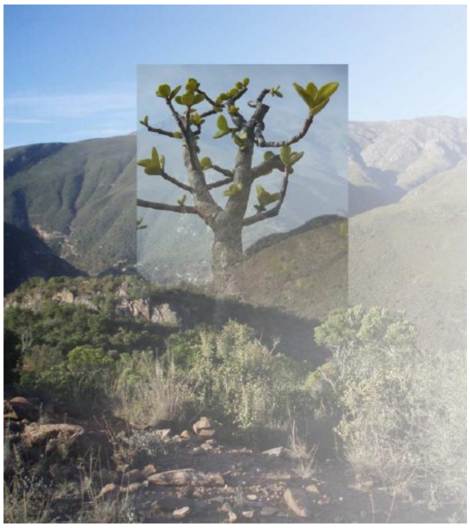
9B Mohr Road
Tokai, 7945
Cape Town
South Africa
T/F +27 (0)21 715 1560
info@c4es.co.za
www.c4es.co.za

C4 EcoSolutions

VCS { VOLUNTARY CARBON STANDARD

Voluntary Carbon Standard Project Description

Addo Elephant National Park, Baviaanskloof Nature Reserve and Great Fish River Nature Reserve Restoration Project (ABFRP)



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Project Document prepared by James Reeler (BSc Hons.), Anthony Mills (PhD) and Mike Jennings (MSc) of C4 EcoSolutions.

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List of Acronyms

ABFRP	Addo Elephant National Park, Baviaanskloof Nature Reserve and Great Fish River Nature Reserve Restoration Project
AENP	Addo Elephant National Park
AFOLU	Agriculture, Forestry and Other Land Uses
ARR	Afforestation, Reforestation and Revegetation
BNR	Baviaanskloof Nature Reserve
C	Carbon
CAP	Climate Action Partnership
CBSA	Combined Basal Stem Area
CDM	Carbon Development Mechanism
CER	Certified Emission Reduction
CDNGI	Chief Directorate National Geo-spatial Information
CFK	Cape Floral Kingdom
CI	Conservation International
CO_2e	Carbon Dioxide Equivalent
CSIR	Council for Industrial and Scientific Research
CSS	Conservation Support Services
DBH	Diameter at Breast Height
DEA	(National) Department of Environmental Affairs
DEDEA	(Provincial) Department of Economic Development & Environmental Affairs
DNA	Designated National Authority
dm	Dry matter
DWAF	Department of Water Affairs and Forestry
DWA	Department of Water
ECPTA	Eastern Cape Parks and Tourism Agency
EPWP	Extended Public Works Programme
EIA	Environmental Impact Assessment
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIB	Gamtoos Irrigation Board
GIS	Geographic Information System
GMO	Genetically Modified Organism
GPS	Global Positioning System
GFRNR	Great Fish River Nature Reserve
ha	Hectare
HCV	High Conservation Values
IDP	Integrated Development Plan
IPCC	Intergovernmental Panel on Climate Change
km	Kilometres
LULUCF	Land Use, Land-Use Change and Forestry
MDG	Millennium Development Goal
NEMA	National Environmental Management Act
NMMU	Nelson Mandela Metropolitan University
PD	Project Document
PDM	Pebble Distribution Method
PGIS	Participatory Geographic Information System
PRA	Participatory Rural Appraisal
PRESENCE	Participatory Restoration of Ecosystem Services and Natural Capital in the Eastern Cape
QA	Quality Assurance
QC	Quality Control

RDB	Red Data Book
R3G	Restoration Research Group
RME	Reliable Minimum Estimate
RU	Rhodes University
SANParks	South African National Parks
SIA	Social Impact Assessment
SOC	Soil Organic Carbon
SOP	Standard Operating Procedure
SOM	Soil Organic Matter
STEP	Subtropical Thicket Ecosystem Project
STRP	Subtropical Thicket Restoration Programme
t	Tonnes
t.d.m.	Tonnes of dry matter
kg.d.m	Kilograms of dry matter
UNFCCC	United Nations Framework Convention on Climate Change
UP	University of Pretoria
US	United States
VCS	Voluntary Carbon Standard
VER	Verified Emission Reduction
WfW	Working for Water/Working for Woodlands
WUR	Wageningen University
yr	Year

1 Project Description:

1.1 Project title:

Title: Addo Elephant National Park, Baviaanskloof Nature Reserve and Great Fish River Nature Reserve Restoration Project (ABFRP)

Version: 3.2

Date: September 2011

Authors: Dr Anthony Mills[1,2]*, James Reeler[2], Sarah-Jane Fox[2], Margaret Matthew[2], Mike Powell[3], Prof Richard Cowling[4]

1.2 Type/Category of the project:

The proposed project is a Voluntary Carbon Standard (VCS) project within the category Agriculture, Forestry and Other Land Uses (AFOLU) and sub-category Afforestation, Reforestation and Revegetation (ARR). It is a grouped project, hereafter referred to as "the proposed ARR project". It currently includes a single site, but additional instances meeting the eligibility criteria will be added in the future, in line with the VCS guidance on grouped projects.

1.3 Estimated amount of emission reductions over the crediting period including project size:

The proposed ARR project will sequester approximately 2.28 million tonnes of carbon dioxide equivalent (CO_2e) over a period of 60 years at an average rate of 38,722 tonnes of CO_2e yr^{-1}. This assumes a survival rate of 70% for all plantations.

1.4 A brief description of the project:

The proposed grouped ARR project is located in the Eastern Cape Province of South Africa. It will restore degraded thicket in The Darlington Dam section of the Addo Elephant National Park (AENP), and will in future include additional conservation areas that meet the eligibility criteria. Both moderately and severely degraded thicket vegetation will be restored. According to the study undertaken by Lloyd (2002) and corroborated by field investigations by Dr Jan Vlok and Mr Mike Powell:

- Moderately degraded thicket:
  - has reduced standing biomass for that particular thicket type;
  - alien plants are obviously present, but not dominant;
  - structural changes in the vegetation are evident, e.g. opening up by cattle, browse lines of goats; and
  - is still fully functional
- Severely degraded thicket:
  - has lost all its functionality;
  - has severely reduced woody biomass compared to fully functional thicket;
  - is generally associated with high levels of human activity (around towns, homesteads, near villages, stock watering points); and
  - is obviously degraded when comparing across fence-line contrasts between "good" condition and "poor" condition rangeland

Degradation of the thicket vegetation by over-browsing (by goats, in particular), prior to gazetting as a conservation area, has caused a significant reduction in biomass, and

[1] Stellenbosch University
* Contact author (mills@sun.ac.za)
[2] C4 EcoSolutions
[3] Rhodes University
[4] Nelson Mandela Metropolitan University

therefore ecosystem carbon stocks, in the project area. The general area is semi-arid, and natural recovery of degraded land is limited as a result of high soil temperatures and poor soil conditions, including slow infiltration. Restoration of project areas will be achieved by planting cuttings of the indigenous thicket tree *Portulacaria afra* Jacq. (*P. afra*) in specific planting sites (contracts). *P. afra* is a common and frequently dominant species in this region. Restoration of the thicket using *P. afra* captures considerable amounts of carbon in biomass and soils (Mills & Cowling, 2006). The project will increase ecosystem carbon stocks and expand the restoration activities through funds generated by the sale of accrued carbon credits.

Planting area

The project aims to restore degraded thicket within protected areas in the Eastern Cape by planting *P. afra* cuttings. The Addo Elephant National Park contains planting sites classified as degraded lands through a comprehensive vegetation analysis (Lloyd et al., 2002). This analysis has been supplemented by field work conducted by Dr Jan Vlok and Mike Powell. A restoration goal of at least 70% of the degraded thicket within the project area has been set. It is hoped that a higher proportion of the degraded land will be restored, but the conservative estimate of 70% is used due to fragmentation within the area – certain degraded fragments are too small for realistic management, and some are too distant from access routes to be reached by planting teams. Nevertheless, if some additional sites are identified as being feasible for restoration, they may be included over the project lifetime.

Future sites that might be incorporated within the proposed grouped project include the Great Fish River Nature Reserve (GFRNR) and the Baviaanskloof Nature Reserve. Both these reserves are contractual nature reserves managed by the Eastern Cape Parks and Tourism Agency (ECPTA). They are not currently included due to the presence of historical land claims on some of the land within the reserves, and will only be included once these claims have been processed.

Once the project is validated, restoration will proceed at an estimated 504 ha yr^{-1}. Planting should be completed within ten years, and the project crediting period will be 60 years. This inclusion of additional sites will extend the planting period, but the crediting period will remain the same. Full development to restored thicket will not occur within the project duration for sites planted after the first ten years.

Addo Elephant National Park

The area used for planting in the AENP was previously owned by farmers, and was incorporated into the reserve in 2003 after land purchases to expand the size of the national park. This planting area is limited to the northern part (Darlington Dam section) of the Park, which currently is not accessible to elephants. The estimated area of severely degraded thicket within the designated long-term planting area is just over 9,400 ha. At least 5,300 hectares of this degraded thicket will be restored through project operations. Trial plantings covering an area of almost 800 ha have been carried out in the Park between 2007 and 2010.

Risks

No genetically modified organisms or invasive species[5] will be used in the proposed ARR project. *P. afra* will be the only species planted. Fire is not a high risk as it is an semi-arid

[5] A full list of invasive species can be obtained from http://www.sana.co.za/Alien-Invasive-Plants/. The proposed project is planting P. afra exclusively, which is a local endemic species. In addition, only cuttings from locally-occurring plants will be used, ensuring the preservation of local genetic diversity.

area and contains little grass cover. *P. afra* is naturally highly fire-resistant, because it is a succulent with a very high moisture content, and therefore the established *P. afra* plants will provide a natural firebreak.

Benefits
It is estimated that restoration of degraded land will sequester approximately 516 t CO_2e ha^{-1} in total within the project area (see Annex 7 for the different carbon pools, confidence intervals and uncertainties). The standing crop of carbon in intact thicket is estimated at between 320 t CO_2e ha^{-1} (Powell, 2009) and 920 t CO_2e ha^{-1} (van der Vyver, 2011). The upper estimate is comparable to many true forest ecosystems (Mills et al., 2005a) and an extraordinarily high value for a semi-arid ecosystem. See Annex 13 for additional details regarding degradation within the project areas.

1.5 Project location including geographic and physical information allowing the unique identification and delineation of the specific extent of the project:

To avoid confusion, the following nomenclature is used throughout this document:

- *Planting site* is any individual area designated for restoration that has a unique identification number, unique geographic location, and is registered on the project database;
- *Contract* is the binding agreement between the project proponents and a contractor who will undertake the planting in a planting site. It is sometimes used as a term to describe the planting site, and shares the same unique identification number;
- *Project area* is any set of project sites that is either owned by or falls under the administration of a single party, and that is managed as a single entity;
- *General area* is the area that encompasses all the project areas within the grouped project.

The current project area is located in the Eastern Cape Province of South Africa (Figure A.12.2). The planting sites are located in degraded thicket landscapes within the Addo Elephant National Park, the boundaries of which will form the proposed ARR project boundary. Additional proposed project areas include the Great Fish River Nature Reserve (GFRNR) and the Baviaanskloof Nature Reserve (BNR), both provincial nature reserves in the Eastern Cape. These areas are not included in the project at present, pending the resolution of historical land claims issues. However, they will be included as part of the grouped project if they meet the eligibility criteria specified in section 1.16.1.

Each planting site within these areas is delineated by a shapefile in ArcView format when it is assigned to a contractor for planting. These shapes are stored along with all relevant data for the contract and planting operations in the permanent online database (see 3.2.9d).The AENP is close to the town of Jansenville, from where the majority of staff is sourced by contractors.

See Annex 12 for more detailed historical and biophysical information regarding the project areas. Additional sites within the project area and in additional conservation areas in the Eastern Cape that meet the VCS criteria, methodology criteria (as specified in AR-AM0002 (V3)) and project eligibility criteria will be included in the project areas in the future, in keeping with the VCS guidelines on project grouping. These additional planting sites will be validated and formally incorporated into the project during each verification period.

More specific boundary information is given below for the project area, and in addition all information is saved in an appropriate digital Geographic Information System (GIS) format (KML 2.2 and ArcView/ArcGIS shapefiles) in the offices of Conservation Support Systems (CSS), the partner involved in preparation and management of all spatial information.

Addo Elephant National Park

The AENP is state land managed by the South African National Parks (SANParks). The park is approximately 164,000 ha in size with plans to expand into a 360,000 ha mega-park, in addition to the proposed proclamation of a 120,000 ha marine reserve. It is important to note that despite the park name, the project area within the national park (see Figure 1 below) is not currently stocked with elephants. The project area is presently too degraded to support elephants. The restoration work will focus on the delineated project area in the northern part of the park (Figure 1), known as the Darlington Dam section.

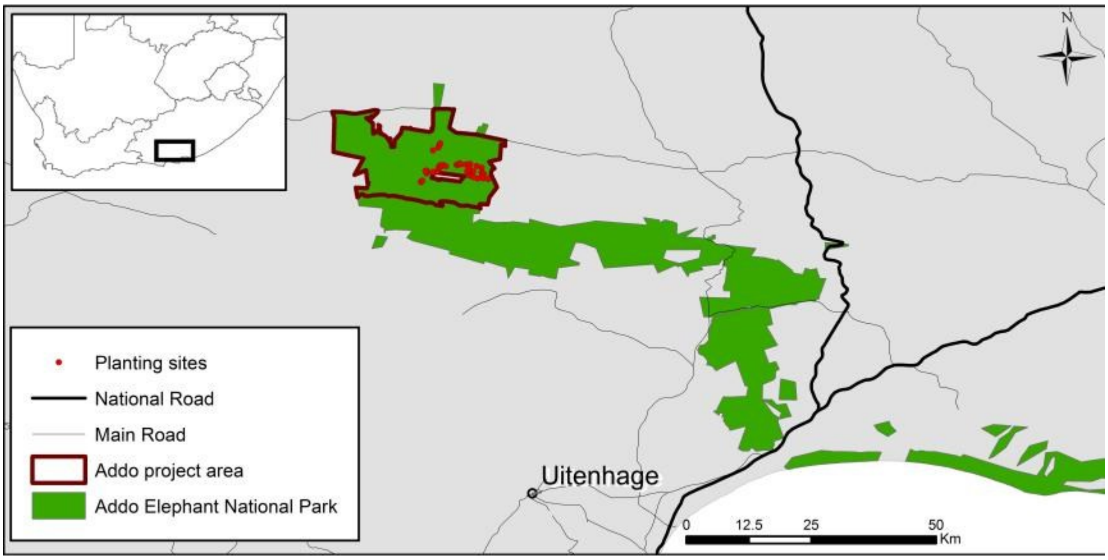

Figure 1: Location of the Addo Elephant National Park and ARR project area in the Eastern Cape, South Africa. The project area is the Darlington Dam section of the National Park, situated in the north of the Park.

1.6 Duration of the project activity/crediting period:

Project start date: 01/01/2004

The Department of Water Affairs (DWAF) provided funding for the early stages of the ARR VCS project activities. Over the period 2004-2010, DWAF contributed approximately US$ 750,000 per year (see Annex 2). This funding was provided specifically to catalyse additional funding for the ARR of degraded thicket through the generation of Verified Emission Reductions (VERs) (See the 2004 Pilot Project Business Plan, Annex 10)[6]. After a portfolio shuffle in government departments in 2009, DWAF became the Department of Water (DWA), and subsequently the Natural Resource Management Programmes (which continues to provide funding for project activities) has been shifted to the Department of Environmental

[6] The Business Plan for the “Eastern Cape Subtropical Thicket Rehabilitation Pilot Project” dated 5 August 2004 indicated that although the Kyoto Protocol had yet to be ratified, carbon trading was already occurring in various places in the world. The Business Plan states that the aims of the pilot project were to assess carbon storage through rehabilitation of spekboom, and to study the economic, social and ecological impacts of the project. It was funded by DWAF specifically to assess and develop methods of thicket rehabilitation for carbon trading.

Affairs (DEA). Securing funding from the sale of VERs will facilitate considerable expansion of the project areas planting sites to be restored. Since project sites planted prior to the date of this project document do not meet the specified methodology, only those sites planted subsequent to project validation will be considered for carbon sequestration and credits.

Crediting Period start date: 01/06/2004
The first planting of *P. afra* cuttings took place in the Baviaanskloof Nature Reserve in January 2004 (Annex 9). Planting in the Addo Elephant National Park began in 2007. Areas planted prior to validation have not been verified, and no baseline was conducted for these sites. Consequently, although they were planted specifically with the aim in mind of securing carbon finance to ensure long-term sustainability, these sites will not be included in the carbon calculations.

Crediting period: 60 years.
It is anticipated that carbon stocks will increase for 50 years after planting (van der Vyver, 2011). The duration of planting will depend on the planting rate, but the current planting plan is for 10 years.

1.7 Conditions prior to project initiation:

The planting sites fall within a national park. Therefore, the condition prior to project initiation is conservation. Although, the land is under conservation, much of it is degraded due to the previous land use of farming. Natural regeneration of the arid and valley forms of thicket does not occur spontaneously after degradation (Sigwela, 2004; Vlok et al., 2003). A number of factors prevent natural regeneration, including an altered micro-climate resulting in extremely high soil temperature and reduced infiltration into soils due to soil hardening. This degradation can be observed as structural simplification (Hoffman & Cowling, 1990), loss of biomass (Lechmere-Oertel et al., 2005a; Mills et al., 2005a; Mills et al., 2005b), loss of soil organic matter (SOM) (Mills & Fey, 2004b; Mills & Fey, 2004a) and/or soil erosion (Lechmere-Oertel et al., 2005b; Mills & Cowling, 2010). Most importantly, with degradation there is a concomitant loss of carbon (Mills *et al.*, 2005a; Mills *et al.*, 2005b) throughout the ecosystem, which can only be recovered through a process of active restoration and regeneration.

Additional evidence of long-term degradation has been demonstrated in a study that showed high mortality with little regrowth in the only significant remaining tree species (*Pappea capensis*) in transformed areas (Lechmere-Oertel et al., 2005a). Aerial photographs of the project area (Annex 15) show clearly that there has been no natural regeneration of thicket in the degraded landscapes for the past 40 years, and that the land was already degraded by at least 1972. All selected planting sites are classified as thicket vegetation as defined by the Subtropical Thicket Ecosystem Project (STEP) (Vlok & Euston-Brown, 2002), and have been identified as degraded or severely degraded by the landscape-level transformation study undertaken by Lloyd *et al.* in 2002.

1.8 A description of how the project will achieve greenhouse gas (GHG) emission reductions and/or removal enhancements:

Degraded thicket vegetation in the project area will be restored by planting *P. afra* cuttings, which will result in the return of ecosystem carbon. The restoration process has been clearly demonstrated at several sites across the thicket biome:

Site name	Location	Study
Krompoort	33°33'S; 25°11'E	(Mills & Cowling, 2006)
Fish River	33°7.5'S; 26°38'E	(Mills & Cowling, 2006)

Rhinosterhoek	(van der Vyver, 2011)

Restoration trials and analyses of historically restored sites have demonstrated a return of an average of 10.33 t CO_2e ha^{-1} yr^{-1} for the project area (corresponding to an accumulation rate of 2.8 t C yr^{-1}: see Annex 7 for the carbon stock meta-analysis). Restoring thicket by planting cuttings of *P. afra* results in the removal of carbon dioxide from the atmosphere and the return of ecosystem carbon (in above ground biomass, below ground biomass, deadwood, litter and SOC), thereby providing removal enhancements. It is important to note that restoration of the project areas would not occur without the project activities (see Section 1.7).

The proposed ARR project activities entail planting *P. afra* cuttings exclusively. *P. afra* is the dominant species in many thicket types in the project areas and is known locally as spekboom. No maintenance of the system is required once the *P. afra* cuttings have established. Game stocking in the project area is carried out by SANParks, and is legally required to be at or below the optimal stocking level. Restoration of the area as a result of the project will improve ecosystem function in the project areas. The canopy of *P. afra* reduces soil temperatures, improves soil quality through the addition of leaf litter, reduces the incidence of frost at ground level and is likely to reduce runoff of rainwater by improving soil infiltration (Mills & Fey, 2004b). These effects improve the micro-climate and soil conditions for natural recruitment of indigenous shrubs and trees (Lechmere-Oertel et al., 2005a).

Grazing and browsing by game (including elephants, which are not currently found in the project area) promotes *P. afra* growth, provided it occurs at optimum stocking levels. This is largely because any such disturbance will result in portions of the *P. afra* plants breaking off and re-sprouting on the ground, thus facilitating additional *P. afra* growth and consequent carbon accrual (Aucamp et al., 1980). This response is typical of the stable ecosystem, to which state the restoration project hopes to return the project areas. In addition, natural ecosystem recovery is likely to be facilitated because of an improved micro-climate at the soil surface. This recovery would entail the dispersal of trees and shrubs into the proposed ARR project area by animals. Indeed, an increase in biodiversity has been observed in several such restoration sites (van der Vyver, 2011).

Activities to be undertaken in the proposed ARR project include the following:

- selection of planting sites;
- appointment of contractors;
- harvesting of *P. afra* cuttings from within the project area;
- planting of *P. afra* cuttings within the planting sites; and
- supplementary planting of *P. afra* cuttings where required.
- long term monitoring and management of the plantings

The DWAF funding was provided for a programme called Working for Water (WfW), in order to provide employment for local communities, whilst restoring indigenous vegetation and seeding the operation potential for a long-term carbon sequestration project funding through international carbon offset finance. WfW is one of the country's Natural Resource Management Programmes, which have recently (2011) been transferred to the national Department of Environmental Affairs. The Gamtoos Irrigation Board (GIB) is the implementing agent for WfW and is responsible for all of the above activities. GIB has appointed Conservation and Support Services (CSS) as their mapping service provider and all spatial development work has been conducted through CSS.

Selection of planting sites

Several constraints must be met before the planting site can be created and before the size of the planting can be considered:

- All areas must fall within the suitability layer[7].
- No new planting sites can overlay old planting sites.
- Spatial details of all supplemental planting contracts are contained in a separate layer and are entered into the spatial database to ensure data continuity and integrity.
- Historical sites and soil depth must be established (soil depth is determined by field visits by the Project Manager[8] after initial planting sites have been identified by CSS).

Two planting methods are employed, namely: mechanical and manual (see descriptions below). Manual planting is used rarely and only for sites that are too steep or too rocky for mechanical planting. The method of planting determines the size of the planting site and is based on the area that can be planted in a 20 day contract. Contracts that make use of a mechanical auger have 26 ha planting sites and manually planted sites are 7 ha in size. Once all the constraints have been satisfied, planting sites are digitized and allocated a unique identification number. These areas are then supplied to the Project Manager with draft contract maps, shapes and identification numbers for field verification of site selection in conjunction with land or reserve managers (logistical considerations are also investigated and considered). Once the sites have been deemed suitable, quotations for planting the site are sourced and sent to the Regional Project Manager[9] for approval. CSS is then notified via e-mail to commence the block-marking of new planting sites and GPS confirmation of old planting sites. Contractors must be present at the block-marking stage to confirm the area that is to be planted.

The planting sites do not require any preparation prior to the planting of the *P. afra* cuttings. *P. afra* is a naturally occurring species in this area and is thus adapted to growing alongside the other species found in the project areas. Planting sites typically have small quantities of shrub and bush vegetation, but the area disturbed by planting is minimal.

Hiring of staff

- GIB uses contractors to undertake the restoration.
- Each contract is specific to a predefined area and must be completed within a given time period[10].
- Each contractor appoints their own staff and signs an employment contract with each staff member for that specific contract.
- Staff are sourced from towns near the project area. Staff to work in the Addo Elephant National Park are sourced mostly from Jansenville (38 staff currently employed)
- The project is expected to be expanded significantly over the long term, with the inclusion of two provincial conservation areas (the Baviaanskloof Nature Reserve and the Great Fish River Nature Reserve) and it is estimated that employment increase over the next ten years.
- Contractors must select their workforce along the guidelines of Expanded Public Works Programme[11] where 60 % of employees should be women, 40 % should be men and 25 % should be under the age of 35.

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[7]The suitability layer is used to determine viable sites for the project. It is a GIS layer representing the intersection of vegetation types identified as spekboom-rich thicket in the STEP vegetation analysis (Vlok & Euston-Brown, 2002) with those areas identified as degraded in the STEP-wide study by Lloyd et al., in 2002.

[8] Each project area is coordinated by a project manager, who coordinates site selection and directs the planting operations.

[9] The Regional Project Manager is in overall charge of the project operations.

[10] Approximately 26 ha are planted in a 20 day contract.

- All contractors must adhere to the Working for Water Project Operating Standards, and undertake self-assessment and reporting on a quarterly basis.
- Most of the staff employed by the project were unemployed prior to the inception of the project.

Harvesting of *P. afra* cuttings
Cuttings, which are approximately 500 - 1,000 mm in length, are harvested from intact thicket within 50 km of each planting site. This reduces the risk of genetic 'pollution'. Additionally, sustainable harvesting (ensuring that no more than 30% of the branches are removed from a single source plant) prevents ecosystem damage, as the biomass harvested is replaced by regrowth. Such sustainable harvesting is possible as thicket (and *P. afra* in particular) has evolved with herbivory (i.e. harvesting) by mega-herbivores such as the African Elephant (*Loxodonta africana*), and the Black Rhinoceros (*Diceros bicornis*) (Kerley et al., 1999), and thus has a strong regeneration capacity. In fact, defoliation is essential if the production potential of *P. afra* is to be increased (Aucamp et al., 1980). A study of the influence of the rest period on the plant mass of defoliated *P. afra* showed that *P. afra* increased in biomass by 49 % over an 18 month rest period (Aucamp, 1979).

Cuttings are stored in the shade for two days to harden them off before planting. This process has been found to improve the survival rate of the cuttings.

Figure 2: A mechanical auger used by an operator to drill a hole for planting *P. afra.* cuttings.

Planting of *P. afra* cuttings
Harvested cuttings of *P. afra* are planted either mechanically using an auger with an adapted drill bit or manually. Mechanical planting occurs according to the following system:

[11] Available from: http://www.epwp.gov.za/

- The ground, where the hole is to be drilled, is moistened with water (approximately 200 ml).
- The auger operator drills a hole in the wet ground (10 - 20 cm in depth, and approximately 10cm wide).
- A member of staff plants the *P. afra* cutting, which is approximately 30 mm in diameter and approximately 1,000 mm in length, into the hole.
- Another member of staff uses a *koevoet* (heavy metal pipe) to compact the soil around the cutting.

The manual planting follows the following system:

- The ground, where the hole is to be dug, is moistened with water (approximately 200 ml).
- A hole is dug by a staff member using a pick or a spade (10 – 20 cm in depth).
- The *P. afra* cutting is planted into the hole.
- The hole is closed and a member of staff uses a *koevoet* to compact the soil around the cutting.

A space of 1.5 to 2 m is left between the cuttings. As mentioned above, the size of a contract depends on whether the planting site is planted mechanically or manually. The cuttings develop into trees/tall shrubs within 10-15 years (van der Vyver, 2011; Mills & Cowling, 2006) and do not require inputs such as watering or fertilization (see Figure 3 below) (Mills & Cowling, 2006; Mills et al., 2007). The planting sites are inspected by the Project Manager to ensure that the correct methods are being used, the results of the planting are satisfactory and the contractor is working in the correct place.

Figure 3: *P. afra* plants between the age of 10 and 15 years.

Supplemental planting of *P. afra* cuttings

Supplemental planting ("blanking" or "inboeting") is performed to replace cuttings that have died. The survivorship in each block is monitored on an annual basis by GIB to assess the need for supplemental planting in order to maintain the effectiveness of the restoration process. Replanting of the cuttings that have died is the only post-planting maintenance that is required for the proposed ARR project. The established *P. afra* plants require neither pruning nor weeding to ensure continued healthy growth.

1.9 Project technologies, products, services and the expected level of activity:

A comprehensive Arcview-based GIS system is used to map and keep record of all large-scale plantings. The GIS system is housed at the CSS offices at 61 New Street in Grahamstown. Way point navigation is undertaken by means of handheld Trimble differential GPS units.

All contracts and monitoring data are stored in the online database maintained by CSS on behalf of the project implementer. The database is spatially explicit and attribute-driven, and is updated on a monthly basis. The database can differentiate monthly planting updates, cumulative planting updates and blanking information (see "Supplemental planting of *P.* afra cuttings" above) to replace cuttings that have died.

