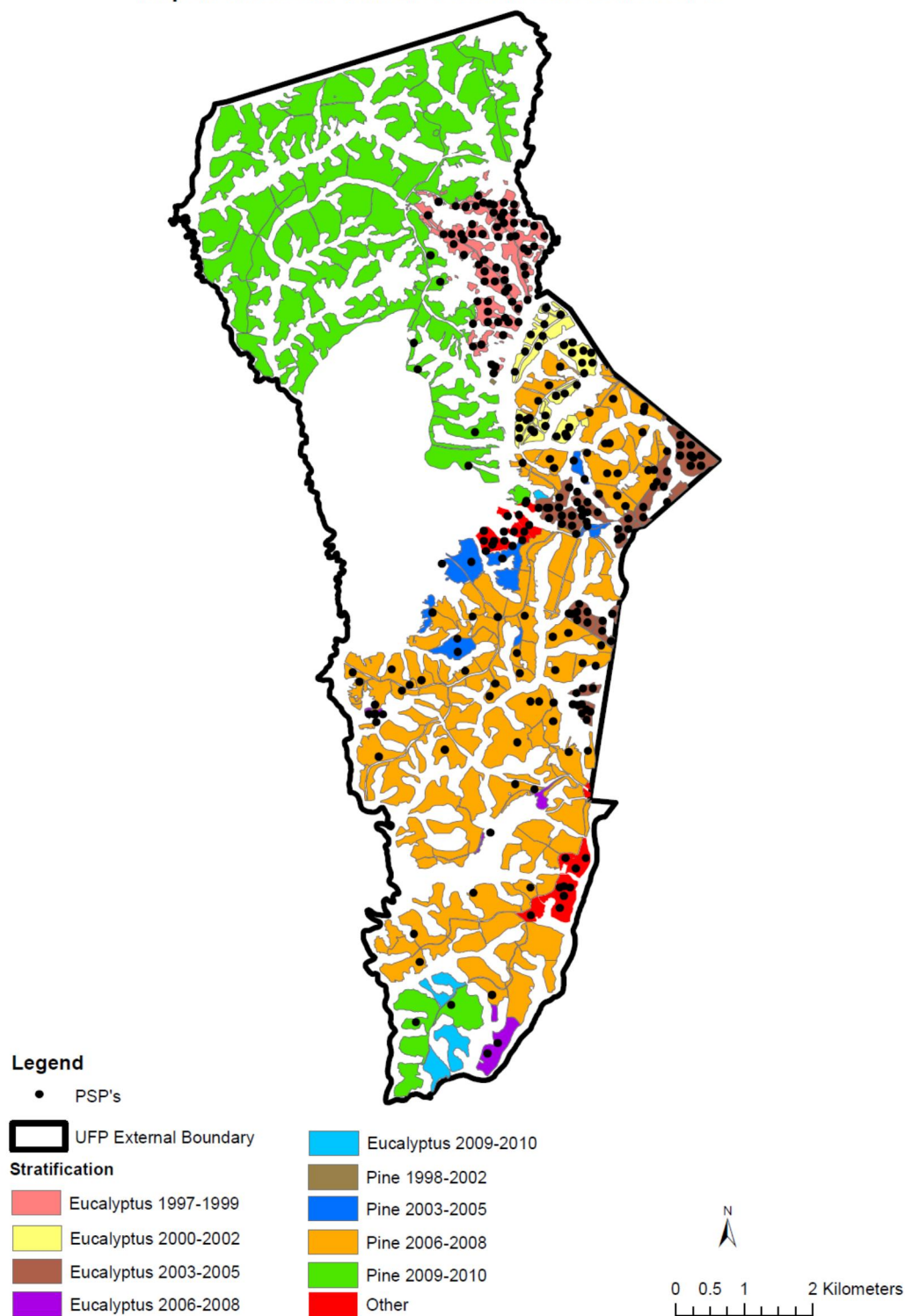


Figure 5.8. Strata and PSPs used for carbon calculations at Mapanda Forest Project

QA/ QC on PSPs

Introduction

The measurement of the Permanent Sample Plots (PSPs) began on the week of 16th June 2012. The participants were trained in forest inventory and how to use a variety of inventory equipment for measuring forest. The training went on for a total of 6 weeks including both classroom and in the field training.