1.10 Compliance with relevant local laws and regulations related to the project:

The proposed ARR project and its activities comply with relevant laws and legislations applicable to a conservation area in South Africa, as well as overarching international and national obligations, including:

Environmental legislation for sustainable development:

- National Environmental Management Act 107 (NEMA) of 1998.
- Environment Conservation Act 73 of 1989.
- National Environmental Management: Biodiversity Act 10 of 2004.
- National Water Act 36 of 1998.
- National Forest Act 84 of 1998.
- National Environmental Management: Protected Areas Act 57 of 2003.
- National Environmental Management: Air Quality Act 39 of 2004.
- National Heritage Resources Act 25 of 1999.

Overarching international and national obligations:

- Convention on Biological Diversity.
- Local Agenda 21.
- The Ramsar Convention.
- The United Nations Framework Convention on Climate Change (UNFCCC).
- Constitution of the Republic of South Africa, 1996.
- The National Biodiversity Framework, 2007.
- South Africa's National Framework for Sustainable Development, 2008.
- The National Spatial Development Perspective, 2003.

The project activities are implemented by local government under the Expanded Public Works Programme, and will comply with labour guidelines and legislation.
The proposed ARR activities will contribute to sustainable development and are expected to have positive social, economic and environmental impacts. Sustainable development is defined in South Africa's NEMA (Act 107 of 1998) as "the integration of social, economic and

environmental factors into planning, implementation and decision making so as to ensure that development serves present and future generations" (Government of South Africa, 1998). This is consistent with the United Nation's definition that reads "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[12]. In particular, sustainable development will be achieved through:

- Increasing biodiversity - particularly shrub and tree diversity – as a result of the planting of *P. afra* cuttings (van der Vyver, 2011) (see Section 1.8).
- Reducing soil erosion and improving stabilization of slopes through the planting of *P. afra* cuttings.
- Improving the functioning of Addo Elephant National Park as a water catchment that supplies high quality water to downstream dams.
- Creating skilled and unskilled employment opportunities. The unemployment rate for the Eastern Cape is 39.5% (Statistics South Africa, 2007); therefore this is an important contribution to local economic development. Poverty alleviation is a major provincial and national objective.
- Building institutional capacity within GIB, DWA, and other involved organisations, related to:
    - ecological training;
    - exposure to the carbon market; and
    - training in the scientific method through interaction with scientists.
- Contributing to local capacity building, environmental education, awareness and knowledge transfer.
- Showcasing South African innovation in environmental sustainability since the proposed ARR project is likely to be the first ARR in South Africa.

1.11 Identification of risks that may substantially affect the project's GHG emission reductions or removal enhancements:

Potential risks to the proposed ARR project's success are considered low, and under conservation conditions, it is anticipated that *P. afra* cutting survival rates will be high (Mills & Cowling, 2006). An overview of potential risks (including non-permanence) is detailed in Table 1 and Table 2 below.

Table 1: Risks common to all projects as specified in the VCS tool for AFOLU risk assessment.

Project risk	Risk rating
Risk of unclear land tenure and potential for disputes	Low – project activities take place on specified government-run national park; all future potential grouped sites are also protected areas. Therefore all land is owned by the state and managed by national or provincial mandated conservation authorities.
Risk of financial failure	Low – running costs for the operation are low13, and carbon finance will assist in the expansion of operations. Carbon credit returns over the project lifetime are anticipated to exceed the restoration costs.
Risk of technical failure	Low – the technical requirements for the project are simple, and have been proved in the field. Field managers have been trained in monitoring operations, and collected

[12] Available from: http://www.un.org/esa/sustdev/index.html
[13] An analysis of the current running costs (supplied through public finance with the goal of generating a viable carbon-financed restoration project) for the project are appended in Annex 2. Carbon finance will allow a significant increase in the scale of operations.

	data is housed in a custom-built spatial database and is regularly backed up.
Risk of management failure	Low – subsequent to planting, the management requirements of the project are exceedingly low due to the resilience of the *P. afra* plantings. Project management arrangements are carried out by a well-established organisation (GIB)[14] that is based in the area, and a management structure has been finalised. The coordination arrangements between all project proponents are formalised in a Memorandum of Agreement, which explains roles and responsibilities, and details a binding conflict resolution strategy.
Risk of rising land opportunity costs that endanger the future viability of the project	Low – planting sites are located on a national park that is statutorily protected, thus alternative land use is not possible. Restoration of degraded land will have only positive economic effects and it will enable an increase in the game stocking levels of the project area as the carrying capacity will increase due to increased biomass.
Regulatory and social risk	Low – all current and future project areas are protected by national legislation.
Risk of political instability	Low – South Africa is a politically stable nation.
Risk of social instability	Low – South Africa is socially stable, and the location of sites within statutory reserves ensures some insulation from local community activities.
Natural disturbance risk	Low – game stocking rates at levels mandated by conservation legislation have been shown to have minimal effects on the growth of *P. afra*, which is adapted to mild herbivory, and can even enhance growth rates as a response to browsing (Aucamp et al., 1980; Mills & Cowling, 2006)Consequently, browsing is not expected to have a significantly negative effect on *P. afra* growth rates. No other forms of natural disturbance are anticipated in the project area.
Devastating fire risk	Low – *P. afra* is a fire-tolerant species due to its succulent (water-bearing) and dense foliage (Kerley et al., 1995; Vlok et al., 2003).
Risk of incidence of pest and disease attacks	Low – *P. afra* is a major component of the natural thicket vegetation and is naturally resistant to pests and diseases in the area.
Risk of extreme climatic events (e.g. floods, drought, winds)	Medium – droughts are frequent in this area, although it is expected that such drought will have limited impact on plant growth due to *P. afra's* drought-resistant succulent nature. Floods tend to occur more readily where large areas of land are degraded, but the flooding is not likely since the project areas are all semi-arid and have very low annual rainfall (see Annex 12 for project climate details).
Geological risk (e.g. volcanoes, earthquakes, landslides)	Low – the Eastern Cape of South Africa is a geologically stable area.

[14] In 2007 GIB was awarded the Water Conservation and Demand Management Trophy (the only award in the agricultural sector on a national basis), and the GIB-run Sand/Bulk Alien Vegetation Clearing Project was awarded winner of the National Project Flagship Competition. In 2006 the Working for Water Project in Port Elizabeth won the Airport Managers Award for Excellence.

Table 2: Risk factor table, indicating the specific potential future risks related to the proposed ARR project (VCS, 2008b).

Risk factor	Risk Rating
Project longevity/Commitment period	
Long-term commitment (i.e. many decades or unlimited) with no harvesting.	Low
Ownership type	
Established NGO or conservation agency owner.	Low
Technical capability	
Proven technologies and ready access to relevant expertise.	Low
Financial capacity	
Demonstrable backing from established financial institutions, NGOs and governments[15]. GIB has a long history of successful project implementation and project financial management, and is regularly audited.	Low
Management capacity	
Substantial previous project experience (≥ five projects) with on-site management team.	Low
Future income	
Appropriate management plan and financial analysis include future income to finance future management activities (e.g. carbon finance to be used for project management, planting and monitoring operations, etc.).	Low
Future/current opportunity costs	
Alternative land uses are unlikely to occur in the future.	Low
Endorsement of project or land use activities by local or national political establishment	
Endorsement given and not likely to change in the future.	Low
Risk of fire to forests	
Fire is rare in the region, and the species selected is highly fire resistant	Low

The risks in Tables 1 and 2 above are the risks specified by the VCS as essential to assessment of the project buffer retained. No additional risks to the project have been identified during the project development.

The highest identified risk is the risk from extreme climatic events in Table 1. This risk is Medium, and the overall identified risk category is therefore Medium (VCS, 2008c). However, since all other identified risks are Low, it is proposed that the lowest buffer within the ARR Medium Risk category be withheld (i.e. 20%).

1.12 Demonstration to confirm that the project was not implemented to create GHG emissions primarily for the purpose of its subsequent removal or destruction:

No significant GHG emissions as a result of degradation of thicket vegetation have been created by the project proponents; all degradation is historically stable. Therefore, the project was not implemented to create GHG emissions for the purpose of their subsequent removal or destruction. Evidence to support this statement is contained within the aerial photographs displayed in Annex 15, which indicate the duration of time over which the ecosystem has been degraded. Furthermore, the mandate of the ECPTA and SANParks is to conserve indigenous vegetation and thus restored sites will be protected in perpetuity. Future

[15] There is some public financing available at present from DWA to ensure that the pilot operations are successful. This money will continue into the future, but additional finance is necessary for the potential restoration area to be expanded.

inclusions for grouping within the proposed ARR project will include only protected areas that have a similar demonstrable history of long-term degradation.

1.13 Demonstration that the project has not created another form of environmental credit (for example renewable energy certificates):

Other environmental credits have not been generated by the proposed ARR project. Additionally, no such credit application has been made (see Annex 5, Figure A .6.2).
The World Bank funding for the establishment of the Baviaansloof Mega-reserve provides for expansion of the area and integration of community activities, but does not allow for restoration, and there is consequently no overlap between the World Bank funding and the proposed project.

The Baviaanskloof Nature reserve's status as a UNESCO World Heritage Site also has no overlap with the project activities, other than geographical. It does not provide restoration funding, and although there are obligations to maintain the site in an appropriate manner for conservation, these conditions are no more restrictive than the national legislation. The proposed project was not considered when Addo was nominated for World Heritage status.

The STEP project is an independent research project that was government-funded. The goal of STEP was to assess the status of the subtropical thicket biome, to identify drivers of degradation, and to identify priority biodiversity sites and sites for restoration. No environmental credits were generated by this project.

The project has benefitted from contributions from a number of sources and NGOs (see Section 6.4), none of which are project proponents or have a claim to the credits generated by this project.

1.14 Project rejected under other GHG programs (if applicable):

Not applicable. This is the first application for carbon sequestration accreditation for the proposed ARR project.

1.15 Project proponents' roles and responsibilities, including contact information of the project proponent, other project participants:

The project proponents' roles and responsibilities are detailed in Table 3 below. See Annex 1 for the signed Memorandum of Agreement between the project proponents and the signed deed of representation.

Table 3: Project proponents' roles and responsibilities.

Name of Party involved [(host) indicates a host Party]	Private and/or public entity(ies)/project participants, roles and responsibilities
Republic of South Africa (host)-Department of Environmental Affairs (DEA)	Public Entity and landowner of Baviaanskloof Nature Reserve, Addo Elephant National Park and GFRNR. (DEA is representing the Republic of South Africa as project developer and project financier)
Eastern Cape Parks and Tourism Agency (ECPTA)	Public Entity (Manager of the Baviaanskloof Nature Reserve and the GFRNR, which will be included once land claims are resolved).
South African National Parks (SANParks)	Public Entity (Manager of the Addo Elephant National Park).

1.15.1 Roles of proponents and participant organisations

1.15.1.1 The South African National Department of Environmental Affairs (DEA)

The government of South Africa is the ultimate landowner of the nature reserves in question. Furthermore, although the project was originally funded through the Natural Resources Management Programmes of the Department of Water Affairs and Forestry, subsequent reorganization of the government departments has transferred the role of administration of the NRM portfolio to the DEA. Consequently, the DEA is both the principal landowner and the principal implementing agent.

The DEA-NRM provides implementation oversight for the ABFRP project. It is responsible for the contracting of service providers, ensuring that the project is managed according to the specified methodology throughout the project period. The DEA-NRM has contracted the GIB to undertake the administration and management of the planting, blanking and initial management of the project areas.

1.15.1.2 GIB

GIB is a contractor under the NRM programme. It has received national awards for its efficacy in implementing these programmes, and is consequently a preferred partner for implementation in the Eastern Cape. It is responsible for the management of the current stage of the project - planting, blanking and management of contractors, as well as oversight of the planning and monitoring of the project. It has developed standard operating procedures for this process, as well as a database for maintaining all project records. These SOPs and database will be handed over to the DEA if GIB is relieved from its implementing role. The project manager of GIB is therefore responsible for the overall project implementation.

GIB is answerable to the DEA in its role as chief implementing agent. Oversight is provided through the ABFRP Committee, and scientific, management and planning guidance is provided by the Eastern Cape Restoration Programme (ECRP) committee.

1.15.1.3 SANParks and ECPTA

Both these organizations are responsible for the management of the protected areas under their respective administration, and consequently for the project area. They are required to maintain the areas for conservation purposes in terms of relevant national legislation, and consequently are vital stakeholders in the ABFRP project. Their role as implementing agents will be to ensure that the restored areas are maintained in order to assist the establishment of *P. afra*. In addition to this long-term management role, they have been involved in the identification of priority areas for restoration through an interactive process of engagement with the principal implementing agency.

1.15.1.4 ECRP committee

The ECRP is a broad-scale programme coordinating the restoration of the landscape of the Eastern Cape of South Africa. The ABFRP falls within the region coordinated by the ECRP, and as such, benefits from the planning activities and scientific advice provided by the ECRP. The ECRP does not play a role in the implementation of the project, but contributes significantly by providing scientific guidance and management planning assistance. It is also responsible for ensuring that the ABFRP realizes its stated goals through monitoring and evaluation of the project. The membership of the ECRP comprises individuals from all parties to the MoA, as well as selected scientific advisers. Further details are available in the Memorandum of Agreement between the project proponents.

1.15.1.5 The Development Bank of South Africa (DBSA)

The role of the DBSA has been identified as the appropriate entity to handle the finances for the ABFRP, including the provision of funds for planting and monitoring of *P. afra*, as well as the sale and management of certified credits generated by the project. A more detailed description of the role of the DBSA is provided below in section 1.15.2. A ring-fenced account called the ABF Biodiversity Account has been created within the DBSA's Drylands Fund.

1.15.1.6 ABF Biodiversity Account Steering Committee

The ABFBA Steering Committee comprises representatives of DEA, SANParks, ECPTA and DBSA, and it manages the funds generated by the ABFRP and residing in the Biodiversity Account. It is also responsible for hiring and coordinating contractors to carry out monitoring and implementation for the project when the principal implementing agent requires it.

1.15.2 Management of VERs within the Spekboom Thicket Restoration Project

The DBSA has been identified to act as the financial vehicle for the project. Specifically, a sub-account of the Drylands Fund (the ABF Biodiversity Account - ABFBA) has been ring-fenced to act as the account through which the monies for the project will be managed by the DBSA. The Drylands Fund was formed jointly through the action of DEA and the DBSA in 2010 in order to act as a fund to facilitate the restoration of drylands areas in South Africa. The ABFBA sub-account is housed within this Fund since it meets the mandate of the governing fund, but will be operated as a separate entity.

This financial entity will own and trade the VERs generated by the project at a market-related rate. The actions of the financial entity will be directed by the ABF Biodiversity Account Committee, which will operate as the management committee for the project. This committee comprises representative members from each of the project proponents. The distribution of income to stakeholders will be decided by this committee. This income will be used to reinvest in thicket restoration and planting of spekboom within the project. The ABFBA committee will arrange and coordinate contractors to fulfil implementation and monitoring roles as required to supplement the actions of the implementing agents. At present, the Gamtoos Irrigation Board (GIB) is nominated as the effective implementing agent carrying out preparation and planting activities within the project area.

The financial entity serves several additional purposes. Firstly, it provides potential investors with an opportunity to invest in the financial entity and thereby expedite the planned planting of *P. afra*. Secondly, it provides transparency and accountability regarding income from the sale of VERs, as well as expenditures. And thirdly, it provides sustainability over the 60 years of the project, in that it does not rely on the existence of any particular institution.

Oversight for the project, including long-term planning, monitoring and evaluation of the ABFRP is provided by the Eastern Cape Restoration Programme Committee. This entity comprises representatives of all the project proponents, as well as a thicket ecologist, and thicket ecosystem carbon accounting and soil specialist, a thicket restoration ecologist, and DEA-NRM representatives, one of whom will chair the committee. The ECRP committee provides in-depth knowledge and experience in: i) thicket ecology; ii) carbon stock accounting in thicket; iii) restoration protocols in thicket; iv) establishment of restoration projects in thicket; and v) VCS project document development. The knowledge within this company includes at least ten peer-reviewed scientific publications on thicket ecology and/or thicket carbon stocks, and at least three decades of experience in Eastern Cape thicket.

GIB, as the current implementing agent, is assigned to undertake the implementation of planting of *P. afra*, which includes the administration of all planting sites and monitoring of contractual commitments.

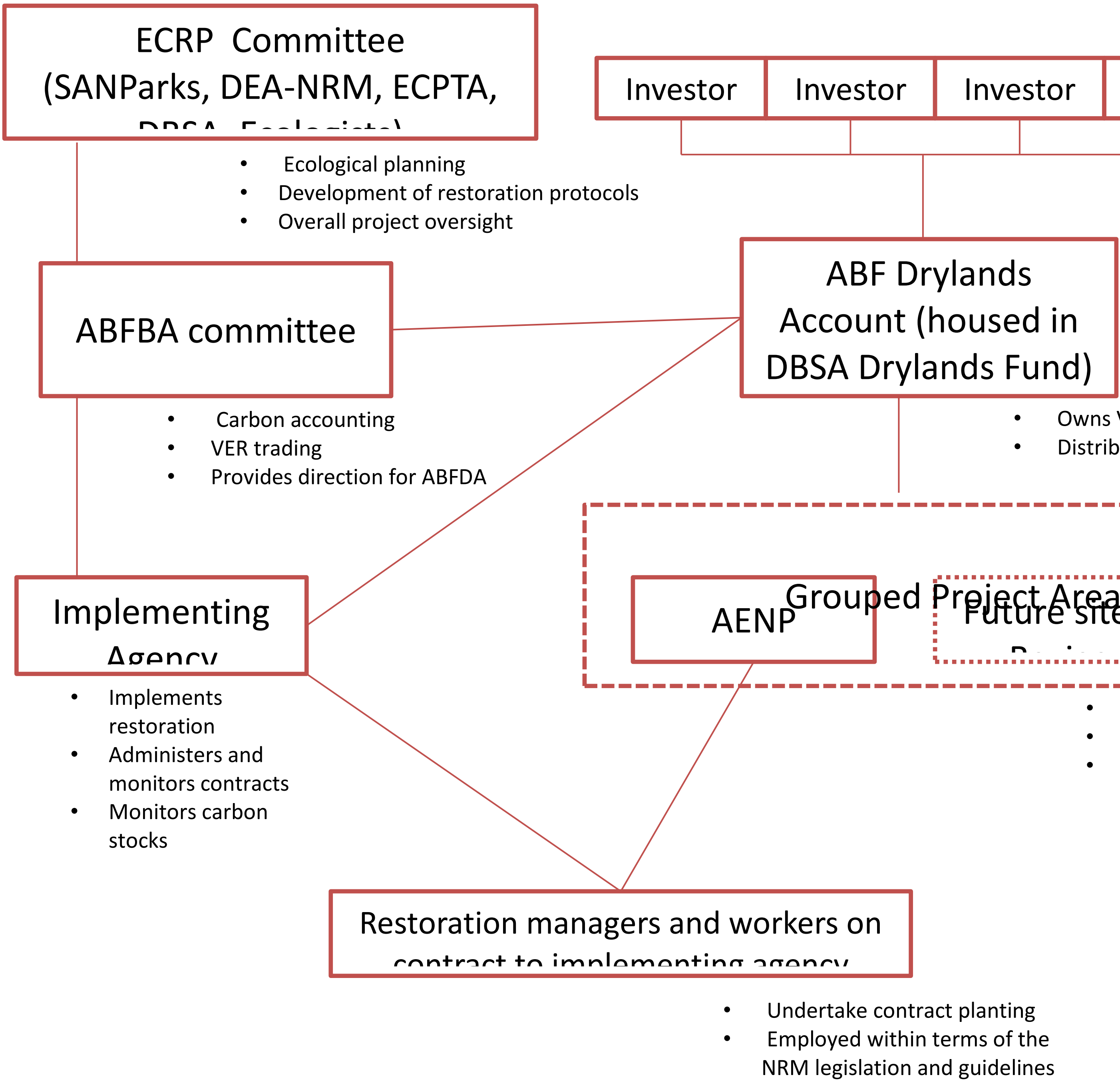

Figure 4: Management of VERs within the proposed project.

Further clarification on the respective roles of all project proponents is detailed within the Memorandum of Agreement appended in Annex 1.

1.16 Any information relevant for the eligibility of the project and quantification of emission reductions or removal enhancements, including legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and temporal information:

1.16.1 Demonstration of eligibility

The selected methodology specifies that the eligibility must be determined using the mandatory tool "Procedures to demonstrate the eligibility of lands for afforestation and reforestation Carbon Development Mechanism (CDM) project activities (Version 01)" (UNFCCC, 2007). This tool will be referred to hereafter as EB35 Annex 18.
EB35 Annex 18 states the following:

"1. Project participants shall provide evidence that the land within the planned project boundary is eligible for an A/R CDM project activity by following the steps outlined below.
(a) Demonstrate that the land at the moment the project starts does not contain forest by providing transparent information that:

- *i. vegetation on the land is below the forest thresholds (tree crown cover or equivalent stocking level, tree height at maturity in situ, minimum land area) adopted for the definition of forest by the host country under decisions 16/CMP.1 and 5/CMP.1 as communicated by the respective DNA;*
- *ii. all young natural stands and all plantations on the land are not expected to reach the minimum crown cover and minimum height chosen by the host country to define forest; and*
- *iii. the land is not temporarily unstocked, as a result of human intervention such as harvesting or natural causes.*

(b) Demonstrate that the activity is a reforestation or afforestation project activity:

- *i. for reforestation project activities, demonstrate that the land was not forest by demonstrating that the conditions outlined under (a) above also applied to the land on 31 December 1989; and*
- *ii. for afforestation project activities, demonstrate that for at least 50 years vegetation on the land has been below the thresholds adopted by the host country for definition of forest."*

According to the Designated National Authority (DNA) for South Africa (i.e. the Department of Minerals and Energy), the minimum definition of forest for reforestation and afforestation under the CDM[16] are as follows:

- a minimum tree canopy cover of 30%;
- a minimum area of 0.05 ha (500 m^2); and
- a minimum tree height of 2 m.

These conditions are exceedingly rigorous, and the procedures required to ensure that no area exceeding this minimum definition is included in the project area would be exceedingly challenging on the scale of the project. For the specified project area, this would require field work or complex GIS analysis using multi-spectral imagery of every 500m^2 unit within the more than 9,400 ha, or over 188,000 individual units.

However, VCS guidance stipulates that where there is a conflict between CDM and VCS criteria, the VCS rules and requirements take precedence (VCS, 2011).In particular, the VCS rules and requirements for ARR projects should be adhered to in order to qualify for registration under the VCS. Consequently, the eligibility is determined using the VCS "Tool for AFOLU Methodological Issues" (VCS, 2008d), page 4.

[16]Available from: http://cdm.unfccc.int/DNA/ARDNA.html?CID=197

4. Determine the eligibility of the land contained within the project boundary on the basis of the VCS "Guidance for Agriculture, Forestry and Other Land Use Projects".

The eligibility criteria for AFOLU activities as defined in the VCS
"Eligible activities in the ARR project category consist of establishing, increasing or restoring vegetative cover through the planting, sowing or human-assisted natural regeneration of woody vegetation to increase carbon stocks in woody biomass and, in certain cases, soils.

Forest management practices such as enrichment planting and liberation thinning shall be considered Improved Forest Management (IFM) project activities. Revegetation activities that primarily target woody biomass production shall be considered ARR project activities."
Additional clarification is provided by the "Guidance for AFOLU Projects" (VCS, 2008b):
"Examples of envisaged VCS ARR activities include: reforestation of forest reserves; ***reforestation or revegetation of protected areas and other high priority sites; reforestation or revegetation of degraded lands;*** *and rotation forestry with long harvesting cycles."*

The project principally targets woody biomass production through the planting and regeneration of *P. afra.* In addition, the project falls within the "envisaged ARR activities" as detailed in the Guidance for AFOLU Projects, since it is revegetation and reforesting of both protected areas and degraded lands.

5. Carbon projects encompassing several land-use activities must satisfy the VCS land eligibility requirements for each activity type for which crediting is being sought.
The project encompasses on a single land-use activity (ARR) and satisfies the VCS land eligibility requirements as detailed in 4 above.

6. Documented evidence shall be provided in the VCS PD that no ARR or ALM project areas were cleared of native ecosystems within the ten years prior to the proposed VCS project start.

No prior afforestation or restoration has taken place in any of the project sites, and none of the sites are temporarily unstocked or cleared of vegetation in the last ten years, as demonstrated by the historical aerial photography (1972 onwards) (see Annex 15).These photographs also indicate that there has been no natural regeneration of thicket in the selected sites for at least 37 years, demonstrating that without the human intervention of the proposed ARR project activities such regeneration will not occur.

It is considered that the above clarifications show that the project is eligible in terms of the criteria specified by the VCS for site eligibility.

1.16.2 Project-specific eligibility

Additional project-specific eligibility criteria are specified by this document to ensure that all project sites are suitable for project operations. These criteria include:

(i) The specified land use in the project area must be conservation. All project areas will therefore either be contractual reserves managed by local or national conservation agencies, or a binding contract for the duration of the project crediting period will be signed by the landowner.

(ii) No land claims in terms of the Restitution of Land Rights Act (1994) are registered against the project area, or all such claims have been legally resolved.

The current project area meets these additional project-specific criteria.

1.16.3 Socio-economic impacts of the proposed ARR project activities

Annex 3 details the how the proposed ARR project fulfils South Africa's sustainable development criteria, and Annex 11 contains further information regarding the socio-economic benefits of the proposed ARR project activities.

The proposed ARR project activities are expected to have net positive socio-economic impacts in that they will: i) increase employment opportunities; ii) improve technical capacity and enable skills transfer; iii) increase economic prospects through improved tourism products; and iv) improve ecosystem services.

Poverty alleviation: The project activities will create employment opportunities for local communities, who are currently faced with high unemployment and limited economic prospects. The unemployment rate for the Eastern Cape is 39.5 %, the second highest for any province in South Africa (StatsSA, 2007). The high unemployment rate is in part due to habitat degradation, which has resulted in a decline of the agricultural sector in this region (Kerley et al., 1999).

Poverty alleviation is one of the key goals of the national and provincial governments and job creation is the main way that this is to be achieved. The project implementer, GIB, currently employs 124 staff. These staff are unskilled and are often unable to find permanent employment. If the project is implemented, carbon revenues will enable planting to be undertaken over 25,000 ha. The scale of operations and number of employees will be increased (5,000 ha of planting per year, with a staff component of approximately 300), boosting local economic development in an impoverished rural area.

It is also important to note that the project promotes gender considerations and opportunities for unemployed youth[17]. The teams closely follow the National Government guidelines of the poverty relief principles (i.e. those taken up by the Department of Public Enterprises' "Expanded Public Works Programme") under which at least 60 % of employees are required to be women and at least 25% of employees are required to be youths (under 35). All contractors are required to adhere to the Working for Water Project Operating Standards, which expand upon the EPWP

Capacity building and skills transfer: The proposed ARR project activities will provide specific training opportunities, which will increase skills and thus improve opportunities for employment for those trained. Team training includes relevant skills such as Health and Safety, First Aid, basic bookkeeping and productivity planning. The work that is provided by the project is on a contract basis and entails physical labour (planting of *P. afra* cuttings) for the majority of employees. In each team of 10-13 staff there is a team leader who is trained to manage the contract, and earmarked to become a business person (carbon entrepreneur). Ten employees have already been trained to be field technicians i.e. they are able to sample soils and plants, and enter data. A further 15 people have been employed in a nursery operated by DWA, where trials on *P. afra* are undertaken and other species are propagated.

Such skills provide opportunities for the labourers to potentially become employed as project managers; field technicians and horticulture technicians. The employment model of such "Expanded Public Works Programme" specifically promotes the transfer of skills so that

[17] According to the Youth Act, the South African Definition of youth is between 14 and 35 years of age, but in terms of the Expanded Public Works Programme only those youths of a legal working age are recruited. The legal working age in South Africa is 15, according to the Basic Conditions of Employment Act 75 of 1997.

those who show promise can move on to start their own private contracting teams and build up their own business. In addition to these skills, some employees may also be enabled to move into the conservation field to become conservation rangers or field guides.

Enhanced tourism: The restoration of degraded thicket in the project areas will enhance the aesthetics of the landscape as a whole, and enable an increase in the game stocking levels (as the carrying capacity will increase due to increased biomass). This will increase the tourism potential of the three conservation areas, consequently improving local economic development in communities surrounding the project areas. In addition, an increase or enhancement of the tourism products offered by the conservation areas will likely result in an increase in tourism revenue. Due to the fact that the project areas are on government owned conservation land, tourism revenues are used to further conservation management practices.