Four different teams from GRAS' Mapping and Inventory (M&I) department established and measured the PSPs in the GRL plantations of Uchindile and Mapanda. There were different team members from different plantations. Each team had a skilled forester as a team leader. The teams consisted of the following staff:

Table 1

<i>Plantation</i>	<i>Team Leader</i>	<i>Team assistant(s)</i>
Mapanda	Peter Nguyeje	Lawrence William
Mapanda	Isaac Mapunda	Halidy Kalinga
Mapanda	Jahulula Edward	Omary Ulengasi
Mapanda	Hosea Eliya	Baraka Luvinga
Uchindile	Peter Nguyeje	James Damian
Uchindile	Isaac Mapunda	Adriano Kilulu
Uchindile	Jahulula Edward	Frank Kifanyi & Adriano Luwola

A control team, independent from the rest of the other teams, carried out part of the Quality Control (QC) on PSPs established in both Uchindile and Mapanda forests. This team consisted of Jimton Titia, Jakob Sandven and Elinewinga Eliushu. Additional QC was done by the four teams above, each doing QCs on PSPs established by the other teams. The aim of the additional QC was also to raise awareness of the quality and control and importance of doing quality measurements. See table 2 for an overview of team leaders.

In line with the PDD and the SOP, QC of the measurements from the PSPs had to be undertaken on at least 10% of the plots to ensure that the measurements were within an acceptable error range.

Analyses of PSP data

All plots were analysed using R and Excel to identify any outliers or any other clear errors. Some errors were discovered and corrected accordingly. Both age vs. height, dbh vs. height and dbh vs. age were plotted to see if any abnormalities were observed. All plots were compared to last year's measurements.

Figure 1 shows an example of the analysis. Team leader Isaac had some outliers due to height measurements carried out on the wrong trees; however, this has been rectified.

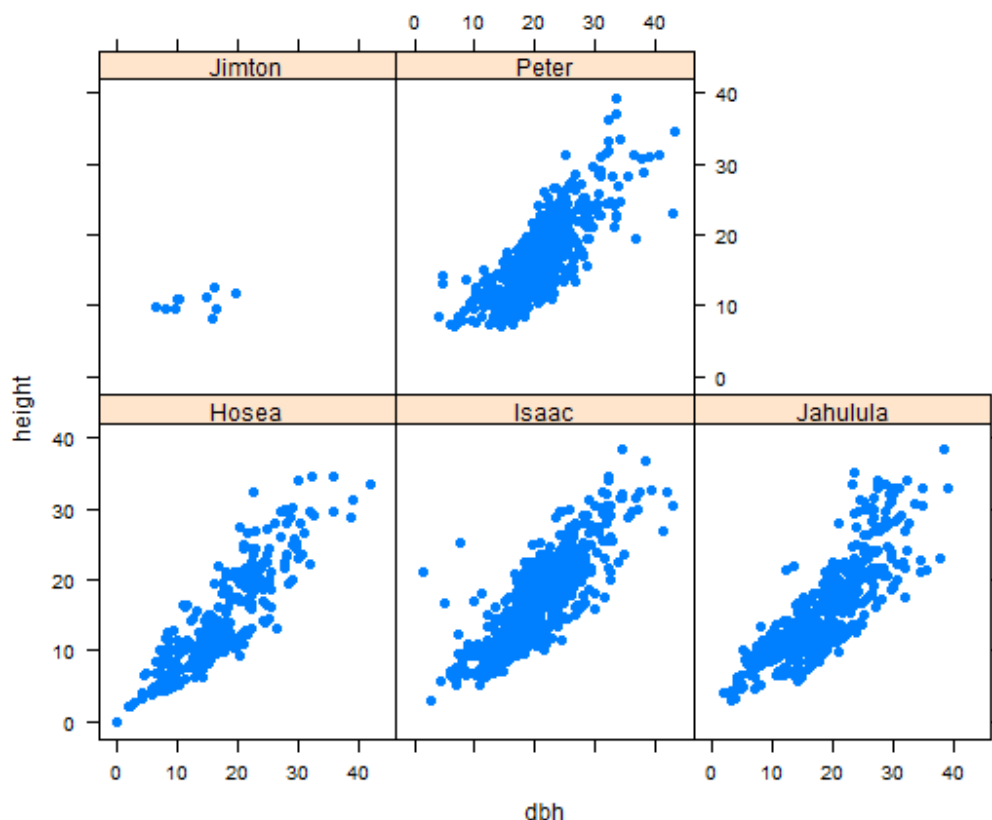


Figure 1 Shows height plots towards dbh for all plots, by the different team leaders.

Results

The total number of PSPs that was measured in Mapanda Forest was 286; in Uchindile the total amount was 96. In order to meet the requirements of the Standard Operating Procedures (SOP), a minimum of 39 QC had to be done. In practice, 27 remeasurements were done in Mapanda and 6 in Uchindile. The plots for QC were chosen randomly.

Each of the three teams above performed the QCs on PSPs established by one of the other two teams. The fourth team performed the QCs on PSPs established by any of the three teams since it was not involved in PSP establishment. The data of the QCs was plotted in the same format as that of the PSPs into an Excel worksheet. The averages between the two data sets were then compared and an error value (in percentage) was calculated using the following formula:

$$Error = \frac{QC\ Value - PSP\ Value}{PSP\ Value} \%$$

This error calculation was done for the total number of trees measured in the plot; the average height of the plot; the average diameter at breast height (DBH); the basal area (BA) and the volume.