Improved ecosystem services: The restoration of degraded thicket will improve the ecosystem services currently provided by the project areas (see Section 1.8). The consequential knock on effect of such improved ecosystem services will have both social and economic benefits. Improved ecosystem services and their associated socio-economic benefits include:

i. Improved soil quality and SOM will result in improved infiltration rates and water retention capacity of the soils (Mills & Fey, 2004a; Mills & Fey, 2004b).
ii. The improved water retention will result in increased water flow and water supply to the project areas and the surrounding water catchments. This will result in improved water security for the local communities as well as the farms surrounding the project areas, and for areas downstream. The economic benefit from improved water supplies is considerable in this drought-prone region, and may reduce the number of expensive engineering solutions required for increasing water supply.
iii. The restoration of degraded thicket will encourage the proliferation of bees and other pollinators in and around the project area (de la Flor Tejero, 2008). This may improve wild plant reproduction within the project areas as well as the reproduction of crops grown in areas surrounding the project areas, leading to improved food production and resulting in an economic boost for farmers in adjacent areas.

The proposed ARR project area is designated for conservation and thus the following are not negatively impacted by this proposed project:

- Land tenure. The land is not owned by local communities thus the proposed ARR project activities do not interfere with any community ownership rights. There are no land claims on any project area in terms of the national legislation, and no adjacent communities have made any such claims informally.
- Religious or culturally significant sites. There are no religious or culturally important sites within the specific planting sites. Sites of constraining historical significance are excluded during site selection. Furthermore, any such sites that did fall within the project area are conserved by the conservation authorities in terms of the relevant national legislation.
- Food production (within the project boundary). No food production activities are permitted in the project areas.
- Access to fuelwood and other forest resources. The project areas are under environmental protection and no access to fuelwood or forest resources is permitted.

The Addo Elephant National Park does not have communities living within its boundaries. The management of the project area has confirmed their willingness to engage in the proposed ARR project, as demonstrated by the letters in Annex 5. The identified community beneficiaries are the contractors and employees hired to undertake the planting process. The contractors are bound by the terms and conditions of the Working for Water Project Operating Standards, and undertake regular self-assessments for themselves and their team, filing quarterly reports to the implementing agent (GIB).

1.17 List of commercially sensitive information (if applicable):

No commercially sensitive information has been excluded from the proposed ARR project.

2 VCS Methodology:

2.1 Title and reference of the VCS methodology applied to the project activities and explanation of methodology choices:

The proposed ARR project uses the VCS approved afforestation and reforestation baseline methodology AR-AM0002 "Restoration of degraded lands through afforestation/reforestation" (Version 3) (UNFCCC, 2009). This methodology is referred to variously as AR-AM0002 (v3) and "the chosen methodology" throughout this document.

This choice of methodology is appropriate as the proposed ARR project will establish woody biomass on severely degraded land in a semi-arid area with low agricultural potential by planting cuttings of the indigenous thicket tree *P. afra*. The degradation of the project area dates back to at least 50 years prior to publication of this document, therefore the proposed ARR project satisfies the requirements that *"no ARR or [Agricultural Land Management] ALM project areas were cleared of native ecosystems within the ten year period prior to the proposed Project Start Date"* (see Annex 15). Current environmental conditions do not permit natural recovery of thicket within these areas, in all likelihood due to the high temperatures, reduced soil quality and reduced soil moisture content of degraded landscapes (see Section 2.2.2).

The project activities fall under the definition of afforestation as defined in the methodology guidelines (VCS, 2008a) "*increasing carbon stocks in woody biomass by establishing, increasing and restoring vegetative cover through the planting, sowing or human-assisted natural regeneration of woody cover*".

2.2 Justification of the choice of the methodology and why it is applicable to the project activity:

Methodology AR-AM0002 (V3) is applicable to the proposed VCS project because the project activities are implemented on areas having low inherent potential to support living biomass without human intervention.

2.2.1 Applicability

The applicability conditions of AR-AM0002 (V3) are addressed as follows:

a) The project activity does not lead to a shift of pre-project activities.

The land use before, during and after project activities is conservation, since the proposed project areas are limited to conservation areas mandated and run by provincial or national conservation agencies. The increase in vegetation within the areas as a result of project activities will improve the land's carrying capacity, and result in a consequent increase in the conservation potential of the areas. Therefore, there is no shift in pre-project activities, and the current land use will be enhanced as a result of the project activities. See more details in the baseline identification procedure in Section 2.4 below.

b) The planting sites to be restored are degraded.

All proposed ARR project planting sites are defined as degraded by a peer-reviewed landscape study (Lloyd et al., 2002), and are confirmed as degraded by pre-project area visits. This classification of degradation meets the criteria laid out by the "*Tool for the identification of degraded or degrading lands for consideration in implementing CDM ARR project activities*" (UNFCCC, 2008), which is therefore satisfied in Step 1 of the procedure. See Section 2.2.2 for additional details.

c) Current environmental/anthropogenic pressures do not permit significant encroachment of natural vegetation.

The project area is typified by low rainfall (less than 500 mm per annum; see Annex 12). The land being restored is severely degraded (see Section 1.4) (Lloyd et al., 2002) and has exceedingly low agricultural potential. Furthermore, the land will remain degraded in the absence of the proposed ARR project activities because the environmental conditions do not permit natural recovery of thicket i.e. the degradation state is stable (Lechmere-Oertel et al., 2005b). This is further confirmed in Section 2.2.2 below.

d) The specified procedure for identifying the baseline confirms that the selected baseline is appropriate.

The application of the procedure for determining the baseline scenario in Section II.4 of the AR-AM0002 (V3) leads to the conclusion that the baseline (identified in Section 2.4 below) is the most appropriate choice for determination of the baseline scenario and that the land would remain degraded in the absence of the proposed ARR project activities. In order to assess land eligibility for the ARR project methodology, the proposed ARR project utilises the procedures to define the eligibility of lands for afforestation and reforestation CDM project activities (UNFCCC, 2007) (see Section 2.2.2).

2.2.2 Demonstration that the land is degraded

The steps outlined in the "Tool for the identification of degraded or degrading lands for consideration in implementing CDM ARR project activities (version 01)" (UNFCCC, 2008) were carried out in order to confirm eligibility. The tool specifies that:

"The procedure to implement the two-stage approach is described below. The presence of one of the following is enough for demonstrating that land is degraded" and/or "degrading":

- *Provide documented evidence that the area had been classified as "degraded" under verifiable local, regional, national or international land classification system or peer-review study.*
- *Participatory rural appraisal, satellite imagery and/or photographic evidence in the last 10 years."*

There have been a number of studies undertaken regarding the degradation processes which occur in the Subtropical Thicket Biome, and a summary of this is presented by the Subtropical Thicket Ecosystem Project (Lloyd *et al.* 2002), which also includes a comprehensive analysis of the extent of thicket degradation throughout the region. This analysis utilised a combination of field surveys and satellite imagery to provide fine-scale degradation maps of the entire Subtropical Thicket Biome. These maps were made available to the public, and GIS layers of these maps form the basis for the selection of suitable areas for planting within the proposed ARR project areas.

The STEP study publication has been adopted by national government and the South African National Biodiversity Institute (SANBI) as a guideline for land cover in the region. The details of the study and interactive maps can be obtained through SANBI's Biodiversity GIS (BGIS) portal[18], as well as the BGIS Landuse Decision Support Tool[19] which is promoted as a means for environmental practitioners to undertake screening as part considered to be definitive for the Subtropical Thicket Biome in terms of Step 1 of the chosen Tool (a credible study produced within the last ten years showing that the specified areas are degraded). This study was used as a baseline estimate to establish both the vegetation class and the extent of degradation for all areas within the project area. A follow up study was undertaken by Dr Jan Vlok and Mr Mike Powell (Powell et al., 2010) that assessed the degradation and vegetation type in greater detail by the application of expert knowledge and field assessment. Degradation in this study was confirmed by comparing the incidence of

[18] See http://bgis.sanbi.org/STEP/STEPreports.asp
[19] See http://bgis.sanbi.org/LUDS.asp

spekboom within sites to untransformed areas in relevant vegetation types. Areas defined as both “moderately degraded” and “severely degraded” have reduced standing biomass and vegetation structural changes (Lloyd et al., 2002)[20] and therefore comply with criterion III (c) (iv) in the relevant CDM tool (UNFCCC, 2008). These areas are therefore eligible for replanting under the chosen methodology

This study and publication meet the qualification criterion III (a) of the selected tool (areas are defined as degraded under a verifiable local land classification system within the last 10 years), and consequently planting sites can be defined as degraded within the conditions of the selected tool.

2.3 Identifying GHG sources, sinks and reservoirs for the baseline scenario and for the project:

GHG sources:

Based on the baseline and monitoring methodology applied by the proposed ARR project activities (AR-AM0002 (V3)), GHG emissions generated by the proposed ARR project (i.e. GHG sources) are negligible and can be excluded from calculations. The sources of emissions listed for consideration under this methodology are: i) emissions from the decline in the carbon stock of non-tree vegetation; and ii) GHG emissions from biomass burning. The former source is discounted for the proposed ARR project because there is no site clearance for land preparation at the start of the programme, and it has been observed that woody shrub vegetation increases as a result of *P. afra* planting (van der Vyver, 2011). The latter source will be monitored *ex post*. It is not anticipated that fire will play a large role in project emissions since *P. afra* is naturally fire resistant as a result of its succulent and dense foliage.

GHG sinks and reservoirs:

The AR-AM0002 (V3) methodology stipulates that major carbon pools for consideration are above and below ground tree biomass, with optional inclusion of soil organic carbon, deadwood and litter. Table 4 shows the carbon pools selected for the proposed ARR project.

Table 4: Identification and justification of carbon pools.

Carbon pool	Selected (yes or no)	Justification
Above ground	Yes	Major carbon pool subject to project activities
Below ground	Yes	Major carbon pool subject to project activities
Deadwood	Yes	Carbon pool subject to the project activities
Litter	Yes	Carbon pool subject to the project activities
Soil organic	Yes	Carbon pool subject to the project activities

[20] In terms of the study by Lloyd (2002), the definitions for degraded thicket are as follows:

- Moderately degraded thicket:
  - has reduced standing biomass for that particular thicket type;
  - alien plants are obviously present, but not dominant;
  - structural changes in the vegetation are evident, e.g. opening up by cattle, browse lines of goats; and
  - is still fully functional
- Severely degraded thicket:
  - has lost all its functionality;
  - has severely reduced woody biomass compared to fully functional thicket;
  - is generally associated with high levels of human activity (around towns, homesteads, near villages, stock watering points); and
  - is obviously degraded when comparing across fence-line contrasts between "good" condition and "poor" condition rangeland

carbon

2.4 Description of how the baseline scenario is identified and description of the identified baseline scenario:

The proposed ARR project area is situated within the Addo Elephant National Park in the Albany Thicket biome of the Eastern Cape. Potential sites that may be included in the site include the Baviaanskloof Nature Reserve and the GFRNR. Thus the current land use classification of the project areas is conservation.

According to the applicability criteria for the chosen methodology, the land is degraded and will continue to degrade in the absence of the proposed ARR project activities (see Section2.2.2). Changes in the carbon stocks in the baseline are thus considered to be zero in the absence of project activities. The baseline scenario is therefore continued conservation within the project areas with no reforestation, resulting in a stable or gradually increasing state of degradation.

The baseline scenario was determined using the following steps as outlined in the AR-AM0002 (V3) methodology:

a) Step 1: Identification of plausible land uses:

See Step 2 below.

b) Step 2: Demonstration that the project areas would remain degraded:

Both Step 1 and Step 2 were carried out using the recommended tool "*Tool for the demonstration and assessment of additionality in A/R CDM activities (Version 02)*" (UNFCCC, 2007) when determining the additionality of the programme. This is detailed in Section 2.5 below. The identified baseline scenario is continued conservation on the sites with no reforestation.

c) Step 3: Demonstrate that the lands to be planted are degraded:

Step 3a: Analyse the historical and existing land use/cover changes in a social-economic context.

Historical land degradation is demonstrated using the approved "*Tool for the identification of degraded or degrading lands for consideration in CDM A/R activities*" (UNFCCC, 2008) as detailed in Section 2.2.2. Degradation of all sites is confirmed by the study examining degradation in the Subtropical Thicket Biome (Lloyd et al., 2002) and is confirmed through initial site visits (see Section 2.2.2).

Step 3b: Provide evidence to show that lands are not expected to regenerate naturally.

Three criteria are provided under the selected methodology which would prove that the lands are likely to remain degraded or degrade further without project activity. The first two (a lack of on-site seed pool or external seed sources that may result in natural regeneration) are demonstrably not applicable, since it has been shown that under project conditions it is possible for many plant species to recover (van der Vyver, 2011). However, there is considerable scientific evidence documented in the literature to show that "*seed sprouting and growth of young trees*" is not possible in areas of severe degradation (Lechmere-Oertel et al., 2005b). Soils from degraded sites show a significant increase of crusting and decreased infiltration (Mills & Fey, 2004b) and soil temperatures are much higher in degraded thicket (Lechmere-Oertel et al., 2005a). Consequently, plant cover has been observed to remain constant or decrease in the absence of project activities (see Annex 15 for a demonstration of the lack of cover change between 1973 and the present).

d) Step 4: Demonstration that the baseline scenarios do not alter the historical land use patterns:

The criteria to be specifically addressed in this section are:

- *Lands do not show significant deviation from the historical land use pattern. To evaluate the deviation in land use, the project participants shall use the data on land use practices, economic policies, and market variables over the most recent 10-year period;*
- *Demonstrate that the national or sectoral land-use policies adopted prior to 11 November 2001 do not influence the areas of the proposed A/R CDM project activity (e.g., because the policy is not implemented, the policy does not target this area, or because there are prohibitive barriers to the policy in this area, etc.*

The first criterion is addressed as follows: All project areas are within nature reserves and national parks run by national or provincial conservation agencies, and consequently the only legal land use is conservation. All of the reserves were designated prior to 1994, and therefore have been under conservation for more than 10 years prior to the project start. Whilst alternative land uses such as grazing of livestock and agriculture were historically practiced on much of the land, these activities may no longer be pursued within the designated conservation areas. The inclusion of these historically degraded areas within the nature reserves has not led to displacement of communities.

The second criterion is also addressed by this argument. Since the areas are designated are protected areas in terms of the National Environmental Management: Protected Areas Act (57 of 2004), no land use policies adopted prior to 11 November 2001 influence the land use. Consequently, the baseline scenario of persistent conservation does not alter the historical land use pattern.

e) Step 5: Demonstration that the chosen baseline does not lead to an increase in carbon stocks or other profitable uses:

The analysis of historical aerial imagery shows no positive change in the vegetation cover of the identified sites over a long period (30 – 51 years). In combination with several published reports on the long term effects of degradation on thicket vegetation in the area (Lechmere-Oertel et al., 2005b; Lloyd et al., 2002), this imagery analysis shows that the chosen baseline (conservation with no reforestation) does not lead to an increase in carbon stocks (Annex 15).

2.5 Description of how the emissions of GHG by source in baseline scenario are reduced below those that would have occurred in the absence of the project activity (assessment and demonstration of additionality):

Objectives of the ECPTA and SANParks include undertaking restoration of the degraded land back to its original intact thicket condition, but such an initiative is prohibitively expensive for government-funded conservation reserves, and is not being undertaken. Indeed, there are currently no other landscape-scale restoration projects involving planting of indigenous tree species taking place on government-owned conservation land within the Eastern Cape. Only provided for restoration of the thicket has been channelled through the Working for Water programme specifically to ensure that this project is able to earn carbon credits, as demonstrated in the business plan (see Annex 10, A 10.2). Carbon finance presents an opportunity to fund this restoration process, overcoming this financial hurdle.

The steps described in the "Tool for the Demonstration and Assessment of Additionality in A/R CDM Project Activities (Version 02)" (UNFCCC, 2007) were used to assess additionality.

a) Step 0: Preliminary screening based on the starting date of the project activity:

Pilot reforestation project activities started subsequent to 31 December 1999 and prior to the current date of registration. The project was implemented in 2004 with the specific aim of obtaining carbon finance in order to allow large scale restoration of the thicket biome. Documentation of this is provided in the business plan and MoUs presented in Annex 10. The business plan is available in full from GIB upon request. The first few pages are included in Annex 10 in the interests of brevity.

b) Step 1: Identification of plausible land uses:

Sub-step 1a: Identify credible alternative land use scenarios to the proposed CDM project activity

Industrial development of the land is considered unlikely due to the distance from significant urban populations. The general area is semi-arid and largely rural. It is typified by low rainfall, high average annual temperatures and generally poor agricultural potential. Common historical land uses in the area include goat pastoralism (Mills et al., 2005a), agricultural cultivation and establishment of leguminous pastures (Sigwela, 2004). The principal land use for the project areas is currently conservation, although land use in the general area reflects a combination of the specified activities, with pastoralism as the principal land use. Consequently, the proposed alternative land uses are:

i. change in land use to a non-conservation-based commercial alternative such as browsing of goats or agriculture;
ii. conservation with reforestation activities that are not funded by the project; and
iii. continued conservation with no reforestation.

The feasibility of these identified alternative land uses are discussed below.

Sub-step 1b: Consistency of credible land use scenarios with enforced mandatory applicable laws and regulations

The national legislation applicable to the project areas include:

- National Environmental Management Act (107 of 1998) (NEMA).
- NEM: Biodiversity Act (10 of 2004).
- NEM: Protected Areas Act (57 of 2004).
- Nature and Environmental Conservation Ordinance (19 of 1974).
- National Forest Act (84 of 1998).
- National Veld and Forest Fire Act (101 of 1998).
- Conservation of Agricultural Resources Act (43 of 1983)
- Fencing Act (31 of 1963).
- Environment Conservation Act (73 of 1989).
- Problem Animal Control Ordinance (26 of 1957).
- National Heritage Resources Act (25 of 1999).
- Public Finance Management Act (1 of 1999).
- Restitution Act (22 of 1994).
- National Water Act (36 of 1998).

Provincial nature reserves are also subject to the Eastern Cape Provincial Parks Board Act (12 of 2003). Additionally, the Baviaanskloof Nature Reserve, as a declared World Heritage Site, is also subject to the World Heritage Convention Act (49 of 1999).

All public-owned land that is specified as a conservation area is legally bound to only undertake activities that conserve current land processes. Specifically, the Baviaanskloof Nature Reserve and GFRNR are both declared "provincial nature reserves" in terms of Section 12 of the NEM: Protected Areas Act. The Addo Elephant National Park is a "national park" in terms of the same legislation.

The Protected Areas Act of 2004 states that:
"Commercial and community activities in nature reserve and world heritage site

> *50. (1) The management authority of a nature reserve and world heritage site may, despite any regulation or by-law referred to in section 49, but subject to the management plan of the reserve or site—*
> *(a) carry out or allow—*
> *(i) a commercial activity in the reserve or site; or*
> *(ii) an activity in the reserve or site aimed at raising revenue.*
> *(b) enter into a written agreement with a local community inside or adjacent to the reserve or site to allow members of the community to use, in a sustainable manner, biological resources in the reserve or site; and*
> *(c) set norms and standards for any activity allowed in terms of paragraph (a) or (b).*
> *(2) An activity allowed in terms of subsection (1) (a) or (b) may not negatively affect the survival of any species in or significantly disrupt the integrity of the ecological systems of the nature reserve or world heritage site."*

In terms of this legislation, any change in the land use to agriculture, grazing or alternative commercial development would impact on species survival and ecosystem function, and consequently cannot be undertaken within the proposed project areas. This is reflected in the strategic management plans for the Baviaanskloof Nature Reserve (Erlank et al., 2009), Addo Elephant National Park (SANParks, 2006) and GFRNR (Kotauli et al., 2006) that specify that the primary purpose of the conservation areas is to ensure ecological integrity and long term conservation of biodiversity in the region.
Consequently, scenario (i) is not feasible in terms of the laws and regulations governing the project areas.

c) Step 2: Investment analysis:
This step was deprecated in favour of the specified alternative, the barrier analysis (Step 3).

d) Step 3: Barrier analysis:
A barrier analysis was conducted to examine the feasibility of scenario (ii) and (iii), using the methodology outlined in Step 3 of the methodological tool "*Tool for the demonstration and assessment of additionality in ARR CDM activities (Version 02)*" (UNFCCC, 2007):

Barriers due to prevailing practice

- **Prior examples:** The proposed ARR project is the first of its kind in the region. No other reforestation activities have been conducted in the area, despite government interest in restoring the subtropical thicket. Due to financial restrictions, landowners typically cannot afford to undertake land management activities such as restoration of vegetation or degraded land. Furthermore, this is the first large-scale (greater than 1,000 ha) restoration project in the country.

Barriers due to local ecological conditions

- **Soil degradation:** Significant soil degradation has occurred in areas characterised by historically high levels of browsing or intensive agriculture. The reduced plant cover resulted in erosion, which in turn has caused a considerable loss of SOM *(Mills & Fey, 2004b)*. Erosion as a result of reduced ground cover has exacerbated this problem. Recovery of thicket in such degraded soils does not occur, likely as a result of the high temperatures, reduced soil quality and reduced soil moisture content of degraded landscapes (see Section 1.7). Analysis of aerial imagery has shown that even over periods of up to 50 years the extent of natural recovery is negligible (see Annex 15).

Barriers due to social conditions

- **Lack of skills:** The manual activities of the proposed ARR project are relatively simple, but the local communities in the area lack training in the necessary planting procedures for project success. Local knowledge regarding landscape management is also limited, and therefore training of the local communities is essential for the success of the proposed ARR project activities.

Investment barriers

- **Capital availability:** No private capital is presently available for restoration operations in the Eastern Cape because there are no clear financial returns: spekboom is not a marketable product as a result of its succulent nature. Although the seed finance for the proposed ARR project has been provided through government investment, the national government is unable to commit larger sums to this project (see the letter from the DEA in Annex 5). This project was conceived in order to enhance the potential for restoration in these areas by providing capital from carbon finance (see the Business Plans in Annex 10: A10.1 and A10.2).
- **Debt funding:** This is not available for the land use scenarios, since the land is publicly-owned, and cannot therefore be used as collateral for loans.

Finally, alternative land use scenario (iii) is the most likely of the proposed scenarios. Under this scenario, land is not reforested, but left to recover naturally. All sites are historically degraded, and have remained so for a considerable period regardless of human activity or the lack thereof. This is confirmed by the analysis of historical aerial imagery, which demonstrates that despite varied historical land uses within the area, natural recruitment in degraded sites is virtually non-existent over a 30 to 50 year time period (see Annex 15). In each of the conservation areas, land degraded by prior land use regimes that has been under conservation has either continued to degrade or failed to improve for more than 40 years.
Consequently, the most plausible scenario is that the land remains degraded in the absence of project activities.

e) Step 4: Common practice analysis:

There are no other carbon market financed reforestation projects in the Eastern Cape as a whole, including in the proposed ARR project areas[21]. As detailed earlier, the project initiation and pilot study were funded by public funds provided through the DWA with a specific focus on upscaling the activities using carbon financing (details in Annex 10). The public sector is unable to provide sufficient funds to ensure reforestation of degraded land in the Eastern Cape (see the letter from DEA, Annex 5), and there is no alternative economic incentive or potentially viable private sector practice that can fill this gap.

The use of this tool demonstrates that project activities are additional.

[21]At the time of this PD, there are no A/R CDM projects registered in South Africa. (see http://cdm.unfccc.int/Projects/projsearch.html), and nor any VCS projects in South Africa (see http://www.vcsprojectdatabase.org/). The Gold Standard does not cover forestry or restoration protocols, the CCB has no other registered project (http://www.climate-standards.org/projects/) in South Africa, and Plan Vivo has no South African projects (http://www.planvivo.org/projects/). No other standard has a registered afforestation project in South Africa. The ABFRP project is the first of its kind in South Africa.

3 Monitoring

3.1 Title and reference of the VCS methodology (which includes the monitoring requirements) applied to the project activity and explanation of methodology choices:

The monitoring plan follows Section III of the approved methodology AR-AM0002 (V3). The monitoring steps and procedures of the methodology are applied to the project context. Aspects of the monitoring requirements for the chosen methodology include:

- Monitoring of the project initiation.
- Monitoring of the area reforested.
- Monitoring of the forest establishment.
- Monitoring of forest management activities.
- Adoption of a monitoring frequency over which carbon pools of the project are monitored, data are collected and changes in the carbon stocks are estimated.

These aspects of the monitoring plan are discussed in detail in Section 3.4, and details relevant to measurement of individual quantities are discussed in the relevant section in Section 3.2.

3.2 Monitoring, including estimation, modelling, measurement or calculation approaches

3.2.1 Purpose of monitoring

The purpose of monitoring is to provide information to the VCS on the progress of the proposed ARR project and to improve the project's efficiency and effectiveness. It is an invaluable tool for good management and will enable the Project Manager to determine whether the resources available are sufficient and are being correctly utilised, whether the rate of planting is sufficient and appropriate, and whether the planting and management plans are being followed.

3.2.2 Monitoring roles and responsibilities

GIB will be responsible for monitoring the project. Planting of *P. afra* is undertaken by contractors according to clearly defined site boundaries and operating procedures (See Section 1.8 and Annex 10 for details).

The planting site will be inspected by the Project Manager during the initial phase to ascertain that the methods and results are up to standard and that the contractor is working in the correct area. If the contractor is in breach of his/her contract, the contract will be cancelled and CSS notified. If the work is sub-standard, the Project Manager will issue instructions to improve the standard. Upon completion of the contract, the planting site is inspected to ensure that the full area has been planted and the completion document is then submitted to GIB. Additionally, CSS is notified to update the planting site status in the spatial database.

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3.2.3 Managing data quality

High quality data will be maintained by following the principles described in Section 3.2.9.

3.2.4 Stratification

The approved methodology recommends a hierarchical approach to stratification. Primary factors for *ex ante* and *ex post* stratification are regional-scale features, such as climate and geographical conditions. Additional sub-strata may be identified where there is sufficient in-stratum variation to necessitate a division to ensure stratum homogeneity. Stratification is subject to a minimum contiguous area defined for a forest by the DNA (in the case of South Africa, this provides an effective minimum area of 0.05 ha).

a) Baseline stratification

Stratification on the basis of species planted is not relevant for the proposed ARR methodology, since only a single species (*P. afra*) is to be planted. Current land use for project area is limited to conservation, and since the land use will not change in the future, land use is not used as a stratification criterion.

Rainfall is a primary factor influencing the growth of plants in semi-arid ecosystems (Mucina & Rutherford, 2006). Rainfall periodicity is bimodal across the region (although the intensity of summer rains decreases in the eastern sites) so rainfall seasonality was not considered as a stratification criterion. There is no significant variation in the mean annual rainfall of the within the project area (see Annex 12). Furthermore, fine-scale temperature data is not available for the project area, so it is assumed that there is no significant variation within the area. Consequently, there is no stratification on the basis of climatic variables. However, there is significant variation in both rainfall and temperatures between the project area and the proposed additional sites to be grouped within the project (see Annex 12). This inter-area variation will be used as the primary stratification criterion, for ex post variation, and the boundaries of the separate project areas will therefore bound the strata.

In low rainfall regions, the impact of soil fertility on plant growth is amplified (Mucina & Rutherford, 2006). Soil fertility was therefore examined to assess its potential as a stratification criterion. Soils in the project areas are derived primarily from sedimentary rocks, including arenites and shales, with occasional conglomerate, sandstone and mudstone variants (Council for GeoScience, 1997). For the stratification study, soil types within the Baviaanskloof Nature Reserve were divided into two simple categories; nutrient-poor soils (originating largely from Table Mountain Group sandstones) and nutrient-rich soils (incorporating alluvial soils and shale-derived soils). An analysis of the variation in carbon stocks between poor and rich soils within the Baviaanskloof Nature Reserve did not demonstrate a significant variation between the two soil types. The carbon stock assessment included above ground, deadwood, litter, root carbon and soil carbon stocks (0-25 cm) under bushes, and the carbon stock data were sourced from the field surveys conducted in the Baviaanskloof Nature Reserve area (see Annex 8). (C stocks (nutrient-poor soil) = 381.27 ± 208.89 t ha^{-1}; C stocks (nutrient-rich soil) = 316.57 ± 229.81; $p = 0.33$ NS). It is possible that soil variations on a very small scale (as low as 0.25 ha) affect the variability of the carbon stock, but such fine scale variations cannot feasibly be included within a stratification programme. Consequently, soil fertility was not included as a stratification criterion.

Topography has not been included as a baseline stratum because there is insufficient evidence available to determine whether topography plays a significant role on *P. afra* growth in the project areas. However, it is possible that this will play a role in *ex post* stratification, if an effect is noted in the monitoring.

b) Ex ante stratification

The *ex ante* stratification makes use of the baseline strata described above. Additional stratification by cohort (i.e.: grouping age for each five years of planting) was not feasible, since there is insufficient information available to extrapolate accurate growth curves at this point. A generic growth curve was therefore used for the *ex ante* calculations. However, annual stratification following the planting plan was undertaken, as shown in the calculations (Annex 14).

c) Ex post stratification

The *ex post* stratification uses the same basic stratification units as the *ex ante* stratification. In addition, if additional project areas are included, the project area boundaries will be used as proxies for climatic variation across the landscape.

Strata will be divided into cohort sub-strata, with each five-year planting period being designated as a separate sub-stratum. This will allow project proponents to monitor the changing rate of carbon accumulation as the plants mature.

The *ex post* stratification will be conducted three years after planting to address the possible changes of planning activity boundary in the unlikely event of significant mortality from a fire, disease or other stochastic disturbance events. Additional strata for monitoring will be added for these disturbed areas and for areas in which supplementary planting is undertaken. This additional stratification will allow for more accurate assessment of the effects of these disturbances on carbon sequestration rates, and will reduce the impact of such rare events on carbon sequestration calculations for the project as a whole.

3.2.5 Monitoring of carbon stocks in the carbon pools

Permanent sample plots will be established for sampling and measurement of carbon pools. Plot locations are taken by means of a GPS device, and are recorded to allow revisiting during each monitoring period. Non-obtrusive, durable permanent markers (metal pegs) will be used to demarcate these areas, reducing the likelihood of selective management practices. Details of the methods used for monitoring the required carbon stocks are as specified in the chosen methodology, and are detailed below.

a) Calculation of change in carbon stocks of pools

The verifiable change in carbon stocks is calculated by applying the stock change method to the data gathered between two monitoring events.

$$\Delta C_{ijk,t} = \left[\Delta C_{AB,ijk,t} + \Delta C_{BB,ijk,t} + \Delta C_{DW,ijk,t} + \Delta C_{L,ijk,t} + \Delta C_{SOC,ijk,t}\right] \cdot [44/12] \quad \text{(M.5)}$$

where:

$\Delta C_{ijk,t}$	verifiable annual changes in the carbon stock of pools for stratum i sub-stratum j species k for year *t*; t CO_2e yr $^{-1}$
$\Delta C_{AB,ijk,t}$	average annual changes in the carbon stock of above ground biomass for stratum i sub-stratum j species k for year *t*; t Cyr $^{-1}$
$\Delta C_{DW,ijk,t}$	average annual changes in the carbon stock of deadwood for stratum i sub-stratum j species k for year *t*; t Cyr $^{-1}$
$\Delta C_{L,ijk,t}$	average annual changes in the carbon stock of litter for stratum i sub-stratum j species k in for year *t*; t Cyr $^{-1}$
$\Delta C_{SOC,ijk,t}$	average annual changes in the carbon stock of soil organic matter for stratum i sub-stratum j species k for year *t*; t Cyr $^{-1}$

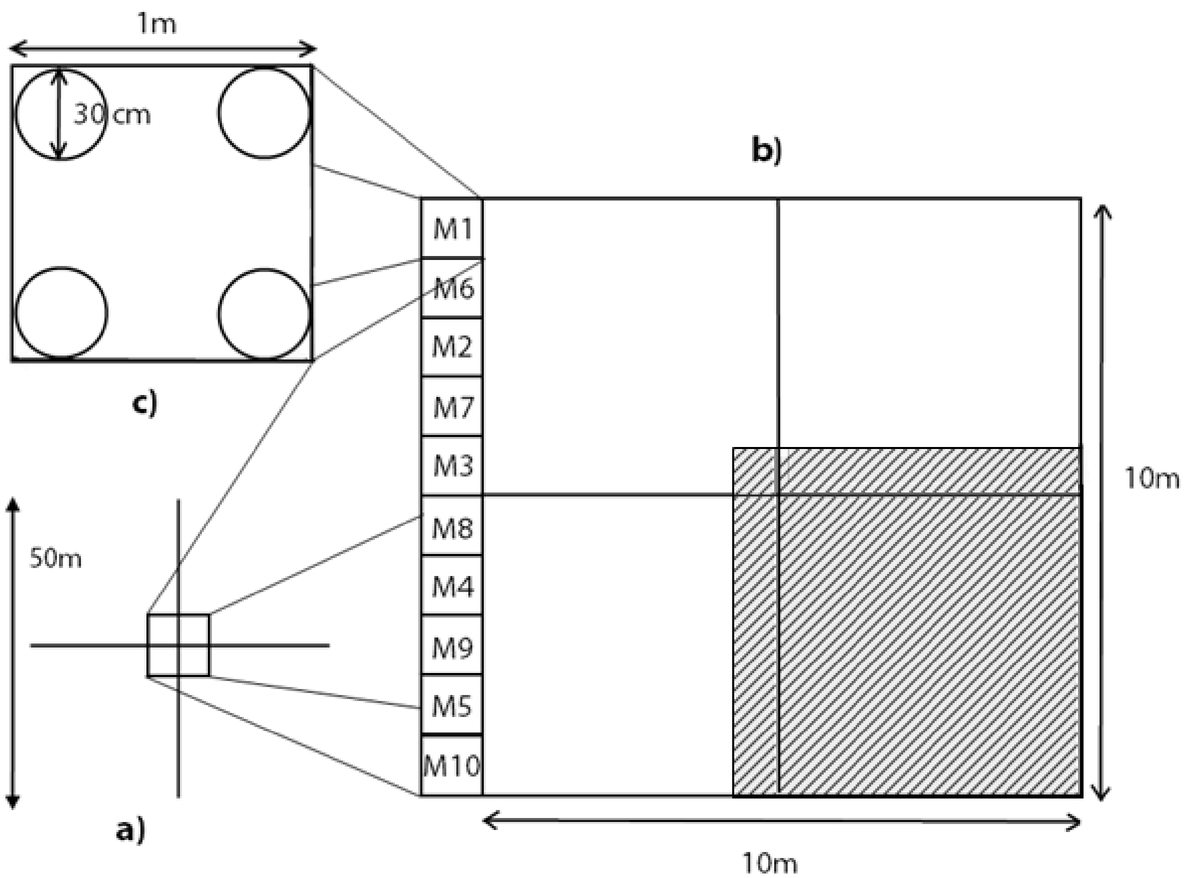

Figure 5: Diagrammatic representation of monitoring sites. a) Each site will comprise a 10m x 10m area, with two 50m long transects for deadwood monitoring bisecting the site; b) monitoring of above ground biomass will be carried out by measuring CBSA of *P. afra* plants in the site. Nested sub-plots (6m x 6m - shaded) will be used for monitoring the growth of offspring plants, and will be used instead of the full plots once stem density becomes too high; and c) litter monitoring will be carried out in peripheral 1m x 1m plots, since removal of litter from *P.afra* would affect the rate of growth of the stand (due to its method of vegetative propagation). Litter measurements will be gathered from 30cm radius circles in the corners of the litter plots, and no litter plot will be used twice. The letters in the boxes correspond to the monitoring period in which they will be used (ie M1= monitoring period 1, M2 = monitoring period 2, etc)

b) Above ground tree biomass

Changes in tree biomass are calculated from the monitoring data on individual trees in the permanent sample plots. The number of permanent sample plots was determined using the relevant calculations specified by the project methodology. The permanent plots were then systematically assigned to each planting year, ensuring a good coverage of all areas. The permanent plots are established randomly within the sites for a given year, and the combined basal stem area (CBSA) of the trees is measured for each plot. CBSA is measured instead of diameter at breast height (DBH) since *P. afra* plants are frequently multi-stemmed, and accurate allometric equations have been developed (see Equation AL.1 below) to use the CBSA (Powell, 2009). CBSA is measured at ground level using digital callipers for each stem, since *P. afra* is a highly branched tree. Each stem will be marked once it has been measured (using a paint mark or coloured thread) to ensure it is not measured more than once. Different coloured markers will be used for consecutive monitoring events to ensure that all stems are counted.

The monitoring design makes use of nested plots. Each plot is 10 m x 10 m in size, since the planting density is very high (approximately 2,500 *P. afra* cuttings will be planted per hectare), which allows the measurement of 25 cuttings. Even where the planting density is lower than specified (due to plant mortality or difficulty in planting), it is probable that at least ten plants (the specified minimum) will fall within the sample plot. Blanking will be undertaken in areas in which mortality exceeds 70%.

Established *P. afra* thicket is exceedingly dense and individual trees may have very large numbers of stems. Consequently, future measurements will be conducted in nested 6 m x 6 m plots when the stands become too thick to readily penetrate for measurement purposes (see Figure 5 above). This would encompass at least 11 original plants when the survival rate is 70% or more. The nested plots will not be used in areas in which it does not encompass at least ten original plants, in order to ensure that a suitable number of plants are measured. In addition, a large number of new *P. afra* plants are expected to be recruited as a result of vegetative reproduction as the stands mature. These additional plants will increase the overall density of the stand.

Mature *P. afra* plants are typified by a spreading “fringe” of stems that grow along the ground before growing upwards. All stems within a fringe parameter will be assigned to the original plant. Additional stems growing outside this fringe will be counted as new plants, and recorded as such.

These measurements will be used to calculate the above ground carbon stock of above ground biomass using the equations below.

$$\Delta C_{AB,ijk,t} = \left(C_{AB,m_2,ijk} - C_{AB,m_1,ijk}\right)/T_B \qquad \textbf{(M.6)}$$

where:

$\Delta C_{AB,ijk,t}$	average annual changes in the carbon stock of above ground biomass for stratum i sub-stratum j species k for year *t*; t Cyr $^{-1}$
$C_{AB,m_2,ijk}$	carbon stock of above ground biomass for stratum i sub-stratum j species k at monitoring event m_2; t C
$C_{AB,m_1,ijk}$	carbon stock of above ground biomass for stratum i sub-stratum j species k at monitoring event $m_{;\,t}$ C
T_B	time between monitoring events m_1 and m_2 of the biomass monitoring; yr

$$\Delta C_{AB,m,ijk} = A_{m,ijk} \cdot MC_{AB,m,ijk} \qquad \textbf{(M.7)}$$

where:

$A_{m,ijk}$	area of stratum i sub-stratum j species k at monitoring event m; ha
$MC_{AB,m,ijk}$	mean carbon stock of above ground biomass for stratum i sub-stratum j species k at monitoring event m; t Cha^{-1}

$$MC_{AB,m,ijk} = MC_{AB\_Tree,m,ijk} + MC_{AB\_NTree\_Shrub,m,ijk} \qquad \textbf{(M.8)}$$

where:

$MC_{AB\_Tree,m,ijk}$	mean carbon stock of above ground tree biomass in stratum i sub-stratum j species k at monitoring event m; t C ha^{-1}

$MC_{AB\_NTree\_Shrub,m,ijk}$ mean carbon stock of above ground non-tree shrub component in stratum i sub-stratum j species k at monitoring event m; t C ha^{-1}

The tree component of above ground biomass is calculated as below:

$$MC_{AB_{Tree},m,ijk} = \frac{\sum_{p=1}^{P_{ijk}} C_{AB_{Tree},m,ijk,p}}{P_{ijk}} \quad \textbf{(M.9)}$$

where:

$C_{AB\_Tree,m,ijk,p}$	plot level above ground tree carbon stock in stratum i sub-stratum j species k plot p at monitoring event m; t C ha^{-1}
p	plot number in stratum i sub-stratum j species k
P_{ijk}	number of plots in stratum i sub-stratum j species k

The methodology makes use of the allometric equation method rather than the biomass expansion method.

$$C_{AB\_Tree,k} = f(DBH_k, H_k) \cdot CF_k \quad \textbf{(M.11)}$$

where:

$C_{AB\_Tree,k}$	carbon stock of above ground tree biomass of species k; t.d.m. ha^{-1}
$f(DBH_k, H_k)$	allometric equation linking merchantable volume to the mean diameter at breast height (DBH) and tree height (H) meters
CF_k	carbon fraction of species k; dimensionless (IPCC default from pg 3.25 of LULUCF GPG: 0.5)

For purposes of the *ex post* calculations, the project will utilise the allometric equation derived by Powell (2009) from field sampling of *P. afra* (Equation AL.1; $R^2 = 0.9696$, $p<0.01$). This equation correlates the above ground carbon stock of a plant to its combined basal stem area. Consequently, the merchantable volume is not recorded, but rather the carbon stock of above ground tree biomass for each site.

$$\log_{10} y = 1.1043(\log_{10} CBSA) + 2.4464 \quad \text{(Powell, 2009)} \quad \text{(AL.1)}$$

where:

y	Above ground dry plant carbon; kg C
$CBSA$	Combined basal stem area; m^2

$$C_{AB\_Tree,m,ijk,p} = \frac{\left(\sum_{tr=1}^{TR} C_{AB\_Tree,k} \cdot XF\right)}{1000} \quad \text{(M.12)}$$

$$XF = \frac{10{,}000}{A_p} \quad \text{(M.13)}$$

where:

XF	expansion factor to represent the per plot value to per hectare value
A_p	plot area; m^2
tr	tree (TR = total number of trees in the plot)

This allometric equation was calculated from the field measurement of large numbers of *P. afra* stems (n>11,000). The values were calculated as averages for stems of 5 specified diameter ranges (10mm, 20mm, 30mm, 40mm, and 50mm) and is valid for stems up to 50mm in size. Additional measurement of larger diameter stems is underway, and the allometric equation will be updated once a full statistical analysis and peer-review process has been undertaken for the revision. This revised equation makes use of the same measurement processes specified in the original study (Powell, 2009).

c) Non-tree biomass

Non-tree biomass in general within the project site is low, and the process of restoration is likely to cause an increase in the shrub component (van der Vyver, 2011). Consequently, it is considered conservative to exclude the non-tree biomass in general from sequestration calculations. However, in certain areas the degraded land has undergone invasion from a local shrub species known as noors (*Euphorbia coerulescens*). Although planting of *P. afra* is not undertaken within stands of *E. coerulescens*, it is possible that a reduction in overall noors biomass might be observed as a result of overshading in some areas. Consequently, the noors shrub component will be monitored *ex post* to ensure that any possible loss is accounted for in the project. No allometric equation is currently available for this species, so an allometric equation and root:shoot ratio will be developed through destructive harvesting in separate sample sites.

The mean carbon stock of the project area is calculated as :

$$MC_{AB\_NTree\_Shrub,m,ijk} = \frac{\sum_{p=1}^{P_{ijk}} C_{AB\_NTree\_Shrub,m,ijk,p}}{P_{ijk}} \quad \textbf{(M.10)}$$

where:

$C_{AB\_NTree\_Shrub,m,ijk,p}$ plot level above ground shrub carbon stock in stratum i sub-stratum j species k plot p at monitoring event m; t C ha^{-1}

p plot number in stratum i sub-stratum j species k

P_{ijk} number of plots in stratum i sub-stratum j species k

The non-tree biomass is therefore estimated using the following equation:

$$C_{AB\_NTree\_Shrub_{m,ijk,p}} = f_k(DB, H, CA, N) \cdot CF_{Shrub} \quad \textbf{(M.15)}$$

where:

$C_{AB\_NTree\_Shrub_{m,ijk,p}}$ carbon stock of above-ground shrub biomass for tree stratum i sub-stratum j species k plot p at monitoring event m; t C ha^{-1}

$f_k(DB, H, CA, N)$ allometric equation linking above-ground biomass (d.m. ha^{-1}) of shrubs to diameter at base (*DB*), shrub height (*H*), crown area (*CA*) and number of stems per hectare (*N*)

CF_{Shrub} carbon fraction of the above ground shrub biomass, dimensionless

Measurement of the non-tree biomass (specifically of *E. coerulescens*) will be undertaken within each sampling plot. The parameters to be measured are not yet established, but will be integrated into the monitoring plan once the allometric equation for *E. coerulescens* has been developed. All monitoring plots will be assessed for this shrub species.

d) Below ground biomass

No monitoring of this carbon pool is undertaken, since the below ground biomass is calculated by multiplying the estimated above ground biomass by the root to shoot ratio, as outlined in AR-AM0002 (V3). The value for this ratio (0.35) has been estimated from empirical data in literature and from field measurements, and is used in the *ex ante* and *ex post* calculations (see Annex 8).

$$C_{BB,m,ijk} = A_{m,ijk} \cdot MC_{BB,m,ijk} \quad (M.16)$$

$$MC_{BB,m,ijk} = [MC_{AB\_Tree,m,ijk} \cdot R_{T,jk} + MC_{AB\_NTree\_Shrub,m,ijk} \cdot R_S] \quad (M.17)$$[22]

where:

$A_{m,ijk}$	area of stratum i sub-stratum j species k at monitoring event m; ha
$MC_{BB,m,ijk}$	mean carbon stock of below ground biomass for stratum i sub-stratum j species k at monitoring event m; t C ha^{-1}
$R_{T,jk}$	root-shoot ratio for tree species k sub-stratum (age class) j; dimensionless
R_S	root-shoot ratio for shrub; dimensionless

The annual change in the carbon stock of below ground biomass is calculated using the following equation:

$$\Delta C_{BB,ijk,t} = \left(C_{BB,m_2,ijk} - C_{BB,m_1,ijk}\right)/T_B \quad (M.18)$$

where:

$\Delta C_{BB,ijk,t}$	average annual change in the carbon stock in the below ground biomass in stratum i sub-stratum j species k for year t; t Cyr $^{-1}$
$C_{BB,m_2,ijk}$	carbon stock of below ground biomass for stratum i sub-stratum j species k at monitoring event m_2; t C
$C_{BB,m_1,ijk}$	carbon stock of below ground biomass for stratum i sub-stratum j species k at monitoring event m_1; t C
T_B	time between monitoring events m_1 and m_2 of the biomass monitoring; yr

e) Deadwood

Underground deadwood is assumed to contribute to the soil organic content (SOC), and is consequently not monitored separately.

$$\Delta C_{DW,ijk,t} = \left(C_{DW,m_2,ijk} - C_{DW,m_1,ijk}\right)/T_{DW} \quad (M.19)$$[23]

where:

$\Delta C_{DWijk,t}$	average annual change in the carbon stock of deadwood for stratum i sub-stratum j species k in t C yr $^{-1}$ for year t; t C

[22] This differs from the published equation in the methodology because there is an error in the equation as printed. By including the area term in equation (M.17), the area is effectively squared, which overestimates the value significantly. The original equation is shown below.

$$MC_{BB,m,ijk} = A_{m,ijk}\left[MC_{AB_{Tree},m,ijk} \cdot R_{T,jk} + MC_{AB_{NTree_{Shrub}},m,ijk} \cdot R_S\right] \quad (M.17)$$

[23] This equation differs from the equation as published in AR-AM0002 (V3) because there is a typographical error in the published equation substituting T_W for T_{DW}. The original equation is shown below:

$$\Delta C_{DW,ijk,t} = \left(C_{DW,m_2,ijk} - C_{DW,m_1,ijk}\right)/T_W \quad (M.19)$$

$C_{DW,m_2,ijk}$	carbon stock of deadwood for stratum i sub-stratum j species k at monitoring event m_2; t C
$C_{DW,m_1,ijk}$	carbon stock of deadwood for stratum i sub-stratum j species k at monitoring event m_1; t C
T_{DW}	time between monitoring events m_1 and m_2 of the deadwood monitoring; yr

The method to be followed for calculating the standing deadwood and the lying deadwood biomass are outlined below.

$$C_{DW,m,ijk} = [B_{SDW,m,ijk} + B_{LDW,m,ijk}] \cdot CF_{DW} \quad \text{(M.20)}$$

where:

$C_{DW,m,ijk}$	carbon stock of deadwood biomass in stratum i sub-stratum j species k at monitoring event m; t C
$B_{SDW,m,ijk}$	biomass of standing deadwood in stratum i sub-stratum j species k at monitoring event m; t.d.m.
$B_{LDW,m,ijk}$	biomass of lying deadwood in stratum i sub-stratum j species k at monitoring event m; t.d.m.
CF_{DW}	carbon fraction of deadwood; dimensionless

Standing deadwood is measured using the same criteria and monitoring frequency as is used for measuring live trees. Decomposition class of a dead tree is categorised according to the following four decomposition classes:

- tree with branches and twigs that resembles a live tree (except for leaves);
- tree with no twigs but with persistent small and large branches;
- tree with large branches only; and
- bole only, no branches.

Biomass is estimated for standing deadwood in class 1, and is limited to the trunk for classes 2 to 4.

Lying deadwood is likely to be low in the early stages of the project, and consequently will only be assessed from the second monitoring period after planting. Lying deadwood is sampled by means of the line intersect method (Harmon & Sexton, 1996), as specified in the chosen CDM methodology. Two 50 m lines that bisect each sample plot are established, and the diameters of all the deadwood (≥ 5 cm) are measured (see Figure 5). Each branch is assigned to one of three density states (sound, intermediate, and rotten) for purposes of biomass calculation. The volume of lying deadwood is calculated using equation M.21 below:

$$V_{LDW,m,ijk} = 9.869 \cdot (\frac{D_{ijk}^{\ 2}}{8}) \cdot L \quad \text{(M.21)}$$

where:

$V_{LDW,m,ijk}$	volume of lying deadwood in stratum i sub-stratum j species k; m^3 m^{-2}
$D_{ijk}^{\ 2}$	squared diameter of pieces of deadwood in stratum i sub-stratum j species k, m^2
L	length of the transect; m

The biomass of lying deadwood is calculated using equation M.22.

$$B_{LDW,m,ijk} = A_{ijk} \cdot \sum_{dc=1}^{dc=3} V_{LDW,m,ijk} \cdot D_{DW,dc} \cdot 10 \quad \text{(M.22)}$$

where:

$B_{LDW,m,ijk}$	biomass of lying deadwood in stratum i sub-stratum j species k at monitoring event m; t.d.m.
$D_{DW,dc}$	basic density of deadwood in the density class – sound (1), intermediate (2) and rotten (3);kg d.m. m^{-3}
A_{ijk}	area of stratum i sub-stratum j species k; ha

The density of wood in each state will be estimated during the first monitoring period through field sampling in the sample sites. Deadwood will be gathered and assigned to one of the three states. The gathered deadwood will then be oven dried, and the average density calculated using the volume estimations. These estimates will be used for all subsequent calculations of deadwood biomass.

f) Litter

Litter sampling will be carried out every five years. Litter is a vital component of the proliferation of *P. afra*, which is able to propagate from cuttings and damaged branches. As a result, sampling within the sample plots could reduce the rate of thicket growth, and will be avoided. Litter sampling therefore takes place in 1 m x 1 m squares situated around the periphery of the sample plot. Litter is sampled using a 30 cm radius circular frame, placed at the four corners of the designated peripheral plot. All litter falling inside the frame is collected and weighed. It is then oven dried and weighed again in order to calculate the moisture proportion and the dry biomass. Subsequent monitoring will use the next-but-one 1 m x 1 m box (see Figure 5 for details).

The equations used for calculating the ex post changes in carbon stock of litter deviate from those outlined in AR-AMS0002 (V3). This deviation is a result of errors in the equations as published in the methodology. The deviation and equations are explained in full in Annex 16 (Deviation 3), and this does not affect the conservativeness of the selected methodology. The dry litter biomass at monitoring time *m* is calculated as follows:

$$B_{L,m,ijk} = A_{ijk} \cdot B_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \quad \textbf{(M.23.dev)}$$

where:

$B_{L,m,ijk}$	Dry litter biomass for stratum i sub-stratum j species k at monitoring event m; t.d.m.
$B_{L_{wet},ijk}$	Wet litter biomass for stratum i sub-stratum j species k at monitoring event m; g m^{-2}
A_{ijk}	Area of stratum i sub-stratum j species k at monitoring event m; ha
MP_L	Weight fraction of moisture of litter biomass (0 to 1) [calculated as (wet weight – dry weight)/wet weight]; dimensionless
a_{ijk}	Area of sampling frame; m^2

The average annual change in the carbon stock of litter from the data at two monitoring intervals will be calculated. As recommended in the Good Practice Guidance on LULUCF (Chapter 3.2, p 3.35), the dry mass of litter is converted into carbon using 0.370 as the default value instead of the default carbon fraction (0.5) used for biomass.

$$\Delta C_{L,m,ijk,t} = \left[\left(B_{L,m_2,ijk} - B_{L,m_1,ijk}\right)/T_L\right] \cdot CF_L \qquad \textbf{(M.24.dev)}$$

where:

$\Delta C_{L,m,ijk,t}$ Average annual change in carbon stock of litter for stratum i sub-stratum j species k at monitoring event m; t C yr^{-1}

$B_{L,m_2,ijk}$ Dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_2; t.d.m.

$B_{L,m_1,ijk}$ Dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_1; t.d.m.

T_L Time interval between m_2 and m_1; yr

CF_L Carbon fraction of litter; dimensionless (IPCC default: 0.370)

g) Soil carbon

Soil carbon will be measured initially and every fifteen years. Four cores from separate locations within each plot will be extracted using a soil corer or spades/chisels if the ground is too rocky for a corer. Cores will be taken to a depth of 40 cm, with two 20 cm horizons. For each monitoring site, soil carbon will be determined through laboratory analysis. Soil carbon inflows will be estimated as the difference between the carbon stock estimates of two consecutive monitoring events.

$$\Delta C_{SOC,ijk,t} = \left[\left(C_{SOC,m_2,ijk,t} - C_{SOC,m_1,ijk}\right)/T_S\right] \qquad \text{(M.25)}$$

where:

$\Delta C_{SOC,ijk,t}$ annual average change in the carbon stock of the soil organic carbon pool in stratum i sub-stratum j species k for year t; t Cyr $^{-1}$

$C_{SOC,m_2,ijk,t}$ carbon stock in the soil organic pool in stratum i sub-stratum j species k in at monitoring event m_2; t C

$C_{SOC,m_1,ijk}$ carbon stock in the soil organic pool for stratum i sub-stratum j species k in at monitoring event m_1; t C

T_S monitoring interval for soil carbon $T_S = m_2 - m_1$; yr

Additionally, bulk density will be determined using an additional core taken within the sample plot. The mass of carbon per unit volume is calculated by multiplying the carbon concentration (percent mass) and bulk density (g/cm3). The bulk density equals the oven dry weight of the soil core divided by the core volume after discounting the volume of coarse fraction of >2 mm. Initial measurements of bulk density have already been done for several sites in the Baviaanskloof Nature Reserve (see Annex 9).

$$C_{SOC,m,ijk,p} = C_{SOC\_Sample,m,ijk,p} \cdot BD_{ijk,p} \cdot Depth_{ijk,p} \cdot FC_{ijk,p} \cdot M \qquad \text{(M.26)}$$

where:

$C_{SOC,m,ijk,p}$ soil organic carbon of plot in stratum i sub-stratum j species k in at monitoring event m in t C ha^{-1}

$C_{SOC\_Sample,m,ijk,p}$ soil organic carbon of the sample in plot p in stratum i sub-stratum j species k determined in laboratory in g C

$BD_{ijk,p}$ bulk density (soil mass/volume of sample) plot p in stratum i sub-stratum j species k determined in laboratory at monitoring event m; t.m^{-3}

$Depth_{ijk,p}$ soil depth at which sample is collected in stratum i sub-stratum j species k; cm

$FC_{ijk,p}$	1- (% volume of coarse fragments/100) to adjust the fraction of sample occupied by coarse fragments > 2 mm plot p in stratum i sub-stratum j species k at monitoring event m
M	multiplier to convert units into t C ha^{-1}

The mean soil organic carbon accumulation will be calculated by pooling the estimates of samples at the monitoring interval.

$$MC_{SOC,m,ijk} = \frac{\sum_{p=1}^{P_{ijk}} C_{SOC,m,ijk,p}}{P_{ijk}} \quad \text{(M.27)}$$

where:

$MC_{SOC,m,ijk}$	mean carbon stock in the soil organic pool in stratum i sub-stratum j species k at monitoring event m; t C ha^{-1}
$C_{SOC,m,ijk,t}$	soil organic carbon of plot p in stratum i sub-stratum j species k at monitoring event m; t C ha^{-1}
p	plot number in stratum i, sub-stratum j species k
P_{ijk}	number of plots in stratum i, sub-stratum j species k

In order to be conservative, the change in SOC is estimated using the Reliable Minimum Estimate (RME) (Dawkins, 1957), as outlined in AR-AM0002 (V3). Under the RME approach, the monitoring results of the plots are pooled to assess the mean at monitoring interval m_1 and m_2. The change in SOC is calculated by subtracting the maximum estimate of the mean at monitoring time m_1 from the minimum mean estimate at monitoring event m_2. The resulting difference represents the minimum change in the mean SOC with 90% confidence between the monitoring interval m_2 and m_1.

$$C_{SOC,m_2,ijk,t} = [MC_{SOC,m_2,ijk} - 90\%ConfidenceInterval] \cdot A_{ijk} \quad \text{(M.28)}$$
$$C_{SOC,m_1,ijk,t} = [MC_{SOC,m_1,ijk} + 90\%ConfidenceInterval] \cdot A_{ijk} \quad \text{(M.29)}$$

where:

$C_{SOC,m_2,ijk}$	soil organic carbon in stratum i sub-stratum j species k at monitoring event m_2; t C ha^{-1}
$C_{SOC,m_1,ijk}$	soil organic carbon in stratum i sub-stratum j species k at monitoring event m_1; t C ha^{-1}

h) Baseline

An initial measurement of the baseline is undertaken during the initial monitoring event, and the initial estimates are used throughout the project crediting period. No further baseline monitoring is required under the selected methodology, since in terms of the eligibility criteria the sites are degraded (and consequently are either deteriorating, or have stable carbon stocks).

i) Number of sample plots

The minimum number of sample plots was determined using the chosen methodology (AR-AM0002 V3), as described in the project calculations (Annex 14). The variables required for the calculation were obtained from an analysis of the literature: sites close to the current project area were used to assess the mean aboveground carbon concentration. The aboveground carbon was selected as the most relevant pool because it is the principal pool that is measured regularly.