The acceptable error calculated on the volume (see **Error! Reference source not found.**) has to be lower than +/- 10%. This is according to the company SOP.

All QC data forms have been archived in folders (separate to folders for the original PSP data) and entered into excel spreadsheets. Data entry into spreadsheets has also undergone quality control with a second member of the QC team checking at least two of the forms and spreadsheets completely – if any errors were found they were amended. Typical errors were found in the misplacement of decimal points or missing data, thus the whole database was checked and the data compared to the original raw data (hard copies).

Table 2. Error calculation for plots in Uchindile Forest Plantation and Mapanda Forest Plantation, where Plots starting with M are from Mapanda and U from Uchindile.

Team	Plot	No trees	Height	DBH	BA	Vol
Hosea	M131_2011	0%	-4%	0%	2%	-2%
Hosea	M159_2011	0%	0%	0%	-1%	-1%
Hosea	M164_2011	0%	1%	-1%	-3%	-3%
Hosea	M51_2011	-13%	5%	11%	-4%	-2%
Hosea	M63_2011	8%	1%	-4%	2%	3%
Hosea	M67_2011	0%	4%	-2%	-4%	-1%
Hosea	M83_2011	8%	2%	0%	11%	11%
Isaac	M121_2011	0%	-1%	3%	10%	9%

Isaac	M134_2011	0%	1%	-1%	-3%	-2%
Isaac	M88_2011	0%	-4%	0%	0%	-1%
Isaac	M89_2011	13%	0%	1%	0%	-1%
Isaac	M93_2011	0%	2%	0%	-2%	-1%
Isaac	U39	0%	6%	-1%	-3%	2%
Isaac	U40	-60%	2%	6%	5%	5%
Jakob	M163_2011	50%	2%	-24%	29%	29%
Jakob	M192_2011	9%	1%	-14%	3%	3%
Jakob	M43_2011	-4%	-8%	-1%	-1%	-2%
Jakob	M46_2011	17%	-2%	-8%	5%	4%
Jakob	M63_2011	8%	0%	-3%	4%	4%
Jakob	M89_2011	18%	2%	-17%	-3%	-3%
Jimton	U304_2011	0%	5%	0%	0%	4%
Jimton	U531_2011	1%	4%	1%	3%	4%
Peter	M05_2010	0%	0%	0%	0%	0%
Peter	M08_2010	0%	-3%	1%	3%	0%
Peter	M132_2011	-9%	-3%	3%	-4%	-6%
Peter	M187_2011	0%	8%	0%	1%	8%
Peter	M221_2011	-14%	-9%	2%	6%	-1%
Peter	M37_2011	2%	0%	2%	5%	6%
Peter	M52_2011	-4%	2%	2%	-4%	-4%
Peter	M54_2011	0%	11%	2%	3%	5%
Peter	M84_2011	2%	-3%	0%	3%	1%
Peter	U325_2011	2%	6%	-1%	-1%	3%
Peter	U489_2011	3%	-6%	12%	22%	20%

Uchindile Forest Plantation

In UFP there was one plot with a large error on the volume (above 10%). This is plot U489_2011 (**Error! Reference source not found.**²). The error in plot 489 is caused by difference in DBH. This plot will be revisited.

Mapanda Forest Plantation

In MFP, there are two plots with a high error (**Error! Reference source not found.**). These plots are M83_2011 and M163_2011. The source of error in these plots (plots number 83 and 163) is in the numbers of trees.

In plots number 83 and 163, the error is high due to a tree that was marked inside the plot in the QC measurement. This single tree was marked to be at a distance of 11.27m from the centre of the plot, right on the border, and it had a big effect on the error of the plot since the number of trees in this plot is less than 10 and that particular tree has a large DBH and a big height. If the data is manipulated and this tree removed from the QC plot, then the error decreases and it is within the acceptable range. However both the plots will be revisited.

Conclusion

The quality control proved that even though errors in the PSP establishment were observed, these were not systematic and therefore the errors are deemed acceptable. However there are some errors such as numbers of trees in the plot, which is likely due to the different and steep terrain in combination with the potential calibration error of the equipment. Another aspect that is likely to have contributed to the errors is the silent marking of the plots. For future verifications the Inventory team will consider increasing the width of the marking and numbering each individual tree with a tag.

The average error on the volumes for all plots in UFP was calculated as 4.4% and as -3.2% for all plots in MFP. These values indicated that the measurements done in the PSPs are satisfactory and that they provide good estimates of the total volume in the forest, and thus allow a good calculation of the total carbon stocks. However there is room for improvement related both to marking of PSP in the field and of recording. Most of the errors related to QC were due to the main steps involved in data capture. For measurements in the future it is recommended to use electronic capture in combination with automatic QC/QA procedures.