The targeted precision used in the calculation was 10% of the mean with a 90% confidence interval. The calculation specified that the minimum number of plots required to reach this level of precision is 10. In order to account for temporal variation as a result of the planting plan, 10 permanent sample plots were assigned to each of the cohort substrata (for a total of 20 sampling plots in the current project area).

The selected methodology (AR-AM0002 v3) specifies an equation for calculating the necessary number of plots to ensure that the required level of precision is maintained. However, there are several errors in the equation as printed, and consequently some minor adjustments were required in order to arrive at a correct estimate for the required number of permanent sample plots. The deviation is detailed in Annex 16A 16.7

$$n = \left(\frac{t\alpha/_2}{A}\right)^2 \left(\sum_{i=1}^{N_s} W_i\, S_i \sqrt{C_i}\right)\left(\sum_{i=1}^{N_s} W_i\, S_i \Big/ \sqrt{C_i}\right) \qquad \text{(M.1.dev)}$$

where:

n	Sample size (number of sample plots required for monitoring)
$t\alpha/_2$	Value of the Student t statistic, for α = 0.1 (implying a 90% confidence level); 2.01
N_s	Total number of strata defined (1)
N_i	Number of potential sample units (permanent sample plots) in stratum *i* (total area/area of a single units = 528,500)
N	Total number of potential sample units (permanent sample plots);(528,500, since there is only one stratum)
S_i	Standard deviation in stratum *i*; 11.11, calculated from literature meta-analysis
A	Permissible error in the mean; 7.15 (10% of mean value calculated from literature)
C_i	Cost of selecting a sample plot in stratum *i* (Default = 1; will be raised if there is a significant difference between different strata once additional project areas are included)
$W_i = N_i/N$	

The calculation provided an estimate of at least 10 plots required to ensure statistical accuracy. The project undertakes to measure at least 12 sites for each sub-stratum within the project area, ensuring that there is accuracy even in the instance of some sites being destroyed through some form of interference or disturbance. These permanent sample plots have been allocated as specified below.

In the case of addition of subsequent grouped sites, the number of sample sites will be calculated for each separate project area using relevant data for the area. The pro

j) Allocation of plots and plot location

Sample plot allocation to the planting sites was done by selecting a random start and assigning plots to separate annual planting sites until the specified number of plots were allocated. The location of the plot within each annual planting group was selected randomly, using the "Generate Random Points[24]" tool script for Arcview.

[24] This script is part of the set of tools provided in the "Hawth's tools" set, and freely downloadable from: http://www.spatialecology.com/htools/rndpnts.php

Since planting sites are geographically dispersed throughout the strata, no more than one plot is assigned to a single planting site. This will reduce the likelihood of spatial autocorrelation between monitoring outputs.

In order to minimise the potential for selective management practices, permanent markers for the sampling sites will be as unobtrusive as possible (metal pegs marking the south-western corner of the plot). Each plot has also been given a unique ID and the GPS coordinates of the site have been recorded, allowing the site to be accurately revisited.

3.2.6 Biodiversity monitoring

Plant diversity will be measured as a proxy for overall diversity within each permanent plot. Tree and shrub diversity will be monitored using belt transects. The transects are 10m wide, and are established along the same 50m intersections through the permanent monitoring plots that are used to monitor deadwood (see Figure 5 above). The presence of trees and shrubs along the belt transect will be recorded as alpha diversity. The vegetation cover will be assessed through the line-intercept method (the cover of each tree or bush that intersects the transect will be assessed).

Forb and grass diversity and cover data will be obtained from three 2m x 2m quadrats randomly located within each permanent monitoring plot.

Each species located within the transect and the quadrats will be recorded, along with the total area covered by each species. These variables will be used to calculate the Simpson's Diversity Index for each site, using the following equation:

$$D = 1 - \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)}$$

where:

D	total diversity
S	the number of species in the permanent monitoring plot/transect
N	total percentage cover of all species
n_i	percentage cover of species *i*

3.2.7 Monitoring of GHG emissions by sources

According to AR-AM0002 (V3), the potential sources of project emissions are emissions from fossil fuel usage whilst carrying out ARR activities, loss of non-tree biomass (not including the herbaceous component) during the site preparation, and biomass burning due to natural fires or from management-related activities. The area subjected to biomass burning will be measured and recorded, and 10

$$GHG_{E,t} = E_{BiomassLoss,t} + E_{BiomassBurn,t} \quad \text{(M.30)}$$

where:

GHG_E	Sum of increases in GHG emissions by sources within the project boundary from the implementation of the proposed ARR project activity; t CO_2e
$E_{BiomassLoss}$	Increase in GHG emissions from the loss of biomass within the project boundary in year t; t CO_2e
$E_{BiomassBurn,i}$	Increase in GHG emissions from biomass burning within the project boundary in year t; t CO_2e

a) Carbon loss through clearance

The loss of carbon stock in the biomass of non-tree vegetation is calculated as follows:

$$E_{BiomassLoss,i} = \sum_i A_{NT\_BiomassLoss,i} \cdot B_{AB\_NTree,i} \cdot CF_{NTree} \cdot \frac{44}{12} \qquad \forall\, t = 1 \qquad \text{(M.31)}$$

$$E_{BiomassLoss,i} = 0 \qquad \forall\, t > 1$$

where:

$E_{BiomassLoss,i}$	Increase in GHG emissions from the loss of biomass in the site preparation within the project boundary in year *t*; t CO_2e
$A_{NT\_BiomassLoss,i}$	area of biomass loss in stratum *i*; ha
$B_{AB\_Ntree,i}$	average biomass stock of non-tree vegetation on land to be planted before the start of a proposed ARR project activity for stratum *i*; t.d.m. ha^{-1}
CF_{NTree}	carbon fraction of dry biomass in non-tree vegetation in t C $(t.d.m.)^{-1}$; dimensionless
$44/12$	ratio of molecular weights of CO_2 and carbon; dimensionless
t	time; yr

However, under the definition of leakage, the methodology specifies that emissions from project transport are considered insignificant and are consequently not included. Furthermore, the project design calls for no removal of non-herbaceous vegetation during the preparation of land (since *P. afra* cuttings are placed in vertical holes and the land is degraded, there is no damage to extant vegetation within the sites). The only potential source of GHG emissions in the project areas is therefore through the action of fires, detailed below.

b) Fires

All fires in the project areas are monitored as a matter of course by the conservation agencies. Where fires occur in the planting sites, monitoring will be conducted by project proponents within three months to assess the impact of the burn on the *P. afra* plantings. Previous experience has shown that the effect of burns on P. afra plantations is minimal, since they are highly fire-resistant as a result of their succulent nature.

Survivorship: This will be assessed by means of a 2 m wide transect through the burn area (50m long or the length of the burn if it is shorter). The survival status of each *P. afra* plant intersected by the transect will be recorded, in order to obtain a percentage survival rate.

Area of burn: If the burn area does not cover the entire project area, the full extent of the burn will be measured by walking the perimeter of the area with a GPS, converting the track to a polygon in a GIS programme, and calculating the relevant area.

$$E_{BiomassBurn} = E_{BiomassBurn,CO_2} + E_{Non-CO_2 BiomassBurn} \qquad \text{(inserted I.1)}$$[25]

$$E_{BiomassBurn,CO_2} = \sum_i A_{BiomassBurn,i} \cdot B_{AB\_Ntree,i} \cdot CE \cdot CF_{NTree} \cdot 44/12 \qquad \text{(M.32)}$$

where:

$E_{BiomassBurn,CO_2}$ Increase in CO_2 emissions as a result of biomass burning; t CO_2e yr^{-}

[25] This equation is implied in AR-AM0002 (V3), but is not specifically included.

$E_{Non-CO_2 BiomassBurn}$ Increase in non-CO_2 emissions as a result of biomass burning; t CO_2e yr⁻

$A_{BiomassBurn,i}$ Area of biomass burn in stratum i in ha yr^{-1}

$B_{AB\_NTree,i}$ Average stock in above ground biomass for stratum i prior to burn in t.d.m. ha^{-1}

CE Combustion efficiency; dimensionless (IPCC default = 0.5)

CF_{NTree} Carbon fraction of dry biomass; dimensionless (IPCC default = 0.43

AR-AM0002 (V3) states that *"Emissions from fires under this methodology include CO2 and as well as CH4 and N_2O."* However, the methodology then specifies only the methane emissions from biomass burn, which is calculated as follows

$$E_{BiomassBurn,CH_4} = E_{BiomassBurn,CO_2} \cdot GWP_{CH_4} \cdot EF_{CH_4} \cdot 12/44 \cdot 16/12 \quad \text{(M.33)}$$

where:

$E_{BiomassBurn,CH_4}$ CH_4 emission from biomass burning; t CO_2e yr^{-1}

$E_{BiomassBurn,CO_2}$ Increase in CO_2 emissions as a result of biomass burning; t CO_2e yr⁻

GWP_{CH_4} global warming potential for CH_4 (IPCC default = 21)

EF_{CH_4} emission factor for CH_4, t CH_4 $(t\ C)^{-1}$ (IPCC default emission ratio of CH_4 = 0.012)

$12/44$ ratio of molecular weights of CO_2 and carbon; dimensionless

$16/12$ ratio of molecular weights of CH_4 and carbon; dimensionless

Furthermore, the methodology then directly contradicts the earlier statement, by showing that the non-CO_2 component of biomass burn comprises the methane component exclusively:

$$E_{Non-CO_2,BiomassBurn} = E_{BiomassBurn,CH_4} \quad \text{(M.34)}$$

Since the methodology specifies that N_2O can be ignored since emissions are likely to be negligible (page 2, Table 2 of AR-AM0002 (v3)), N_2O is not considered as a potential source of emissions.

3.2.8 Actual net GHG removals by sinks

The actual net greenhouse removals by sinks at each verification period will be calculated by subtracting the increase in GHG emissions within the project area from the verifiable changes in the carbon stocks of all carbon pools in the project boundary. It is measured in t CO_2e removed by sources as a result of the project implementation.

$$\Delta C_{ACTUAL} = \sum_{i=j} \sum_{j=1} \sum_{k=1} [\Delta C_{ijk} - GHG_E] \quad \text{(M.35)}$$

where:

ΔC_{ACTUAL} Actual net greenhouse gas removals by sinks; t CO_2e yr^{-1}

ΔC_{ijk} verifiable annual changes in the carbon stock of pools for stratum i sub-stratum j species k; t CO_2e yr^{-1}

GHG_E GHG emissions by sources within the project boundary as a result of implementation of the proposed ARR project activity; t CO_2e

3.2.9 Quality control (QC) and quality assurance (QA) procedures to be applied to the monitoring process

To ensure that the net anthropogenic GHG removals by sinks are measured precisely, credibly, verifiably and transparently, a quality assurance and quality control (QA/QC) procedure is implemented, including:

- Collection of reliable field measurements.
- Verification of methods used to collect field data.
- Verification of data entry and analysis techniques.
- Data maintenance and archiving.

If after implementing the QA/QC plan it is found that the targeted precision level is not met, then additional sample sites will be randomly assigned, and supplementary field measurements will be conducted until the targeted precision level is achieved. This is in line with the recommendations from the chosen methodology.

a) Reliable field measurements

The methodology emphasises the importance of collecting reliable field measurement data as an important step in the quality assurance plan. Staff involved in the field measurement work will be fully trained in the field data collection and data analysis. Standard Operating Procedures (SOPs) for each step of the field measurements will be adhered to at all times. These SOPs will detail all the phases of the field measurements and contain provisions for documentation for verification purposes, so that measurements are comparable over time and can be checked and repeated in a consistent fashion. To ensure the collection of reliable field data:

- Field-team staff will be fully aware of all procedures and the importance of collecting field measurement data as accurately as possible.
- Field teams will install test plots if needed in the field and measure all pertinent components using the SOPs.
- Field measurements will be checked by a qualified person to correct any errors in techniques.
- A document that details that these steps have been followed will be presented as a part of the project documents. The dated document will list all names of the field team, together with their signatures and the project leader will certify that the team is trained.
- Any new staff will be adequately trained.

b) Verification of field data collection

To verify that plots have been installed and the measurements taken correctly, 10% of plots will be randomly selected and re-measured independently. Key re-measurement elements include the location of plots, CBSA, deadwood, litter and soil carbon. The re-measured data shall be compared with the original measurement data. Any deviation between measurement and re-measurement below 5% will be considered tolerable and above 5% will be considered an error. Any errors found shall be corrected and recorded. Any errors discovered should be expressed as a percentage of all plots that have been re-checked to provide an estimate of the measurement error.

c) Verification of data entry and analysis

Reliable estimation of carbon stocks in each pool requires correct entry of data into the data analysis spreadsheets. To minimize the possible errors in this process, the entry of both field data and laboratory data will be reviewed using expert judgment and, where necessary, comparison will be taken with independent data to ensure that the data are realistic. Communication between all personnel involved in measuring and analyzing data should be used to resolve any apparent anomalies before the final analysis of the monitoring data is completed. If there are any problems with the monitoring plot data that cannot be resolved, the plot should not be used in the analysis.

d) Data maintenance and archiving

Because of the long-term nature of the ARR project activities, data will be archived and maintained safely. It will be kept for at least two years after the end of the crediting period. Data archiving shall take both electronic and hard copy forms, and copies of all data will be provided to each project participant. All electronic data and reports will also be copied on durable media such as DVDs. Copies of the DVDs will be stored in multiple locations. The archives shall include:

- copies of all original field measurement data, laboratory data, data analysis spreadsheets;
- estimates of the carbon stock changes in all pools and non-CO_2 GHG and corresponding calculation spreadsheets;
- GIS products, including geodatabases, shapefiles and linked contract information; and
- copies of the measuring and monitoring reports.

All data gathered is stored on the online database maintained by CSS and initiated by GIB (www.cssreports.bizsuite.co.za). The data quality control is undertaken according to the SOPs established by CSS, and housed on the database. Data is regularly backed up from the online servers to ensure long-term stability. Furthermore, the database is constructed in Microsoft Active Server Pages, a mature and well-developed web technology. This will allow the database to upgraded as simply as possible to future generations of technology as it becomes appropriate. In addition, hard copies of all relevant materials will be stored by GIB, and handed over to the relevant parties as required during project implementation.

Overall management of the data management system and quality control rests with the ABFRP Programme Manager. The database is password-protected, and users can be granted “read only” or “read-write” access according to the discretion of the Programme Manager.

3.3 Data and parameters monitored / selecting relevant GHG sources, sinks and reservoirs for monitoring or estimating GHG emissions and removals:

The chosen CDM methodology (AR-AM0002 (V3)) specifies that no monitoring of the baseline is required. Furthermore, within the scale of such projects, the emissions from project activities are negligible, and the methodology specifies that they can be discounted. The data and parameters to be collected within the monitoring programme for *ex post* estimation are detailed in Table 5 and Table 6, below:

Table 5: Data and variables to be monitored during project implementation.

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data monitored	Comment
2.1.1.01	Stratum ID	Stratum maps	Alphanumeric		Prior to the project		Stratification within the project will be by project area as a proxy for climate characteristics.
2.1.1.02	Sub-stratum ID	Stratum maps	Alphanumeric		Prior to the project		Criteria derived from the year of planting in each stratum to identify age classes
2.1.1.03	Precision level	Sample frame	%	e	Prior to the project	100%	10% precision level adopted for the purpose of QA/QC.
2.1.1.04	Standard deviation of each stratum	Sample frame	Number	e	Prior to the project; 5 years	100%	To estimate the number of sample plots in each stratum & sub-stratum. Re-calculated after the first monitoring period to ensure sufficient plots have been assigned.
2.1.1.05	Sample size	Sample frame	Number	c	Prior to the project	100%	Calculated for each stratum and substratum based on 2.1.1.03 and 2.1.1.04 with equations M.1 and M.2.
2.1.1.07	Plot location	Project and plot maps	Alphanumeric	m	5 years	100%	Plot location is noted using permanent markers or GPS.
2.1.1.08	Age of plantation	Plot data	Year	m	5 years	100% sample plots	From the record on the year of project planting.
2.1.1.09	No. of trees	Plot measurement	Number	m	5 years	Trees in plots	Trees are counted in the plots of each stratum.

2.1.1.10	Combined Basal Stem Area (CBSA)	Plot measurement	cm	m	5 years	Trees in sample plots	Measurement of CBSA at each monitoring event.
2.1.1.11	Mean CBSA	Calculated	cm	c	5 years	Trees in sample plots	Calculated using the data in 2.1.1.10.
2.1.1.18	Carbon stock of above ground tree biomass	Calculated	t C	c	5 years	100% sample plots	Calculated based on 2.1.1.11 using allometric Equation AL.1.
2.1.1.20	Diameter at the base of shrub	Plot measurement	cm	m	5 years	100% sample plots	Measurement of *E. coerulescens* in substratum/stratum at each monitoring period
2.1.1.21	Height of shrubs	Plot measurement	m	m	5 years	100% sample plots	Measurement of *E. coerulescens* in substratum/stratum at each monitoring period
2.1.1.22	Crown diameter of shrubs	Plot measurement	m	m	5 years	100% sample plots	Measurement of *E. coerulescens* in substratum/stratum at each monitoring period
2.1.1.23	Number of stems in the shrub	Plot measurement	count	m	5 years	100% sample plots	Measurement of *E. coerulescens* in substratum/stratum at each monitoring period
2.1.1.24	Carbon stock of above-ground shrub biomass [$C_{AB\_NTree\_Shrub,m,ijk,p}$]	Calculated	t.d.m. ha-1	m	5 years	100% sample plots	Calculated for *E. coerulescens* based on allometric equations and estimated with equation M.15.

2.1.1.27	Mean carbon stock of above ground shrub biomass per ha	Calculated	tC	m	5 years	100% sample plots	Calculated based on equation M.10
2.1.1.29	Mean carbon stock of above ground tree biomass	Calculated	t C	c	5 years	100% sample plots	Calculated by averaging individual tree carbon stock estimates for each plot.
2.1.1.31	Carbon stock of below ground tree biomass	GPG LULUCF	t C	c	5 years	100% sample plots	Calculated using root shoot ratio (2.1.1.30) and above ground tree biomass (2.1.1.18).
2.1.1.32	Carbon stock of below ground shrub biomass per ha	Calculated	tC	m	5 years	100% sample plots	Calculated based on equation M.17 for *E. coerulescens* only.
2.1.1.34	Change in the carbon stock of below ground biomass	Calculated	t C	c	5 years	100% sample plots	Calculated based on equation M.19.
2.1.1.34	Change in carbon stock of below-ground biomass [$\Delta C_{DW,ijk,t}$]	Calculated	tC	m	5 years	100% sample plots	Calculated based on equation M.19
2.1.1.35	Standing deadwood	Plot measurements	t C	m	5 years	100% Sample plots	It is measured in the same way as live tree measurements.
2.1.1.36	Lying deadwood	Plot measurements	t C	e	5 years	100% sample plots	It is measured using line-intersect method and estimated with equations M.22 & M.23.

2.1.1.37	Total deadwood	Plot measurements	t C	c	5 years	100% sample plots	Calculated based on 2.1.1.35 and 2.1.1.36 with equation M 19.
2.1.1.38	Carbon in the litter biomass	Plot measurements	t C	m	5 years	100% sample plots	Litter sampling technique is used and dry weight is taken and samples and M.24 & M.25.
2.1.1.39	Soil organic carbon samples in the substratum /stratum	Plot measurements	g C /100 g soil	m	15 years	100% sample plots taken from plots per stratum	Stratified sampling is used to estimate the soil organic carbon using laboratory methods.
2.1.1.40	Bulk density of soil sample [$BD_{ijk,p}$]	Plot measurements	g cm^{-3}	m	15 years	100% sample plots	Measured in the stratum /sub-stratum.
2.1.1.41	Soil depth	Plot measurement		m	15 years	100% sample plots	Measured in the stratum /sub-stratum.
2.1.1.42	Area of stratum & sub-stratum	Stratification map and data	ha	m	5 years	100% of strata and substrata	Actual area of each stratum and sub-stratum.
2.1.1.43	Change in the stock of soil organic carbon in the stratum / substratum	Calculated	t C	c	15 years	100% sample plots	Calculated based on the monitoring data of two soil monitoring events using equation M.26.
2.1.1.44	Soil organic carbon in the sub-stratum / stratum /species	Calculated	tC	m	15 years	100% sample plots	Calculated based on the area of substratum/ stratum /species and soil organic carbon estimated from sampling using equation M.27

2.1.1.45	Mean soil organic carbon per ha	Calculated	t C ha^{-1}	m	15 years	100% sample plots	Calculated based on the plot level soil carbon data using equation M.28
2.1.1.46	Soil organic carbon with 95% in the mean per ha	Calculated	t C	c	15 years	100% sample plots	Calculated based on the area of sub-stratum and stratum using equation M.29 and M.30.
2.1.1.47	Sum of changes in carbon stocks CO_2e	Calculated from plot data	t CO_2e	c	5 years	100% Project data	Calculated using the equation M.5.
2.1.2.13	Area of the burn	Measured	ha	n	Annual	100% burn areas	Measured for strata and sub-strata
2.1.2.14	Mean biomass per unit area	Measured before slash and burn	t.d.m. ha^{-1}	m	Annual	100% burn areas	Sample survey for strata and sub-strata before the occurrence of biomass burn
2.1.2.15	Proportion of biomass burnt	Measured before slash and burn	Ratio	m	Annual	100% burn areas	Sampling survey after slash and burn
2.1.2.17	CO2 emission from biomass burn	Calculated	t CO_2e yr^{-1}	c	5 years	100%	Calculated using equation M.32
2.1.2.20	CH_4 emission from biomass burn [$E_{BiomassBurn,CH4}$]	Calculated	t CO_2e yr^{-1}	c	5 years	1	Calculated using equation M.33
2.1.2.30	Total GHG emission from biomass burn	Calculated	t CO_2e yr^{-1}	c	5 years	100%	Calculated using equation I.2
Bio.1	Number of bush and tree species	Line transect	Number	m	5 years	100% of sample plots	All plants intersecting the established line transects in the permanent sample plots.
Bio.2	Number of forb and grass species	Plot measurements	Number	m	5 years	100% of sample plots	Three 2m x 2m quadrat samples per sample plot

Bio.3	Species cover	Plot measurements	Number	m	5 years	100% of plants in biodiversity samples	Estimated for all plants identified in biodiversity sampling
Bio.4	Simpson's diversity index	Calculated	none	c	5 years	100% of sample plots	Calculated from Bio.1, Bio.2 and Bio.3
NM.1	Weight fraction of moisture of litter biomass [MP_L]	Plot measurement	dimensionless	c	5 years	100% of sample plots	Calculated by measuring wet weight of litter, then drying it ([wet weight - dry weight]/ wet weight)
NM.2	Multiplier to convert units of soil sample into tC ha^{-1} [*M*]	Plot measurement	dimensionless	c	5 years	100% of soil samples	Depends on the size of the soil sample, and must be calculated for each soil sample by multiplying the carbon concentration (percent mass) by the bulk density (g/cm^3)

Table 6: Data and parameters estimated once

ID number	Data variable	Source of data	Data unit	Measured (m), calculated (c) or estimated (e)	Recording frequency	Proportion of data monitored	Comment	Default value
2.1.1.06	Plot ID	Plot maps	Alphanumeric	c	Prior to the project	100%	Identified and mapped for each stratum and sub-stratum.	-
2.1.1.16	Wood density	Local data, GPG for LULUCF	kg m^{-3}	e	Prior to sampling	100% sample plots	Default value for *Aluadia procera* used (Zanne et al., 2009), since it is the only available plant density for the family *Portulaceae*. Actual density to be calculated by field sampling prior to first monitoring.	0.383

2.1.1.17	Carbon fraction of above ground tree biomass	IPCC GPG for LULUCF	t C (t.d.m.)$^{-1}$	e	Prior to the project monitoring	100% tree species	IPCC default (Pg 3.25 of Chapter 3.2 of LULUCF GPG)	0.500
2.1.1.26	Carbon fraction of *Euphorbia coerulescens* [CF_{Shrub}]	GPG LULUCF/ AR-AMS0002 (v3)	t C (t.d.m.)$^{-2}$	c	Prior to first monitoring	100%	IPCC default value (pg 67 of AR-AM0002 v3)	0.500
2.1.1.30	Root:shoot ratio for tree biomass [$R_{T,jk}$]	Local data	dimensionless	e	Prior to project	100%	Calculated from field assessments by project and literature meta-analysis (See Annex 8 of the PD)	0.350
2.1.1.33	Root:shoot ratio for E. coerulescens biomass [R_S]	Local data, Field measurements	dimensionless	c	Prior to first project monitoring	100%	To be calculated from field measurements of destructively harvested E. coerulescens at sites adjacent to the project area by comparing the oven-dry mass of above-ground and below-ground structures.	-
NM.10	Carbon fraction of standing deadwood [CF_{DW}]	IPCC GPG for LULUCF	t C / t.d.m. ha^{-1}	e	Prior to project	100%	Default is estimated to be the same as for living trees. IPCC default (pg 3.35 of Chapter 3.2 of LULUCF GPG)	0.500
NM.11	Decomposition factor for *P. afra* [DC_k]	Expert estimate	dimensionless	e	Prior to project	100%	Expert estimate from A.J. Mills (pers. comm.) based on low incidence of *P. afra* deadwood in thicket stands	0.800
NM.3	Biomass combustion efficiency [*CE*]	AR-AMS0002 (v3)	dimensionless	e	Prior to project	100%	IPCC default (AR-AMS0002	0.500

NM.4	Carbon fraction of litter [CF_L]	IPCC GPG for LULUCF	t C (t.d.m.)$^{-1}$	e	Prior to project monitoring	100%	IPCC default (pg 3.35 of Chapter 3.2 of LULUCF GPG)	0.370
NM.6	Basic density of deadwood in the density class – sound (1), intermediate (2) and rotten (3) [$D_{DW,dc}$]	Field estimate	kg d.m. m^{-3}	c	Prior to first monitoring	100% of sample plots	Values calculated by estimating volume for samples in each density class, and then measuring the weight of the oven-dry biomass for each class.	-
NM.7	Emission factor for CH_4 [EF_{CH4}]	IPCC GPG for LULUCF	t CH_4 (t C)$^{-1}$	e	Prior to project	100%	IPCC default (Table 3A.1.15 of LULUCF GPG)	0.012
NM.8	Global warming potential for CH_4 [GWP_{CH4}]	AR-AMS0002 (v3)	t CO_2e (t CH_4)$^{-1}$	e	Prior to project	100%	IPCC default (AR-AMS0002)	21.000
NM.9	Natural mortality rate of *P. afra* [M_k]	IPCC GPG for LULUCF	mortality yr^{-1}	e	Prior to project	100%	IPCC default for deciduous forest selected as most appropriate default (since the growth rate is lower than that of tropical forest)	0.012

3.4 Description of the Monitoring Plan

Specific procedures and responsibilities for monitoring are specified in the ABFRP monitoring plan, which is housed in the project online database.

3.4.1 Monitoring of the project initiation

The proposed ARR project consists of a number of discrete sites distributed across the AENP. Potential additional sites will also be within protected areas in the Subtropical Thicket Biome of the Eastern Cape. The area was identified through field surveys and remote sensing to confirm the state of degradation in relevant thicket vegetation types. Boundary coordinates for the project area were determined during the initial desktop boundary survey and scoping activities. Not all identified areas have been finalised, and consequently additional areas will be included during future operations through the provisions of VCS's grouping policy. The determining features for the project area were determined in accordance with the methodology outlined in the project planting plan.

Project initiation includes the following activities:

- Field surveys and remote sensing are used to determine the exact boundary of each planting site within the project area. In cases where additional sites are to be included under the provisions for project grouping under the VCS guidelines[26], additional information will be provided and projections will be adjusted *ex post*.
- The geographical coordinates (latitude and longitude) of each corner of site polygons are determined by GPS, collected, and exported to GIS software (ArcView). Maps of the actual planting site boundaries are prepared, and examination of remotely sensed data (historical and current) is undertaken to ensure planting site eligibility within the conditions outlined by the selected methodology. Planting site size is 7 ha for manual planting or 26 ha for mechanical planting.
- Manual planting is undertaken where the ground is too rocky or the gradient too steep to allow for the use of the mechanical auger. Manual planting sites are smaller because progress is slower in order to allow contract completion within an equivalent time period to mechanical planting.
- Planting contract details are attached to the spatial imagery in a geodatabase, maintained by CSS. Consequently planting data, survivorship and other additional relevant information can be obtained readily for a chosen site.
- Site preparation is implemented according to the practice documented in Section 1.8, i.e.:
    - no tillage;
    - minimum-impact plantings using a mechanical auger or manual labour to prepare holes into which the *P. afra* cuttings are planted; and
    - regular spacing of holes.
- Preparation of the cuttings in a standardised manner to maximise survivorship. This includes ensuring that no more than 30% of source plants are harvested, and storing cuttings in the shade for two days.

The project area boundary is the Darlington Dam area of the northern Addo Elephant National. Land use and economic activities that occur outside the project boundary have no influence on the project over the crediting period. The risk of fire is very low as *P. afra* is a naturally fire-resistant species due to its succulent (water-bearing) and dense foliage (Kerley et al., 1995; Vlok et al., 2003). Any fires within the project boundaries will be monitored as part of Section 3.4.3)

Personnel involved in the monitoring shall be trained in the early stage of the project so that they are equipped to implement the steps and procedures of the monitoring process.

[26] Available from: http://www.v-c-s.org/faq.html#question34

Procedures used in monitoring of the project activities are subject to quality assurance/quality control measures; as outlined in Section 3.2.9

3.4.2 Monitoring of the area reforested

Contracts are awarded for planting of specified planting sites within the project area boundaries. The area to be planted will be calculated from maps and confirmed via GPS on the ground. After completion of the contract, the contract map and measured map will be compared. The contract is only paid once the area has been checked by GIB and signed off as completed. (See Section 3.2: Monitoring Roles and Responsibilities for more detail.)

Table 7: Variables measured in each stratum for purposes of monitoring the area reforested.

ID Number	Data Variable	Data Unit	Measured (m), calculated (c), estimated (e) default (d)	Recording frequency	Number of data points / Other measure of number of collected data.	Comment
3.4.2.1	Recommended spacing for plantings	m	m	Once	100% of contracts	Recommended spacing for all strata.
3.4.2.2	Deviation from recommended spacing	%	c	After each contract is completed.	100% of contracts	Deviations from recommended spacing may occur as a result of site topography or other local features. Single percentage reflecting deviation from recommended spacing.
3.4.2.3	Supplemental planting ID	Alpha-numeric	c	When each supplemental planting is required	100%	Separate contracts for planting.
3.4.2.4	Supplemental planting	ha	c	After each supplemental planting contract is completed.	100%	Carried out as separate contracts
3.4.2.5	Area burnt by fire	ha	e	Annual		From Park Management report. Area mapped in GIS. Causes, season, and duration of fire recorded if available.

3.4.2.6	Strata characteristic (rainfall)	mm/yr	m	Annual		From Park Management report. Mapped in GIS. Details on area affected by drought or flood if applicable.

3.4.3 Monitoring of the forest establishment

In order to ensure adherence to the silvicultural practices outlined in Section 1.9 and the methodology guidelines, the following monitoring practices will be undertaken for the first three years after planting:

- Information on planting dates, drainage, frost and other climatic extremes will be recorded.
- Site preparation: the method used to plant the cuttings does not entail removal of vegetation from the site thus there are no emissions from loss of biomass activities. Consequently there will be no monitoring of site preparation.
- Mortality monitoring by means of a 200 m x 5 m transect through each planting site: Mortality estimates are taken every year. Mortality data is assessed using the equation below and supplemental planting is undertaken where mortality is more than 30%.This ensures that environmental risks are countered.

$$Mo = \frac{A_t \cdot Dv \cdot Sp_R}{Su_t}$$

where:

Mo	Mortality (%)
Su_t	Survivor count in transect
A_t	Transect area (ha)
Dv	Recorded deviation of site from recommended planting density (%)
Sp_R	Recommended planting density (stems ha^{-1})

Table 8: Variables measured for each stratum for purposes of monitoring the forest establishment.

ID Number	Data Variable	Data Unit	Measured (m), calculated (c), estimated (e) default (d)	Recording frequency	Number of data points / Other measure of number of collected data.	Comment
3.4.3.1	Total planting days	day	c	Year 1 – 3		Number of contracts multiplied by 20 days per contract.
3.4.3.2	Drainage, frost and other climatic extremes	varies		Year 1 – 3		Taken from Park Management report.
3.4.3.3	Mortality	%	c	Annual		Survivorship monitoring

						by means of a transect through each planting site.

3.4.4 Monitoring of forest management activities

The selected methodology requires monitoring of all forest management procedures conducted from initiation to the end of the project implementation period. However, the selected technologies require minimal forest management after the initiation period (no harvesting, thinning or fertiliser is required).

Once *P. afra* is established there is a low risk of fire and so no fire breaks are created in the planting sites. Domestic livestock are not permitted within the project areas and thus there will be no fencing of the planting sites. Once project areas are restored, game will return to the area. SANParks and ECPTA are contractually bound to employ appropriate stocking rates, which will ensure that the impact of herbivory by indigenous species is not significant. Low levels of herbivory have been shown to promote the rate of recruitment of *P. afra*, and may stimulate overall thicket growth (Aucamp et al., 1980).

The following procedures will be implemented from the fourth year after planting:

- Natural and anthropogenic disturbance (including fire and other catastrophic events) will be recorded by date, location, volume of biomass (and area) lost, and
- Supplemental planting activities recorded.

Table 9: Variables measured for purposes of monitoring the forest management activities.

ID Number	Data Variable	Data Unit	Measured (m), calculated (c), estimated (e) default (d)	Recording frequency	Number of data points / Other measure of number of collected data.	Comment
3.4.4.1	Natural / Anthropogenic disturbance (area).	ha	c	Following disturbance at planting site.	100%	From Park Management report. Area mapped in GIS.
3.4.4.2	Natural / anthropogenic disturbance (tons of carbon in the 5 pools).	tC	c	Following disturbance at planting site.	100%	Date, location, volume of biomass lost.

3.4.5 Monitoring frequency

Monitoring of the area reforested and of forest establishment will be conducted as indicated in Table 7, Table 8 and Table 9 until the end of the third year, to verify that establishment is successful. Survivorship monitoring will be at least every three years, and annually for the first three years after the initial planting.

Monitoring of vegetation carbon pools (above-ground and below-ground biomass, litter and deadwood) will be conducted every five years to prepare for the verification process. Soil carbon monitoring will be conducted at the project start and every fifteen years thereafter.

Community impact monitoring will be carried out within the first year after validation, once the methodology has been finalised. This is in line with the CCBA guidelines, which indicates that a monitoring methodology must be completed within six months of validation.

Monitoring of biodiversity impacts will be undertaken every five years on the same permanent samples plots that are used for carbon estimation.

After each monitoring period, the number of required permanent sample sites will be recalculated to ensure that the total error does not exceed 10% of the mean at a 90% confidence level. If additional sites are required, they will be assigned randomly within planting sites, following the systematic manner described in 3.2.5 (j).

Table 10: Frequency of monitoring of all parameters.

Monitoring activity	Variable monitored	Extent of monitoring	Frequency
Carbon and forest monitoring	Survivorship monitoring	100% of planting sites	Initially, and at least once every 3 years
	Tree biomass (aboveground)	100% of monitoring plots	Initially, and once every 5 years
	Deadwood	100% of monitoring plots	Initially, and once every 5 years
	Litter	100% of monitoring plots	Initially, and once every 5 years
	Soil	100% of monitoring plots	Initially, and once every 15 years
Biodiversity assessment	Alpha plant diversity	100% of monitoring plots	Initially, and once every 5 years
Community impact monitoring	Full community impact assessment	All contractors and employees	Initially, and once every 5 years
	Feedback reports from advisory committees	All advisory committees	Quarterly
	Self-reporting questionnaires from contractors in line with WfW guidelines	All contractors	Quarterly
	Staff training exercises	All contractors	Upon completion of each contract

4 GHG Emission Reductions:

4.1 Explanation of methodological choice:

The proposed ARR project uses the approved afforestation and reforestation baseline methodology AR-AM0002 (V3): “Restoration of degraded lands through afforestation/reforestation”.

In order to assess land eligibility for the ARR project methodology, the project utilizes the “Procedures to demonstrate the eligibility of lands for afforestation and reforestation project activities” (UNFCCC, 2007). See Section 1.16 for details.

Methodology AR-AM0002 (V3), like the proposed ARR project activities, pertains to ARR of degraded land, and includes above ground and below ground carbon pools. In addition, the methodology includes deadwood, litter and SOC as additional carbon pools.

a) Plant growth model

For the *ex ante* and baseline calculations, a growth model based on observed growth rates in literature studies for areas close to the project area was used to calculate the annual growth for *P. afra*. The difference in the average aboveground biomass in degraded and intact/restored spekboom thicket (60.41 t ha^{-1}) for sites close to the project area (see Annex 7 and Annex 14) was used to estimate the growth rate of *P. afra* over the 50 year re-establishment period. The overall aboveground biomass per hectare was then divided by the density of *P. afra* plants per hectare in order to calculate the average biomass per mature plant. It was further assumed that the growth of *P. afra* plants was governed by the common sigmoid self-regulating curve observed in many plant species (Mills et al., 2007). This reflects the slow initial growth rate of the plantings and of the 7- and 13-year-old plants in the literature analysis. The plant growth curve was calibrated using the intrinsic growth rate cited in literature to arrive at a realistic growth rate for the species. The equation used provides incremental growth per annum, and is shown below:

$$B_t = B_{t-1} + B_{t-1} \cdot r\left(1 - \frac{B_{t-1}}{K}\right) \qquad \textbf{I.3}$$

where:

B_t	aboveground dry biomass at year *t;*
B_{t-1}	aboveground dry biomass at year *t-1;*
r	intrinsic growth rate, dimensionless; 0.28 (Mills et al., 2007)*;*
K	maximum biomass, t ha^{-1}*;*(60.41, calculated from literature analysis; see Annex 14

The survival rate of the plants over the 50 year establishment period is assumed to be 70%. This rate is high in comparison to boreal forests, where regular thinning is required and competitive shading often reduces the survival rate. However, observation of the *P. afra* plant density in field sites both in the literature and in the field analysis (Annex 8) show densities of at least 1750 plants per hectare from a single initial planting, which corresponds to70% of the planned planting density. The project undertakes to conduct blanking to ensure establishment of a similar density of *P. afra* plants.

4.2 Quantifying GHG emissions and/or removals for the baseline scenario:

The chosen methodology recognises two possible land uses in the baseline scenario: i) degraded bare lands or degraded lands that have vegetation below the thresholds of forest defined by the DNA (i.e. 4.2.1 below); and ii) degraded lands on which small amounts of afforestation occurred prior to the project and can be expected to continue in the absence of the project (i.e. 4.2.2 below).

4.2.1 Degraded bare lands and degraded lands

Baseline estimation for the first case, as outlined above, is detailed by the selected methodology for both degraded land with sparse non-woody vegetation and for areas with isolated trees. For areas with no spekboom or tree cover, the baseline estimate is given as follows:

$$\Delta C_{BDL_{ijk,t}} = 0 \quad (B.1)$$

where:

$\Delta C_{BDL_{ijk,t}}$ Average annual change in the carbon stocks of bare lands or degraded lands with spare pre-existing vegetation in stratum i sub-stratum j species k; t CO_2e yr^{-1}

For areas with isolated trees, the changes in carbon stocks of the living biomass shall be estimated for isolated trees and the baseline net GHG removals by sinks is calculated as follows:

$$\Delta C_{BDL_{ijk,t}} = \Delta C_{BDL\_LB_{ijk,t}} \quad (B.2)$$

where:

$\Delta C_{BDL\_LB_{ijk,t}}$ Sum of annual changes in the carbon stocks of living biomass (above- and below-ground) in stratum i sub-stratum j species k; t CO_2e yr^{-1}

i Stratum of the baseline

j Sub-stratum of the baseline

k Species of the baseline

t Time of monitoring

The sum of annual changes in living biomass are equivalent to the sum of changes in above and belowground biomass for trees and non-tree shrubs, as well as for the litter, deadwood and soil pools. However, according to the methodology, soil organic carbon is expected to decrease under the baseline scenario for bare and degraded lands with no pre-project afforestation. Furthermore, considering the negligible amounts of deadwood and litter in the degraded lands under the baseline scenario, the methodology assumes that the change in carbon stocks of these pools is zero for all strata.

$$\Delta C_{LB_{ijk,t}} = \Delta C_{LB\_Tree_{ijk,t}} + \Delta C_{LB\_NTree_{ijk,t}} \quad (B.10)$$

Finally, the change in the living biomass of non-tree components is not considered under the baseline scenario. For tree species other than *P. afra* the literature and aerial imagery (Annex 7 and Annex 15) shows that there is a gradual decrease in tree cover, and consequently in the baseline scenario all tree cover other than *P. afra* is ignored. Therefore the equation to estimate the change in the living biomass is equivalent to an estimate in the change in carbon stocks of the current *P. afra* population:

$$\Delta C_{LB\_Tree_{ijk,t}} = (C_{2,LB\_Tree,ijk} - C_{1,LB\_Tree,ijk})/T_B \cdot 44/12 \quad (B.11)$$

$$C_{LB\_Tree,ijk} = C_{AB\_Tree,ijk} + C_{BB\_Tree,ijk} \quad \text{(B.12)}$$

$$C_{AB\_Tree,ijk,t} = A_{ijk} \cdot nTR_{ik} \cdot f_k(DBH,H) \cdot CF_k \cdot \left(\frac{1}{1000}\right) \quad \text{(B.15)}$$

$$C_{BB\_Tree,ijk} = C_{AB\_Tree,ijk,t} \cdot R_k \quad \text{(B.14)}$$

where:

$C_{2,LB\_Tree,ijk}$	Total carbon stock in living biomass of trees for stratum i sub-stratum j species k; calculated at time 2, t C
$C_{1,LB\_Tree,ijk}$	Total carbon stock in living biomass of trees for stratum i sub-stratum j species k; calculated at time 1, t C
T_B	Number of years between times 2 and 1
$C_{AB\_Tree,ijk,t}$	Carbon stock in above-ground biomass of trees for stratum i sub-stratum j species k, t C
$C_{BB\_Tree,ijk,t}$	Carbon stock in below-ground biomass of trees for stratum i sub-stratum j species k, t C
A_{ijk}	Area of stratum i sub-stratum j species k; ha
nTR_{ik}	Number of trees in stratum i species k; trees ha^{-1}
$f_k(DBH,H)$	Allometric equation quantifying the relationship between above-ground biomass to the diameter at breast height (DBH) and tree height (H) of tree species k; kg $tree^{-1}$
CF_k	Carbon fraction of species k; dimensionless
R_k	Root:shoot ratio of species k; dimensionless (0.350, as determined in field measures described in Annex 8)

However, the locally specific allometric equation determined for the species in question directly estimates the amount of carbon per plant, and uses the CBSA (combined basal stem area) rather than DBH to determine this:

$$\mathrm{Log_{10}C_{mass}} = (1.1043 \cdot \mathrm{Log_{10}CBSA}) + 2.4464$$ **(AL.1)** (Powell, 2009)

where:

$\mathrm{C_{mass}}$	Mass of carbon per tree in stratum i sub-stratum j species k; kg C
$CBSA$	Combined basal stem area of the tree; m^2

Consequently, the estimation of the baseline carbon sinks deviates slightly from the equation as specified by the chosen methodology. This deviation is in line with the recommendations from the VCS for selection of local allometric values, and is considered to be conservative. The deviation is detailed in Annex 16 (Deviation 1), and the alternative equation is specified below:

$$C_{AB_{Tree},ijk,t} = A_{ijk} \cdot nTR_{ik} \cdot f_k(CBSA) \cdot \left(\frac{1}{1000}\right) \quad \text{(B.15 dev)}$$

The baseline scenario has been calculated conservatively in the ex ante situation. The following assumptions were made for the calculation:

- Isolated *P. afra* trees are found throughout the project area at a density of 100 per hectare. This is considerably higher than the observed numbers for the field sites already planted. However, this conservative value was used for calculations until the final baseline estimate of tree density can be provided.
- The average CBSA of isolated *P. afra* plants corresponds to that of a half-grown (28 year old) tree. This is a conservative assumption since many of the isolated *P. afra* plants observed in the field are considerably larger than this, and few are fully

mature. In the absence of project activity, the rate of seeding and vegetative reproduction of *P. afra* is very low, as a result of the high soil temperatures.

- Isolated *P. afra* plants will grow according to the same growth curve of planted trees (i.e. until a peak size at 50 years of growth). This is a conservative assumption, since the growth of isolated *P. afra* trees in the project area has observed to be very low and slow in the absence of project activities.

Table 11: Calculated baseline carbon sequestration by isolated trees in degraded land within the project boundary (t CO_2e) over the project duration

Year	C seq.	Year	C seq.	Year	C seq.
1	3,386	21	142	41	0
2	3,611	22	103	42	0
3	3,759	23	75	43	0
4	3,818	24	54	44	0
5	3,782	25	39	45	0
6	3,653	26	28	46	0
7	3,440	27	20	47	0
8	3,157	28	15	48	0
9	2,821	29	11	49	0
10	2,454	30	8	50	0
11	2,079	31	5	51	0
12	1,717	32	4	52	0
13	1,384	33	3	53	0
14	1,092	34	2	54	0
15	845	35	1	55	0
16	643	36	1	56	0
17	483	37	1	57	0
18	359	38	1	58	0
19	265	39	0	59	0
20	194	40	0	60	0

These assumptions likely overestimate the potential baseline accumulation within the *ex ante* calculations. This overestimation is deliberate, since it preserves the conservativeness of the *ex ante* calculations. However, a final baseline estimate will be calculated by the end of the year of project initiation (2011) using accurate field measurements. In order to calculate this value, which will remain valid throughout the crediting period (and is not required to be monitored, as specified in AR-AMS0002 V3) the forest cover within the project area was divided into three classes in line with the methodology specified by the planting plan. Within each of the three classes, ten starting points have been randomly determined using a suitable script in Arcview. From each of these points, the CBSA of all P. afra plants in a transect 5m in width and extending 100m is assessed. These measurements are used to calculate the baseline aboveground carbon (for the pool being studied) for the whole project area, in line with the selected methodology (Equation B.2, page 6). This baseline quantification will be adopted for all areas within the specified stratum.

The baseline quantification species other than *P. afra* is not required, since it has been demonstrated in the literature that the average cover of all other species decreases in the absence of project activity. However, baseline estimation and monitoring of noors (*Euphorbia coerulescens*) will be undertaken throughout the project in order to assess the impact of project activities. No other significant non-tree plant species is located within the project area.

4.2.2 Degraded lands with pre-project ARR

In this second scenario, small amounts of ARR activities historically undertaken in the region are anticipated to continue in the absence of project activities. No areas were identified as falling within this scenario, since reforestation in the Eastern Cape is currently non-existent in the absence of project activities.
Consequently,

$$\Delta C_{BAR_{ijk,t}} = 0$$

where:

$\Delta C_{BAR_{ijk,t}}$ Average annual change in pre-project ARR attributable to stratum i sub-stratum j species k; t CO_2e yr^{-1}

Consequently, the baseline net GHG removal by sinks is set to zero. The baseline will be re-evaluated at the end of the first crediting period as per the EB decisions and guidance in this regard.

4.2.3 Calculation of the baseline scenario

The baseline scenario is calculated using the equation below.

$$\Delta C_{BSL_t} = \sum_i \sum_j \left[\sum_k \Delta C_{BAR_{ijk,t}} + \Delta C_{BDL_{ijk,t}} \right] \quad \text{(B.4)}$$

However, since $\Delta C_{BAR_{ijk,t}}$ has a baseline estimate of 0, the baseline scenario is basically the sum of the sequestration by isolated trees, as shown above. These trees are estimated to reach maturity within thirty years of project initiation and stop sequestering carbon, and the total baseline carbon sequestered therefore gradually decreases through the project duration. This is shown in Table 11.

4.3 Quantifying GHG emissions and/or removals for the project:

4.3.1 Verifiable changes in carbon stocks of pools

Empirical methods and literature studies were used to establish values for the annual change in *ex-ante* carbon stock for all project sinks, using equation B.17 from the selected methodology:

$$\Delta C_{ijk,t} = \left[\Delta C_{AB,ijk,t} + \Delta C_{BB,ijk,t} + \Delta C_{DW,ijk,t} + \Delta C_{L,ijk,t} + \Delta C_{SOC,ijk,t}\right] \cdot [44/12] \quad \text{(B.17)}$$

where:

$\Delta C_{ijk,t}$ Average annual change in carbon stock in the pools for stratum i sub-stratum j species k in year t; t CO_2e

$\Delta C_{AB,ijk,t}$ Average annual change in carbon stock in the above ground biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

$\Delta C_{BB,ijk,t}$ Average annual change in carbon stock in below ground biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

$\Delta C_{DW,ijk,t}$ Average annual change in carbon stock in deadwood for stratum i sub-stratum j species k in year t; t C $yr^{-1}t$

$\Delta C_{L,ijk,t}$ Average annual change in carbon stock in litter for stratum i sub-stratum j species k in year t; t C yr^{-1}

$\Delta C_{SOC,ijk,t}$	Average annual change in carbon stock in soil organic carbon for stratum i sub-stratum j species k in year t; t C yr^{-1}
$44/12$	Ratio of molecular weights of CO_2 and carbon; dimensionless

a) Changes in the carbon stocks of above ground biomass (C_{AB})

The above ground biomass was calculated using the stock change method from the methodology, with all values for the variables sourced from literature reviews and the baseline empirical study:

$$\Delta C_{AB,ijk,t} = \left(C_{AB,ijk,t_2} - C_{AB,ijk,t_1}\right)/T_B \quad \text{(B.18)}$$

$$C_{AB,ijk} = \left(C_{AB\_Tree,ijk} + C_{AB\_NTree,ijk}\right) \quad \text{(B.19)}$$

where:

C_{AB,ijk,t_1}	Carbon stock in above ground tree biomass stratum i sub-stratum j species k calculated at time t_2; t CC_{AB,ijk,t_1} Carbon stock in above ground tree biomass stratum i sub-stratum j species k calculated at time t_1; t C
C_{AB,ijk,t_2}	Carbon stock in above ground tree biomass stratum i sub-stratum j species k calculated at time t_2; t CC_{AB,ijk,t_1} Carbon stock in above ground tree biomass stratum i sub-stratum j species k calculated at time t_2; t C
T_B	Number of years between measurement at time t_2 and t_1 for biomass
$C_{AB\_Tree,ijk}$	Carbon stock of above ground biomass of living trees for stratum i sub-stratum j species k; t C
$C_{AB\_NTree,ijk}$	Carbon stock of above ground non-tree biomass for stratum i sub-stratum j species k; t C

The chosen methodology specifies that it "*is possible to omit non-tree woody biomass in the* ex ante *estimation, provided that this is conservative.*" Since no non-tree vegetation is planted by project activities, but growth of non-tree vegetation is likely to be enhanced by project activities (van der Vyver, 2011), it is considered conservative to omit non-tree biomass accumulation.

$$C_{AB\_Ntree,ijk} = 0 \qquad \text{(conservative)}$$

Consequently, the non-tree component will be excluded from the *ex ante* estimation, and only the tree component of above ground biomass is quantified using the allometric equation method.

$$C_{AB_{Tree},ijk,t} = A_{ijk} \cdot nTR_{ik} \cdot f_k(DBH, H) \cdot CF_k \cdot \left(\frac{1}{1000}\right) \quad \text{(B.21)}$$

where:

$f_k(DBH, H)$	Allometric equation quantifying the relationship between above ground biomass of tree species k; kg tree^{-1} to the diameter at breast height (DBH) and tree height (H) for species k; dimensionless. Mean DBH and H values can be estimated for stratum i sub-stratum j species k
A_{ijk}	Area of stratum i sub-stratum j species k; ha
nTR_{ik}	Number of trees in stratum i species k; trees ha^{-1}
CF_k	Carbon fraction for species k; t C (t.d.m.)$^{-1}$

Step 1 of the allometric equation method (see page 15 of AR-AM0002 (V3)) specifies that local allometric equations relevant to the species are to be used as a priority. The allometric equation for *P. afra* growth developed by Powell (2009) is used for the *ex post* estimation due to its high correlation between estimated and observed carbon mass (R^2= 0.9696, *p*=0.00224, n >12,000, as specified on page 51 of the thesis). Since this allometric equation directly provides the amount of carbon per tree, it replaces both the terms $f_k(DBH, H)$ and CF_k in Equation B.21. This deviation is detailed in Annex 16, and the modified equation is shown below:

$$C_{AB_{Tree},ijk,t} = A_{ijk} \cdot nTR_{ik} \cdot f_k(CBSA) \cdot \left(\frac{1}{1000}\right) \quad \text{(B.21.dev)}$$

The allometric equation is shown below:

$$\mathrm{Log_{10}C_{mass}} = (1.1043 \cdot \mathrm{Log_{10}CBSA}) + 2.4464 \quad \textbf{(AL.1)} \text{ (Powell, 2009)}$$

where:

$\mathrm{C_{mass}}$ Mass of carbon per tree in stratum i sub-stratum j species k; kg C

$CBSA$ Combined basal stem area of the tree; m^2

The calculation of ex ante aboveground biomass has been done using the growth model derived from the literature meta-analysis (Annex 8) and calculations (Annex 14). The growth model is the same as the model used for the baseline assessment, and is described in more detail in the baseline calculations section 4.2.3a).

b) Changes in the carbon stocks of below ground biomass (C_{BB})

The change in below ground biomass is specified as the sum of all changes in below ground tree biomass and non-tree biomass:

$$\Delta C_{BB,ijk,t} = \Delta C_{BB\_Tree,ijk,t} + \Delta C_{BB\_Ntree,ijk,t} \quad \text{(B.30)}$$

where:

$\Delta C_{BB\_Tree,ijk,t}$ Average annual change in carbon stock in below ground tree biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

$\Delta C_{BB\_Ntree,ijk,t}$ Average annual change in carbon stock in below ground non-tree shrub biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

As with the above ground biomass, the non-tree biomass is conservatively omitted from *ex ante* estimation:

$$\Delta C_{BB\_Ntree,ijk,t} = 0 \quad \text{(conservative)}$$

Below ground biomass is represented as a proportion of the above ground biomass. The tree biomass is calculated using the root-shoot ratio (0.350) assessed from the literature for *P. afra* growth rates in the region (see Annex 8, pg 154), following Step 1 identified in the methodology. This root:shoot ratio falls within the recommended range specified by the IPCC in the Guidelines for Greenhouse Inventories (IPCC, 1996). The formula for calculation of the below-ground biomass is the same as that specified for the non-tree biomass, as well as for the baseline calculation of below-ground biomass. This is a deviation from the selected methodology, and is detailed in Annex 16. It is considered that this deviation does not violate the conservativeness of the methodology:

$$\Delta C_{BB\_Tree,ijk,t} = \Delta C_{AB\_Tree,ijk,t} \cdot R_{T,k} \quad \text{(I.1)}^{27}$$

[27] See Deviation 2 in Annex 16.

where:

$\Delta C_{AB\_Tree,ijk,t}$ Average annual change in carbon stock in above ground biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

$R_{T,k}$ Root-shoot ratio for species k; dimensionless

c) Changes in the carbon stocks of deadwood (C_{DW})

The average annual change in the deadwood biomass is calculated based on natural mortality and the estimated changes in the above ground biomass:

$$\Delta C_{DW,ijk} = \Delta C_{AB\_Tree,ijk,t} \cdot M_k \cdot (1 - DC_k) \quad \text{(B.34)}$$

where:

$\Delta C_{DW,ijk}$ Average annual change in carbon stock in above ground biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

M_k Average annual rate of natural mortality for species k; dimensionless (IPCC default for deciduous forest: 0.0116)

DC_k Decomposition factor for species k; dimensionless (0.8, expert estimate from A.J. Mills (pers. comm.) based on low incidence of P. afra deadwood in thicket stands)

It is anticipated that deadwood mass in the stands will be very low in the early stages of the restoration project, but deadwood may accumulate in the stands in later crediting periods. *P. afra* is able to root and grow from cuttings, so damage to plants often provides a means for vegetative reproduction (Aucamp et al., 1980). The mortality rate is unknown, and so the IPCC default value (0.0116) for deciduous woodland was used (IPCC, 2006), since the other default values are for vegetation and climates (tropical rainforest and coniferous forest) that are significantly different from the conditions found in the project area. No figures are available on the rate of formation of deadwood in the thicket. However, field assessments in restored spekboom thicket have showed very low concentrations of deadwood as a result of a high decomposition rate. The decomposition factor was estimated by expert opinion[28] to be 0.8, and is therefore not as robust as other estimates in the PD. However, since the estimate results in low deadwood incidence, it is considered that any error is conservative.

d) Changes in the carbon stocks of litter (C_L)

AR-AM0002 (V3) specifies that if the carbon stocks in litter are to be included in ex-ante calculations, then the following *ex post* equations from the monitoring section should be used:

$$C_{L,m,ijk} = A_{ijk} \cdot C_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \quad \textbf{(M.23)}$$

$$\Delta C_{L,m,ijk,t} = \left[\left(C_{L,m_2,ijk} - C_{L,m_1,ijk}\right)/T_L\right] \cdot CF_L \quad \textbf{(M.24)}$$

where:

$C_{L,m,ijk}$ Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m; tC

$C_{L_{wet},ijk}$ Carbon in wet litter biomass for stratum i sub-stratum j species k at monitoring event m; g m^{-2}

MP_L Weight fraction of moisture litter biomass (0 to 1) [(wet weight – dry weight)/wet weight]; dimensionless

a_{ijk} Area of sampling frame; m^2

[28] A.J. Mills, February 2011, pers. comm.

$\Delta C_{L,m,ijk,t}$	Average annual change in carbon stock of litter for stratum i sub-stratum j species k at a monitoring event m; t C yr^{-1}
$C_{L,m_2,ijk}$	Carbon stock of litter in stratum i sub-stratum j species k at monitoring event m_2; t C
$C_{L,m_1,ijk}$	Carbon stock of litter in stratum i sub-stratum j species k at monitoring event m_1; t C
T_L	Time interval between monitoring event m_2 and monitoring event m_1; yr
CF_L	Carbon fraction of leaf litter; dimensionless (IPCC default: 0.370)

However, there is an error in these equations (see deviation 3, Annex 16) and a further deviation for the *ex ante* situation is registered in order to use the empirical measurements obtained from the literature meta-analysis. This deviation is explained in full in Annex 16 (deviation 4), and is not considered to violate the conditions for deviations outlined in the VCS methodology (VCS, 2008a). The equations used to calculate the *ex ante* change in the carbon stock of litter are as follows:

$$C_{L,m,ijk} = A_{ijk} \cdot C_{meta,ijk,m} \quad \textbf{(M.23.ex.ante)}$$

$$\Delta C_{L,ijk,t} = \left[\left(C_{L,ijk,t_2} - C_{L,ijk,t_1}\right)/T_L\right] \quad \textbf{(M.24.ex.ante)}$$

where:

$C_{L,m,ijk}$	Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m; t C
MP_L	Weight fraction of moisture of litter biomass (0 to 1) [(wet weight – dry weight)/wet weight]; dimensionless
A_{ijk}	Area of stratum i sub-stratum j species k at monitoring event m; ha
$\Delta C_{L,m,ijk,t}$	Average annual change in carbon stock of litter for stratum i sub-stratum j species k at monitoring event m; t C yr^{-1} (Calculated from literature meta-analysis (see below): 0.342 tC ha^{-1} yr^{-1})
$C_{L,m_2,ijk}$	Carbon in dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_2; t C (from literature meta-analysis (average of intact and 50 year restored areas): 17.67 tC ha^{-1})
$C_{L,m_1,ijk}$	Carbon in dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_1; t (from literature meta-analysis (average of degraded sites near project area): 0.55 tC ha^{-1})
T_L	Time interval between m_2 and m_1; yr (50 years)
CF_L	Carbon fraction of litter; dimensionless (IPCC default: 0.370)
$C_{meta,ijk,m}$	Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m calculated from meta-analysis; tC ha^{-1}

The default value for the annual change in litter was estimated from field measurements detailed in the literature meta-analysis (). The total change in mean litter carbon between degraded (0.55 tC ha^{-1}) and restored/intact sample sites (17.67 tC ha^{-1}) near to the project area was divided by the time of establishment (50 years) in order to estimate the mean annual increment in litter. This value (342 kg C ha^{-1} yr^{-1}) was used throughout the ex ante calculations to calculate the total projected litter accumulation for the project.

e) Changes in the stocks of soil organic carbon (C_{SOC})

Ex ante SOC changes were assessed empirically through experimental determination and through a literature meta-analysis (see Annex 7 and Annex 14). SOC accumulation is estimated using the following equations from the chosen methodology:

$$\Delta C_{SOC,ijk} = \left[\left(C_{SOC\_For_{ijk}} - C_{SOC\_Non\_For_{ijk}}\right) \cdot A_{ijk}\right] / T_{For,ijk} \quad \textbf{(B.35)}$$

$$C_{SOC\_For_{ijk}} = C_{SOC\_REF_{ijk}} \cdot f_{ijk} \quad \textbf{(B.36)}$$

where:

$\Delta C_{SOC,ijk}$	Average annual carbon stock change in soil organic matter for stratum i sub-stratum j species k; t C yr^{-1}
$C_{SOC\_For_{ijk}}$	SOC stock of afforested/reforested area or forested area that corresponds to the stratum i sub-stratum j species k; t C ha^{-1}
$C_{SOC\_Non\_For_{ijk}}$	SOC stock of non-forested degraded lands that correspond to the stratum i sub-stratum j species k; t C ha^{-1} (Default calculated from literature meta-analysis (average of degraded sites close to project area): 89.74 t C ha^{-1})
A_{ijk}	Area of stratum i sub-stratum j species k; ha
$T_{For,ijk}$	Time period required for transition from $SOC\_Non\_For_{ijk}$ to SOC_For_{ijk}; yr (50 years)
$C_{SOC\_REF_{ijk}}$	Reference SOC stock under the native unmanaged in t C ha^{-1}. '*SOC_REF*' refers to the stable soil organic carbon under native forests. (Default calculated from literature meta-analysis (average of intact and 50 year old restored sites): 136.52 t C ha^{-1})
f_{ijk}	Adjustment factor for the effect of management intensity; dimensionless. The value for adjustment factor is expected to range between 0-1. Since stocking rates are designed to fully restore thicket vegetation, a value of 1 was used.

Further details on the calculation of the default values are available in Annex 7 and Annex 14.

Ex post analysis of SOC changes will also be conducted using the stock change method specified above.

4.3.2 GHG emissions by sources

This quantifies the project emissions resulting from the implementation of the proposed ARR project. The methodology lists likely sources of emissions as: emissions from fossil fuels used in carrying out ARR project activities (site preparation and silvicultural operations); loss of non-tree biomass (not including herbaceous components) in the site preparation; and biomass burn due to natural fires or from management-related activities. The equation for calculation of the GHG emissions as a result of project activities provided in AR-AM0002 (V3) does not, however, include fossil fuels. Hence they are discussed in the leakage section (see 4.3.3 below).

Table 12: Identification and justification of emission sources.

Emission sources	Gas	Included/Excluded	Justification/Explanation
Burning of biomass	CO_2	Included	
	CH_4	Included	
	N_2O	Excluded	Potential emission is negligibly small
Burning of fossil fuels	CO_2	Excluded	Potential emission is negligibly small
	CH_4	Excluded	Potential emission is negligibly

			small
	N_2O	Excluded	Potential emission is negligibly small
Other mechanical fuel use	CO_2	Excluded	Not applicable
	CH_4	Excluded	Not applicable
	N_2O	Excluded	Not applicable
Use of fertilizers	CO_2	Excluded	Not applicable
	CH_4	Excluded	Not applicable
	N_2O	Excluded	Not applicable

The equation for calculation of emissions is:

$$GHG_E = E_{BiomassLoss} + E_{BiomassBurn} \quad \textbf{(B.38)}$$

where:

GHG_E Sum of increases in GHG emissions within the project boundary from the implementation of the proposed ARR project activity; t CO_2e

$E_{BiomassLoss}$ Increase in GHG emissions from the loss of biomass in the site preparation within the project boundary; t CO_2e

$E_{BiomassBurn}$ Increase in GHG emissions from biomass burning within the project boundary; t CO_2e yr^{-1}

a) Emissions from the decline in the carbon stock of non-tree vegetation

The area affected by site preparation for the project is minimal since the *P. afra* cuttings are planted vertically by means of an auger. The hole itself is no more than 8 cm in diameter, but a conservative 20 cm x 20 cm area is used for calculation of the affected area. Calculations of the carbon stock of non-tree biomass affected are carried out using the equation below:

$$E_{BiomassLoss,t} = \sum_i A_{NT_{BiomassLass},i} \cdot B_{AB\_NTree,i} \cdot CF_{NTree} \cdot \frac{44}{12} \qquad \forall t = 1 \quad \textbf{(B.39)}$$

$$E_{BiomassLoss,t} = 0 \qquad \forall t > 1$$

where:

$E_{BiomassLoss}$ Increase in GHG emissions from the loss of biomass in the site preparation within the project boundary; t CO_2e

$A_{NT\_BiomassLass,i}$ Area of stratum i; ha

$B_{AB\_Ntree,i}$ Average biomass stock of non-tree vegetation on land to be planted before the start of a proposed ARR project activities for stratum *i*; t d m ha^{-1}

CF_{NTree} Carbon fraction of dry biomass; t C $(t\ d\ m)^{-1}$

$44/12$ Ratio of molecular weights of CO_2 and carbon; dimensionless

t Time; yr

b) Emissions from biomass burning

Ex ante calculation of fire risk was based on expert opinion estimates of fire susceptibility in the area. It is anticipated that there will be minimal GHG emissions from biomass burning due to *P. afra*'s fire resistance. *P. afra* is naturally highly fire-resistant, because it is a succulent with a very high moisture content, and thereafter the established *P. afra* plants will provide a natural firebreak. *Ex post* monitoring will include fire damage if it occurs, and additional strata will be introduced to deal with potential fire effects.

The equations specified by AR-AM0002 (V3) for calculation of biomass burning emissions were incorrect as printed, and an equation was omitted. These were corrected, and the deviations (detailed as deviations 5 and 6 in Annex 16) are considered to be conservative. The equations used are shown below:

$$E_{BiomassBurn} = E_{BiomassBurn,CO_2} + E_{Non-CO_2\_BiomassBurn}$$ (inserted I.2 see deviation 5 in Annex 16 [A 16.5])

$$E_{BiomassBurn,CO_2} = \sum_{i} C_{AB\_Tree,ijk,t} \cdot F_{Burn} \cdot CE \cdot 44/12$$ (B.40.dev: See deviation 6 in Annex 16 [A 16.6)

$$E_{BiomassBurn,CH_4} = E_{BiomassBurn,CO_2} \cdot GWP_{CH_4} \cdot EF_{CH_4} \cdot 12/44 \cdot 16/12$$ (B.41)

$$E_{Non-CO_2\_BiomassBurn} = E_{BiomassBurn,CH_4}$$ (B.42)

where:

$B_{AB\_Ntree,i}$	Average stock in aboveground biomass for stratum i; t.d.m. ha^{-1}
CF_{NTree}	Carbon fraction of dry biomass; t C $(t.d.m.)^{-1}$
$44/12$	Ratio of molecular weights of CO_2 and carbon; dimensionless
$A_{BiomassBurn,i}$	Area of biomass burn; stratum i; ha yr^{-1}
$B_{AB\_NTree,i}$	Average stock in above ground biomass for stratum i prior to burn; t.d.m. ha^{-1}
CE	Combustion efficiency; dimensionless (IPCC default = 0.5)

N_2O emissions from burning are excluded, since potential emissions are negligible.

4.3.3 Estimation of leakage

The project areas consist of severely degraded lands which support low living biomass, and the land use is unchanged. Consequently, the land should continue to provide the same services, and there is no anticipated leakage as a result of project activities.

$$LK_t = 0$$ (B.44)

where:

LK_t	CO_2 emissions from leakage in t CO_2e yr^{-1}

Under the chosen methodology, all fuel emissions for the proposed ARR project are deemed to be negligible, and can be discounted[29].

4.4 Quantifying GHG emission reductions and removal enhancements for the GHG project:

The actual net GHG removals by sinks are calculated using the following equation:

$$\Delta C_{ACTUAL} = \sum_{i=1}\sum_{j=1}\sum_{k=1}[\Delta C_{ijk} - GHG_E]$$ (B.43)

[29] The methodology applied to the proposed ARR project, AR-AM0002 (V3), stipulates that the CO_2 generated through transport use during project activity is deemed negligible in comparison to the CO_2e sequestered.

The plant weight and total carbon mass of each plant will increase in time, peaking after approximately 50 years. The growth curve for *P. afra* was estimated using a standard sigmoid growth function, as described in Mills *et al.* (2007). The end point of the growth curve was determined by the literature meta-analysis, averaging peak values for above-ground *P. afra* carbon concentration in intact and restored thicket in areas close to the project area. The curve is shown below, and the calculations are available in Annex 14.

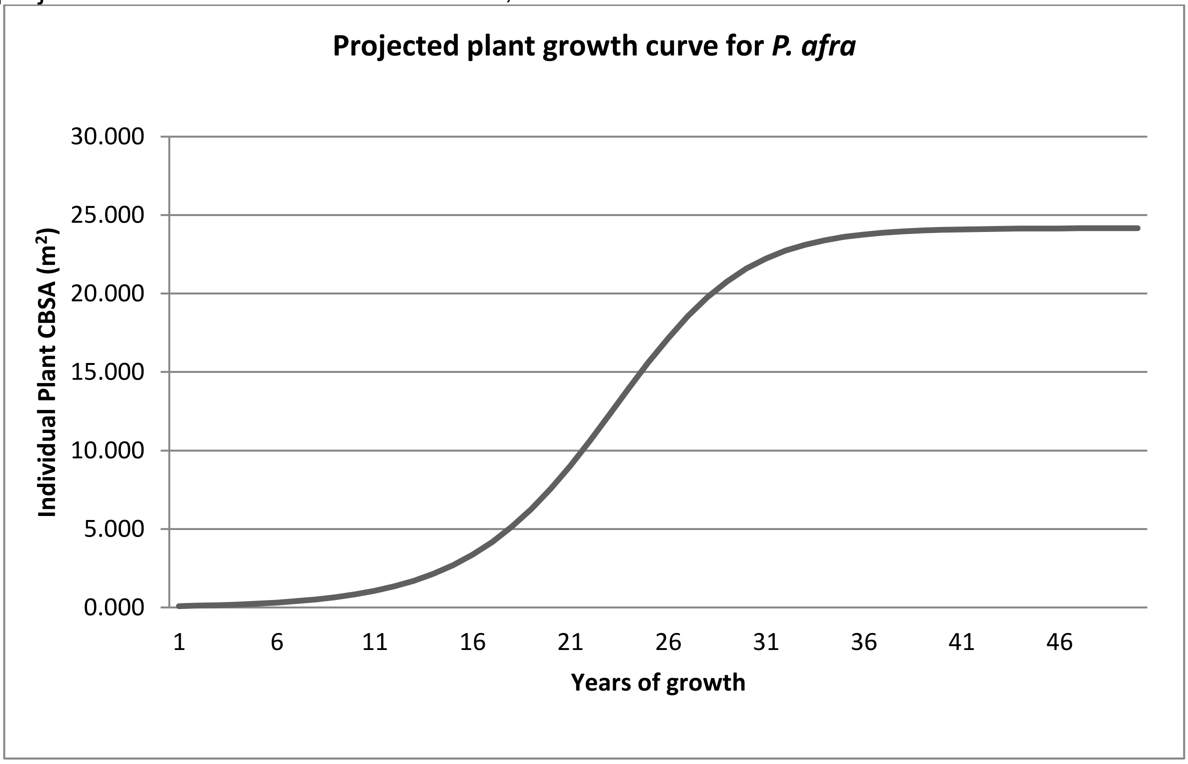

Figure 6: Curve used to estimate growth of *P. afra* (per plant).

Allometric equation for calculating carbon sequestration in *P. afra* plants:

$$\log y = 1.1043(\log CBSA) + 2.4464$$ (Powell, 2009) (AL.1)

where:

y	Above ground dry plant carbon; kg C
$CBSA$	Combined basal stem area; m^2

Carbon is expected to accumulate within the restored land for a period of 50 years after planting. The rate of accumulation will likely differ from one project area to the next, according to the environmental conditions of each area. However, since there is only one project area at present, the calculations did not account for variation in environmental characteristics between sites, and merely examined the sub-stratification criteria of the planting year. The rate of accumulation for each planted hectare is displayed in Figure 8 below.

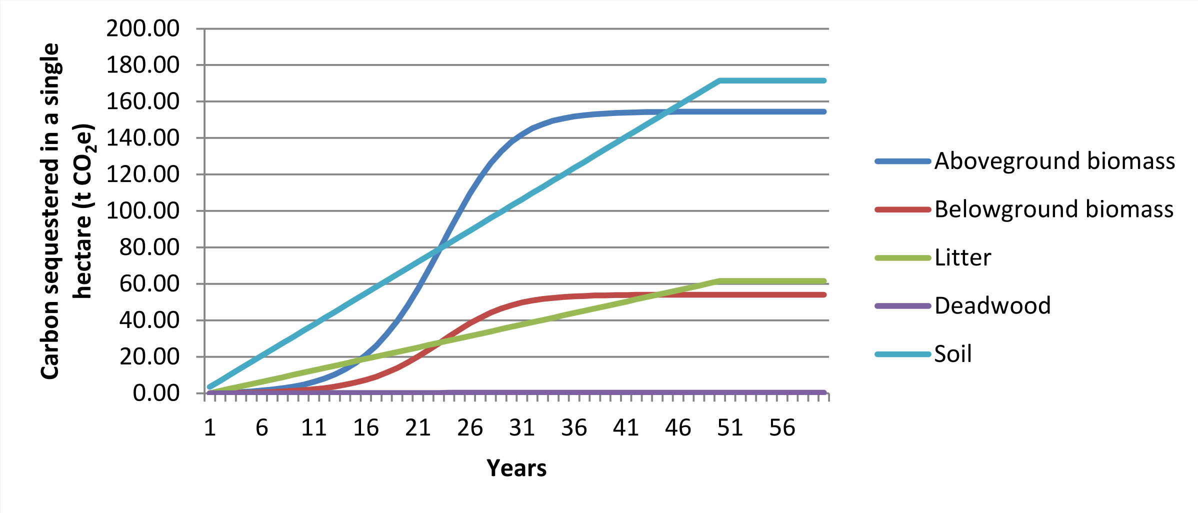

Figure 7: Carbon mass accumulation per hectare over a 60 year period (calculated using the ex ante equations specified in AR-AMS0002 V3 using the Excel spreadsheet appended in Annex 14).

4.4.1 Net anthropogenic greenhouse gas removals by sinks

Anthropogenic GHG removals are calculated as follows:

$$C_{AR-CDM} = \Delta C_{ACTUAL} - \Delta C_{BSL} - LK_t \quad \textbf{(B.45)}$$

where:

C_{AR-CDM}	Net anthropogenic GHG removals by sinks in t CO_2e yr^{-1}
ΔC_{ACTUAL}	Actual net GHG removals by sinks in t CO_2e yr^{-1}
ΔC_{BSL}	Baseline net GHG removals by sinks in t CO_2e yr^{-1}
LK_t	CO_2 emissions from leakage in t CO_2e yr^{-1}

The rate of carbon sequestration is estimated to be 10.33 t CO_2e ha^{-1} yr^{-1} for 50 years after planting. This is based on rates of carbon sequestration indicated from a review of seven peer-reviewed papers and theses (see Annex 7), and the methodology-specified equations.

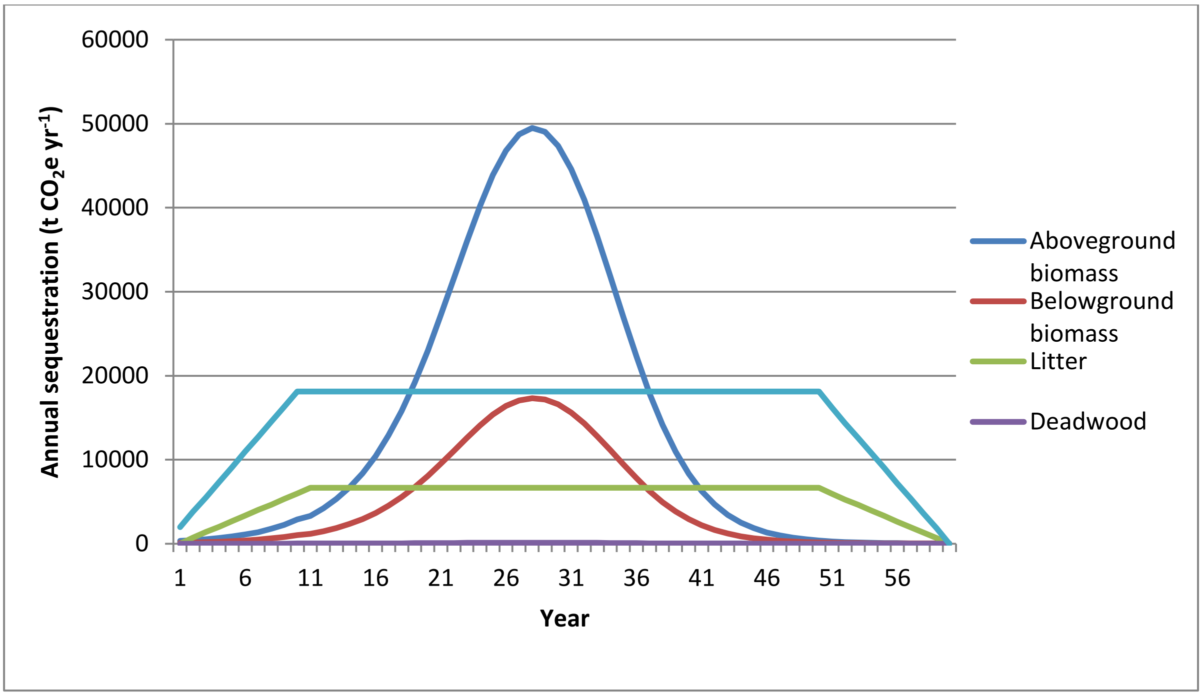

Figure 8: Calculated annual carbon sequestration for each carbon pool in the entire project area over the project duration.

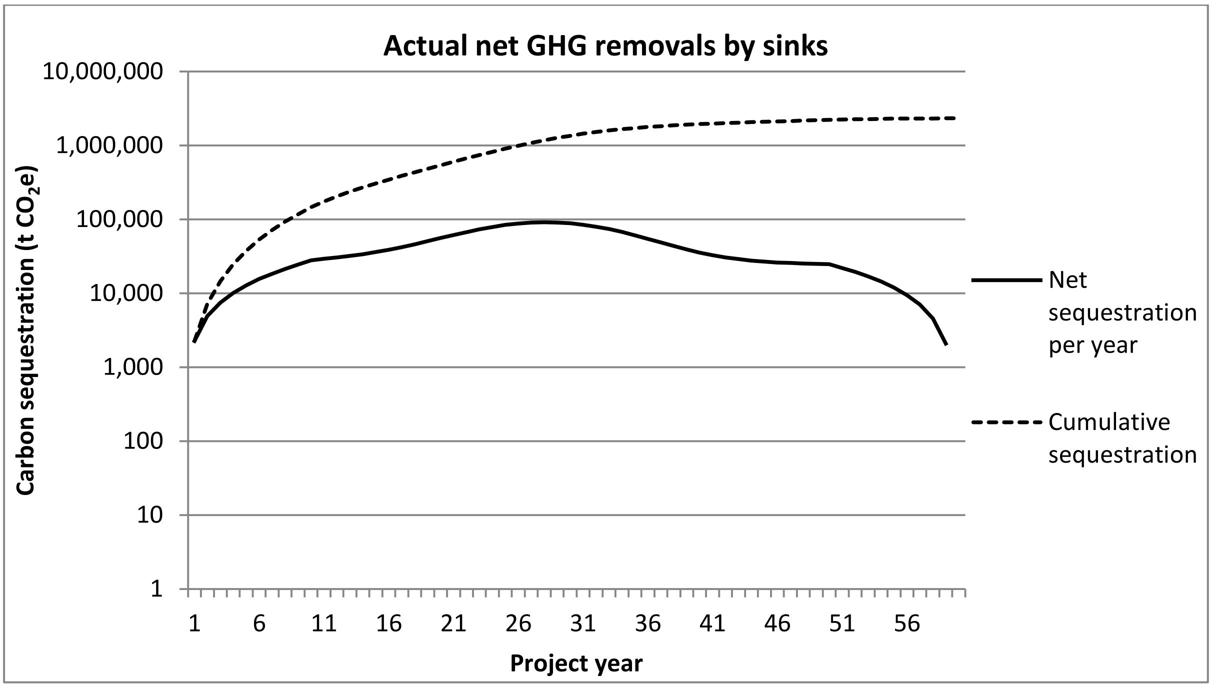

Figure 9: Total cumulative carbon sequestration and net annual sequestration for the project

The total carbon sequestration potential per unit land area is 516 t CO_2e ha^{-1}, as estimated from the literature review (Annex 7). The total carbon sequestration potential for the entire project (5,285 ha) over a 60 year period is calculated using the methodological equations to be 2.28 million t CO_2e (see Table 12). All calculations for this estimate were carried out using the equations from AR-AM0002 (V3), and were performed in Excel). The spreadsheet is attached as Annex 14, and interim calculation tables are available in the spreadsheet.

Table 13: Estimation of net anthropogenic GHG removals by sinks (t CO_2e).

Year	Estimation of baseline net GHG removals by sinks (t CO_2e)	Annual estimation of net anthropogenic GHG removals by sinks (t CO_2e)	GHG emissions from fossil fuel consumption on site	Estimation of leakage (t CO_2e)	Estimation of net anthropogenic GHG removals by sinks (t CO_2e)
Year 5	18,452	37,539	0	0	19,087
Year 10	12,229	107,766	0	0	95,537
Year 15	4,446	161,440	0	0	156,994
Year 20	1,062	233,492	0	0	232,429
Year 25	216	365,012	0	0	364,796
Year 30	42	449,083	0	0	449,040
Year 35	8	366,622	0	0	366,613
Year 40	2	221,303	0	0	221,302
Year 45	0	146,915	0	0	146,915
Year 50	0	126,839	0	0	126,839
Year 55	0	84,753	0	0	84,753
Year 60	0	22,609	0	0	22,609
Total (t CO_2e)	0	2,323,372	0	0	2,286,914

5 Environmental Impact:

The proposed ARR project will not cause any significant negative environmental impact. According to Sections 24 and 24D of the NEMA, 1998 (Act No. 107 of 1998), neither an EIA nor Basic Assessment is required as the project activities do not trigger any of the Environmental Impact Regulation listed activities published in Government Notice No. R 385 of 2006 (No. R. 386 and 387, 21 April 2006 including amendments 3 July and 9 October 2009).

Additionally, the project has received an EIA waiver from the Eastern Cape Provincial DEDEA (Annex 5, Figure A .6.6). The project operations are the same in all areas, and have clear environmental benefits. This waiver is indicative of legislative approval of the operations.
Environmental benefits of the proposed ARR project include:

- **Reduced silt loads in dams and rivers**. Soil erosion will be reduced through the planting of *P. afra* cuttings.
- **Improved aesthetics**. The restoration of thicket will improve the aesthetic beauty of the ARR project areas.
- **Improved habitat for browsing herbivores**. Browsing herbivores will likely return to the ARR project areas following successful afforestation.
- **Improved biodiversity in terms of indigenous shrubs and trees**. Shrub and tree diversity will increase as a result of the planting of *P. afra* cuttings, as their canopy reduces soil temperatures, improves soil quality through the addition of leaf litter, reduces the incidence of frost at ground level and is likely to reduce runoff of rainwater. All of these effects will improve the microclimate and soil conditions for natural recruitment of indigenous shrubs and trees.
- **Greater ecosystem productivity**. The improved biodiversity will also result in an increase in ecosystem productivity.

Information regarding the ecology of degradation and restoration of thicket, including the benefits associated with restoration of thicket, has been published in the following scientific papers:

Hoffman, M.T., and R.M. Cowling. 1990. Desertification in the lower Sundays River Valley, South Africa. *Journal of Arid Environments* 19:105-117.

Mills, A.J. & Fey, M.V. 2004. Soil carbon and nitrogen in five contrasting biomes of South Africa. *South African Journal of Plant and Soil* 21:94-103.

Mills, A.J. & Fey, M.V. 2004. Transformation of thicket to savanna reduces soil quality in the Eastern Cape, South Africa. *Plant and Soil* 265:153-163.

Lechmere-Oertel R.G., Kerley G.I.H. and Cowling R.M. 2005a. Patterns and implications of transformation in semi-arid succulent thicket, South Africa. *Journal of Arid Environments* 62, 459–474.

Lechmere-Oertel R.G., Kerley G.I.H. and Cowling R.M. 2005b. Landscape dysfunction and reduced spatial heterogeneity in soil resources and fertility in semi-arid succulent thicket, South Africa. *Austral Ecology* 30, 615–624.

Mills, A.J., Cowling, R.M., Fey, M.V., Kerley G.I.H., Donaldson J.S., Lechmere-Oertel, R.G., Sigwela, A.M., Skowno, A.L. & Rundel, P. 2005. Effects of goat pastoralism on ecosystem carbon storage in semi-arid thicket, Eastern Cape, South Africa. *Austral Ecology* 30:797-804.

Mills, A.J., O'Connor, T.G., Donaldson J.S., Fey, M.V., Skowno, A.L., Sigwela, A.M., Lechmere-Oertel, R.G. Bosenberg, J.D. 2005. Ecosystem carbon storage under different land uses in three semi-arid shrublands and a mesic grassland in South Africa. *South African Journal of Plant and Soil* 22:183-190.

Mills, A.J., & Cowling, R.M. 2006. Rate of carbon sequestration at two thicket restoration sites in the Eastern Cape, South Africa. *Restoration Ecology* 14:38-49.

Additional information regarding the positive environmental benefits of thicket restoration with *P. afra* are published in the MSc theses of Mike Powell (Powell, 2009) and Marius van (van der Vyver, 2011). The proposed ARR project will improve the biodiversity status/ecosystem functioning of the land, thereby meeting national obligations within the Conventions of Biodiversity and Desertification[30]. Furthermore, the Southern African Millennium Ecosystem Assessment Report (Biggs et al., 2004) highlighted environmental degradation, including soil erosion, watercourse destruction and biodiversity loss, as a confounding influence on the regions' ability to achieve the Millennium Development Goals (MDGs). The proposed ARR project will thus also contribute to addressing environmental degradation within the project areas, thereby assisting in the achievement of the MDGs.

[30] South Africa is a signatory to both the United Nations Convention to Combat Desertification and the United Nations Convention for the Protection of Biodiversity; but to date progress in accordance with these two programmes has been limited.

6 Stakeholders' comments:

6.1 Brief description of how comments by local stakeholders have been invited and compiled:

Extensive stakeholder consultation was followed for the Baviaanskloof Nature Reserve, the first project area. Stakeholder engagement will be conducted for the Addo Elephant National Park and GFRNR sites should the VER funding be obtained. The following stakeholders were identified and consulted: the local Farmers Associations, neighbouring local communities, ARR project workers, the local municipality, the Baviaanskloof Steering Committee and the Thicket Forum (an annual gathering of scientists and managers working in the Subtropical Thicket Biome). The project information was presented to stakeholders through workshops, PowerPoint presentations and meetings. The following outlines the stakeholder interactions, their comments and the project developers' responses to their comments.

18th October 2006: Dr Christo Marais (Operations Manager, Working for Water[31]) introduced the topic of carbon trading through restoration of subtropical thicket at a meeting of the Farmers Association members in the town of Patensie. The PowerPoint presentation titled "Carbon trading and subtropical thicket restoration" included the following: i) background information on climate change and carbon trading; ii) the status of subtropical thicket degradation in the Eastern Cape as well as changes over time in the Patensie (Gamtoos) valley; iii) the potential of *P. afra* to drive the ARR project in the Baviaanskloof; iv) preliminary results and major challenges; and v) the steps ahead.

11th June 2007: Yolande Vermaak (Project Officer, GIB) and Mike Powell (Rhodes University (RU) and Subtropical Thicket Restoration Programme coordinator) held a meeting for the ARR project workers to inform them about the Subtropical Thicket Restoration Project's goals and objectives and to ascertain whether the workers supported the project. Mr Powell provided an overview of the purpose of the meeting followed by a thorough description of the project. This description included the following: i) why the project needs to be undertaken; ii) the drivers behind climate change; iii) the Kyoto Protocol; iv) reducing CO_2 emissions through reforestation; and v) the guidelines which the ARR projects needs to follow. Mr Powell and Ms. Vermaak held the meeting in both English and Afrikaans to facilitate understanding between the workers.

16th - 20th July 2007: Mr Mike Powell presented the proposed ARR project for the Baviaanskloof Nature Reserve at the Thicket Forum. The Thicket Forum is an affiliation of stakeholders which includes, amongst others, research and management institutions, landowners, and private enterprises. The forum aims to facilitate the sharing of lessons regarding research, management and education within the Subtropical Thicket Biome (which includes the Addo Elephant National Park and GFRNR), and the formulation of priority actions within these disciplines to promote the conservation of landscapes and the enhancement of livelihoods in the Subtropical Thicket Biome.

8th October 2007: A meeting was held with local (indirect) stakeholders on land belonging to Chris Lamprecht, who is the Chairman of the Baviaanskloof Farmers Union in the western Baviaanskloof. The stakeholder group consisted of farmers and landowners with property adjacent to the project area (and enclosed within the greater Baviaanskloof Nature Reserve). Pieter Kruger and Dieter Van den Broeck (from PRESENCE - a network of scientists) personally invited attendees to the meeting. The meeting consisted of two presentations.

[31] Working for Water and Working for Woodlands are part of the same group of programmes organised and run by government.

Firstly, Mr Mike Powell explained the rationale and drivers for the project across the different scales. This included: i) the global outlook (climate change, Kyoto Protocol, CDM, carbon sequestration); ii) national drivers (South Africa as a signatory to Convention on Biological Diversity and Desertification, MDGs and poverty alleviation strategies); and iii) local relevance (the implications of large-scale land degradation and the potential for farmers to engage in ARR activities). Mr Mike Powell outlined the ARR project activities in the Baviaanskloof Nature Reserve specifically related to ongoing experimental activities, parties involved, results to date and the relevance for landowners adjacent to the project. The benefits of ARR and thicket restoration were discussed as well as current risks and uncertainties (including those of the carbon market). A discussion followed after the presentation.

The second presentation was given by Emmanuelle Noirtin, a M.Sc. student from Wageningen University (WUR), the Netherlands. Miss Noirtin, representing a group of four WUR students, outlined their research (focused on the Baviaanskloof Nature Reserve) on eliciting stakeholder perceptions of the socio-economic importance of the Subtropical Thicket Biome and stakeholder willingness to engage in restoration. During the meeting, an A5 information leaflet about the students' research and its relevance to subtropical thicket restoration was distributed.

October – November 2007: In line with the student presentation above, farmers and communities in the western Baviaanskloof (adjacent to project area in the reserve) received a number of informal visits from the four WUR students as part of their socio-economic and stakeholder assessments. During this field research period, considerable awareness was generated about the proposed ARR project as well as feedback from stakeholders regarding its perceived potential and ability to deliver benefits to farmers and communities.

11th - 13th November 2007: A workshop was held at Zandvlakte in the western Baviaanskloof. Scientists (from RU, Nelson Mandela Metropolitan University (NMMU), University of Pretoria (UP), Stellenbosch University, WUR, Council for Scientific & Industrial Research (CSIR)), implementers (from ECPTA and GIB), Government (DWA), NGOs (from WWF-SA, EarthCollective), private consultants and students attended the event. The aim of the workshop was to identify key scientific questions and knowledge gaps related to restoration implementation. A significant amount of time during the workshop was devoted to discussing the broader implications of ARR. The pilot Baviaanskloof Thicket Restoration Project was the primary example used to gain expert input and generate discussion on approaches currently being adopted. Related presentations were given by Dr Anthony Mills and Mr Mike Powell.

17th November 2007: Yolande Vermaak (Project Officer, GIB) and Dieter Van den Broeck orally presented progress of the proposed ARR project at the quarterly western Baviaanskloof Farmer's Union meeting (held on the farm of Johan Lamprecht). Project background was presented along with the following: i) relevance to landowners; ii) carbon stocks in thicket; iii) benefits to farmer's engaging in restoration; iv) how the ARR works; v) how farmers can enter the carbon market; vi) related income opportunities; and vii) barriers to be overcome. The major objective of the presentation was to assist these farmers – as indirect stakeholders – in becoming familiar with the concept of ARR and to gain a better understanding of the proposed ARR project in the adjacent nature reserve and how they would benefit from VCS or CDM approval in the future.

29th November 2007: Mr Mike Powell delivered an oral presentation to the Sewefontein community about proposed ARR activities in the Baviaanskloof Nature Reserve. The members of both of the local communities in western Baviaanskloof (Sewefontein and

Zaaimanshoek) were personally invited by both the community leaders and the WUR students who were active in these communities with their field research. Mr Powell discussed the current status of the ARR project, relevance to these communities and potential benefits, opportunities and challenges.

5th December 2007: Matthew Zylstra delivered a brief presentation to the Baviaanskloof Steering Committee Meeting covering major outcomes of the workshop held 11-13th November, 2007. This included an update of the proposed ARR project and, with student co-presenter Ignacio de la Flor, provided an overview of the preliminary outcomes of the related socio-economic research undertaken with farmers and communities in the western Baviaanskloof.

29th January 2008: Project facilitators from the proposed ARR project and related Subtropical Thicket Restoration Programme submitted a 'Motivation Document' outlining project objectives and activities to the Baviaanskloof Municipality to seek the Steering Committees institutional support for its inclusion within the Integrated Development Planning (IDP).

19th February 2008: Dieter Van den Broeck gave a presentation to the Farmers Association in the town of Patensie. The presentation outlined the activities and opportunities related to the proposed ARR project in the Baviaanskloof.

21st February 2008: Dieter Van den Broeck (Project Manager, PRESENCE) and Matthew Zylstra (Project Facilitator, PRESENCE) met with Wayne Erlank (Regional Manager, ECPTA) to report on the proposed ARR project application progress, elicit feedback and clarify any questions which may have arisen during recent months.

8th March 2008: Matthew Zylstra reported back on activities and progress to the Baviaanskloof Farmer's Union. The role of PRESENCE and the roles of various collaborating organisations feeding into PRESENCE were discussed in relation to how to make landscape restoration an on-ground reality for landowners and communities. Various avenues and opportunities for incentives were briefly discussed, such as payments for water services and carbon credits.

Summary of the comments received:
In general, no direct comments towards proposed ARR activities in the Baviaanskloof Nature Reserve were expressed. Comments predominantly relate to implications of possible future ARR roll-out to adjacent areas and not specifically to the proposed ARR activities.
The landowners of surrounding farms and the workers directly involved gave their support to the proposed ARR project (see Annex 5, Figure A. 5.8: Indication of support for the A/R project from the GIB contract workers.).

However, to ensure a thorough and transparent stakeholder process, the following section lists general comments and feedback elicited during the abovementioned stakeholder interaction sessions.

11th June 2007: As per Annex 5, approval of the project was given. The workers confirmed that they supported the proposed ARR project and only had questions related to logistical issues. These included:
Cedric (Project Contractor, from Zaaimanshoek community) had a problem with the carrying out of the *P. afra* cuttings;
Loretta enquired as to why they cannot fence off the area where they have planted in order to prevent baboons from causing damage to replanted areas.

16th - 20th July 2007: No comments were recorded due to the nature of the event.

8th October 2007: During the meeting, farmer Boetie Terablanche expressed his scepticism towards research projects which "come and go" in the Baviaanskloof without initial project plans ever leaving the ground. Mr Terablanche questioned whether this proposed ARR project would follow the same trajectory after the pilot phase in the Baviaanskloof Nature Reserve was completed.

October – November 2007: During the period October – November 2007, students from WUR informally contacted stakeholders in the western Baviaanskloof adjacent to the Baviaanskloof Nature Reserve and proposed ARR project area. Relevant feedback from the consultation is catalogued as follows:

Community:
Denna (inhabitant and trust member of Sewefontein community) recalled the story of when an alien cactus of Mexican origin (*Opuntia ficus – indica (L.))* was declared as an invasive weed in Baviaanskloof 30-40 years ago. Without consulting the local people, the Government of South Africa decided to eradicate the cactus by releasing a moth in Baviaanskloof Nature Reserve, which killed the cactus. As the local people ate the edible fruits of the cactus and used them as animal fodder and as a sugar source, they were unhappy with the decision to remove the cactus from their surrounds. Denna asked whether such a situation could occur with the proposed ARR project. By planting *P. afra* on a large scale, Denna questioned whether in effect one would create the same situation as when the cactus was everywhere. And if not, Denna wondered why the Government chose to remove the cactus all those years ago.

Other general comments from communities that were recounted during consultation:

- "The proposed ARR project looks promising because it is seen to bring jobs to the communities".
- "The proposed ARR project will serve to improve biodiversity in the area as many plants are currently dying and the area is becoming less green".

Workers:
Cedric (Project Contractor, from Zaaimanshoek community) said that he enjoyed his job in the pilot project (of the proposed ARR project) because it offered him the opportunity to work in nature. He thought it helped them (the workers) to better appreciate nature. Cedric believed that the proposed ARR project would improve air quality and was also important so that "nature is there for my children". He added that although it was challenging work planting the trees every day, it was for a good purpose. Cedric also felt that the proposed ARR project was a good project because it improved job creation.

Abigail (former Project Contractor, from Zaaimanshoek community) said that her work with the pilot project had given her the opportunity to learn about nature, whereby she had become more interested in visiting the natural sites in the Baviaanskloof Nature Reserve. Abigail added that she had become more aware of the beauty of the flora and fauna in the Reserve as a result of her involvement in the pilot project. Abigail reported that she had previous frustrations with the salary contract conditions whereby payment of salaries was 30 days in arrears after completion of work.

George commented that he felt that the planting of *P. afra* was good but wondered whether there was a need to plant other vegetation in the area.

Jan Magleties (church leader, Zaaimanshoek community) said that the proposed ARR project was a good project because it created jobs and kept people busy and away from crime.

Farmers: (living adjacent to the Baviaanskloof Nature Reserve)
Boetie Terablanche and his wife expressed both interest in and criticism of the proposed ARR project (should future phased implementation extend to their lands). They queried as to why so much research had been undertaken regarding *P. afra* because *P. afra* does not always grow everywhere (e.g. not in the flat areas of the valley) and, in their view, other thicket species seemed to have been ignored. Mr Terreblanche also wondered how the broader proposed ARR project would manage to plant large areas of land with all the *P. afra* – in terms of where labourers could be sourced from, how they would be paid and how seasonal work could be utilized to get a lot of work done within a short period of time. Mr Terablanche mentioned that, if the proposed ARR project were offered on his land, even though he would be prepared to take all the livestock off his land if needed, he would not be prepared to wait 20 years to see project results; the activities would need to be something that improved his livelihood.

Thys Cilliers expressed a willingness to engage in proposed ARR activities should the proposed project in the Baviaanskloof Nature Reserve be approved and a similar project offered for implementation on his property. Mr Cilliers also showed some scepticism about carbon sequestration; mainly because, on a larger scale, he felt that institutional capacity and willingness was lacking. Mr Cilliers was also concerned about the fact that research tended to be forgotten and nobody implemented the research results. According to Mr Cilliers, carbon sequestration had already been discussed for the last ten years but to date not a single project had been implemented. Mr Cilliers recommended and endorsed the idea of developing a pilot carbon sequestration project to persuade everybody and give evidence that the mechanism could actually work.

Pieter Kruger noted that there are currently no incentives for restoration and, as a result, farmers were reluctant as they did not see economical benefits from ARR activities and they needed income assurance. He added that when approved, the proposed ARR project had the potential to provide this assurance to landowners.

Quintis Bezuidenhout commented that the larger vision of the proposed ARR project appeared to be viable over the long-term and an excellent idea which had the potential to help companies reduce emissions.

An additional question which arose across various stakeholder groups was what mechanisms were available to reward farmers who had managed their land and conserved original vegetation types (i.e. avoided deforestation)? The potential of REDD activities to address this issue will be examined.

17th November 2007: Farmer Boetie Terablanche raised the question as to whether the costs invested in terms of time, research and project set-up would be recouped with accreditation gains. Mr Terablanche suggested that money invested in researching carbon credits and restoration could be better given to farmers to begin conserving their lands immediately.

Farmer Thys Cilliers expressed his opinion about carbon sequestration. According to Mr Cilliers, proposed activities are taking too long to be implemented and he was anxious about seeing and receiving results in several years.

29th November 2007: Given the historical realities of the area, many communities were wary of projects which seemed to promise much but ended up delivering little. Community members had seen such instances on numerous occasions during the recent past. In this regard, one attendee in particular stressed the need to be aware of past realities and that all proposed activities should be done in cooperation with the local communities. During the meeting held for all community members resident in the western Baviaanskloof (living outside the Baviaanskloof Nature Reserve), the following points were raised by attendees:

- the possibilities for workers involved in the project to obtain some kind of training course with a certification;
- the length of time before community members received money related to the proposed ARR project;
- the way in which the ARR system worked: who paid and how benefits were provided;
- the decision-making process within Zaaimanshoek; in contrast to farmers/ landowners, all decisions made by Zaaimanshoek community members needed to go through the church, as the community lived on church land, and deciding by oneself would not always be appropriate;
- the situation which would arise if one community was given preference over another, resulting in neighbouring community members trying to move to another community to benefit from the newly generated employment from the proposed ARR project; and
- the promising potential of the proposed ARR project to provide new income and employment opportunities in the area over the short to mid-term timeframes.

5th December 2007: Stakeholders sitting on the Baviaanskloof Steering Committee indicated that they were familiar with the proposed ARR project. No further comments were received.

1st February 2008: The Baviaanskloof Municipality responded with positive confirmation that pilot projects related to the proposed ARR project had received support from the municipal IDP Steering Committee and were slated for inclusion within the revised IDP.

19th February 2008: No comments were received during the meeting. Merwe de Preez (Board of Directors, Patensie Farmer's Association) and Pierre Joubert (Director, GIB) provided additional points of clarification to stakeholders present. Numerous farmers contacted project facilitators informally after the date and expressed interest in being kept informed about future experimental trials of the proposed ARR project.

8th March 2008: No major comments were made in relation to *P. afra* or the proposed ARR project consultation. Comments centred more on the motives for restoring water systems in the valley. Links were made to thicket restoration and a more integrated/combined 'labelling' for restoration activities for land-owners.

6.2 Report on how due account was taken of any comments received:

Indirect stakeholders residing adjacent to the project:

The majority of comments and feedback fielded during indirect stakeholder consultation related to future scenarios of the proposed ARR project should it be VCS approved and be in a position to be trialled on adjacent lands. In many cases, the project team did not yet have information available to speculate on those scenarios. In all such cases, project facilitators maintained openness and honesty in saying that they were unable to promise anything in the early phases but would duly record all concerns and investigate them accordingly.

October – November 2007: In response to scepticism about the proposed ARR project being another "here one day, gone the next" scenario, it was emphasized that the intention is to establish the proposed ARR project on a large-scale over the long-term. The project aims to benefit both farmers and communities and everything will be done to ensure that the scenario eventuates. However, the success of the project moving forward rests largely, if not almost entirely, on the approval of the proposed ARR project in the Baviaanskloof Nature Reserve.

Whenever possible, answers were given to other concerns raised. For example, with concerns related to planting only *P. afra*, it was emphasized that *P. afra* should be seen as the financial entity– the catalyst – for reforestation which could then allow for the return of a host of other native species to the reforested area over time. It was explained that the proposed ARR project was open to receiving anecdotal evidence from stakeholders in terms of their own experiences with growing *P. afra*.

17th November 2007: In relation to concerns raised by farmers regarding the amount of research money being allocated for research and proposed ARR project accreditation, the project team agreed that whilst it was not the ideal situation, significant research was required to find out "what works and what does not" and what is needed to be done to certify the process and fill knowledge gaps. It was pointed out that the proposed ARR project is the driver to restore lands and it is therefore essential to determine whether *P. afra* reforestation can work so that money can be spent efficiently into the future. It was also stressed that the current financing for ARR is money earmarked for research, and the conditions of financing is that research funds cannot be used for any other purposes. A comparison was given that carbon farming could be seen like any other farming technique where, initially, industry/sectoral research was needed to determine how to maximize returns and efficiency for (e.g. livestock) farming and related effects and impacts. The project officers openly admitted that whilst the team was working very hard on gaining ARR accreditation, no guaranteed timeframe could be given for financial benefits linked to reforestation and it should be seen as a mid- to long-term investment.

27th November 2007: In relation to questions and discussion raised during the community meeting, Mr Mike Powell listened to concerns and provided clarification. This included explaining how the ARR process worked, a review of the rationale behind the proposed ARR project, and the ways in which the proposed ARR project could involve the communities. Mr Powell stressed that the proposed ARR project was optional to the community; they have the power to choose whether they want to become involved or not. In addition, it was made clear that the project was dependent on certification (in terms of being able to receive money) and that, should certification be received, the derived benefits must be shared. All other comments and concerns raised were dealt in a fair and open manner between meeting attendees.

8th March 2008: The meeting was a two-way discussion which included sharing of views and opinions.

6.3 Mechanisms for on-going communication

On-going communication will be facilitated through continued presence and presentations at the Annual Thicket Forum. Continual communication and meetings will be held with labourers, workers and relevant Baviaanskloof Nature Reserve staff.

A monitoring plan will be developed to monitor the continued well-being of workers on the project. A survey will be conducted annually by GIB and every labourer working for GIB's contractors will be interviewed. The survey will include questions designed to detect changes in the communities' perception of their well-being as a result of project activities. An initial study has been undertaken to assess the socioeconomic impact of the project[32].

An advisory committee has been established for the current project area and the two proposed project areas. These committees comprise contractors, contract employees and other community stakeholders, and are a forum in which these stakeholders can raise issues. The committees generally meet monthly unless, unless community members are unable to make the meetings. Issues raised at these meetings either through employees, contractors or other representatives are then passed on to the implementing agent. I fhte issues are not readily addressed, a follow-up meeting with other relevant stakeholders is established to ensure that all issues are addressed.

All contractors are required to adhere to the standards applicable for the Extended Public Works Programme, and more specifically the Operational Standards for the Working for Water Programme (WfW, 2007). This includes stringent health and safety requirements, regular training of employees, and completion of a self-assessment questionnaire quarterly. These self assessments are then provided to the implementing agent and the DEA-NRM project, which conduct their own assessments to ensure that all contractors are adhering to the specified regulations.

6.4 Interaction with NGOs and other partner organisations

A number of NGOs have played a role in the development of the project and the current document. All such NGOs have endorsed the project, and are therefore stakeholders in the success of the project. However, these NGO's have no financial interest in the project, and have no claim to the carbon credits generated through project action.

Climate Action Partnership (CAP)

The CAP is an umbrella organisation representing a number of partner organisations, all interested in ensuring action is taken to mitigate and adapt to climate change. CAP, through the DG Murray Foundation, awarded seed funding to the Wilderness Foundation to develop a business case for subtropical thicket restoration in the Eastern Cape. This business case was subsequently published as the booklet "Investing in sustainability: restoring degraded thicket, creating jobs, capturing carbon and earning green credit" (Mills et al., 2010).

It also provided assistance with the development of the initial business plan for restoration of the Baviaanskloof Nature Reserve.

Wilderness Foundation (WF)

The Wilderness Foundation is the lead implementer for the Baviaanskloof Mega-Reserve Project in the Eastern Cape. It was involved in the development of the initial business case for subtropical thicket restoration. In addition, it undertook trial spekboom plantings in the Baviaanskloof Mega-reserve, and funded the establishment of the Subtropical thicket Restoration Programme, which started in 2004. The STRP was then passed over to the government of South Africa and incorporated under the Working for Woodlands (in the Natural Resource Management programmes) and ECRP programmes. The goal of STRP was to become a fully self-sustaining restoration project through the securing of carbon finance.

[32] The socioeconomic report can be downloaded from: http://dl.dropbox.com/u/8458610/Thicket%20project/Validation%20docs/CSS_Socio_Economic_Report_Feb2011.pdf

The pilot plantings were located on land provided by both the ECPTA and WF, to experiment with various planting techniques and determine the most effective strategy for restoration.

Restoration Research Group (R3G)

R3G has been involved in the proposed project since its inception, providing scientific expertise and guidance. The group comprises a number of scientists with expertise in thicket vegetation, restoration, carbon sequestration and ecology. The members of R3G have contributed to the initial business case, and guided the pilot plantings. Latterly, R3G members have been employed by the project to drive the development of the PD. R3G will continue to provide scientific expertise for the monitoring and development of the project.

United Nations Educational, Scientific and Cultural Organization (UNESCO)

UNESCO identified the Cape Floral Kingdom (CFK) as a World Heritage Site in 2004, as a result of the exceptional biodiversity within the region. The Baviaanskloof Nature Reserve is situated at the interface between five biomes including the CFK, and is one of the six CFR World Heritage sites. This prestigious designation was central to the decision to form the Baviaanskloof Mega-Reserve.

Conservation International (CI)

CI has expressed its approval of the proposed project, which is in line with the organisation's mandate. CI in South Africa has had some experience in developing carbon projects,a nd was therefore able to provide valuable advice during the development of the project. This assistance took the form of reviews, document proofing and general methodological advice.

The Subtropical Thicket Ecosystem Project (STEP)

STEP was launched in 2000 with the aim of conducting a thorough conservation planning exercise for the Subtropical Thicket Biome. This was carried out by means of a landscape-level, GIS-based spatial analysis supported by extant data and ground truthing (Lloyd et al., 2002). The maps and plans generated by this project have provided a critical basis for the development of the current project. The STEP project was funded by the Global Environment Facility (GEF), and implemented by the Terrestrial Ecology Research Unit at the NMMU.

Participatory Restoration of Ecosystem Services and Natural Capital in the Eastern Cape (PRESENCE)

PRESENCE is a research project co-funded by Wageningen University and Research Centre and the Department of Water Affairs, with academic collaboration through Rhodes University. A fair amount of research into the biological, social and economic impacts of thicket restoration in the Eastern Cape (amongst other things) has come from this programme, and has contributed to the body of knowledge upon which the ABFRP draws.

7 Schedule:

Start of crediting period: 01/01/2004
Crediting period: 60 years
End of crediting period: 31/12/2064

Table 14: Schedule of activities for the project period. Schedule takes effect from 2011

Project year	Fire monitoring	Initial monitoring	Planting	Community monitoring	Survival monitoring	Inboeting (supplementary planting)	Biodiversity monitoring	Plant biomass (ABG, litter and deadwood) monitoring	Soil carbon monitoring	Verification
1	All sites	A	A	Yes	All	As required	Sites A	Sites A	Sites A	
2	All sites	B	B		All	As required	Sites B	Sites B	Sites B	
3	All sites	C	C		All	As required	Sites C	Sites C	Sites C	
4	All sites	D	D		All	As required	Sites D	Sites D	Sites D	
5	All sites	E	E	Yes	All	As required	Sites A-E	Sites A-E	Sites E	All sites
6	All sites	F	F		All	As required	Sites F	Sites F	Sites F	
7	All sites	G	G		All	As required	Sites G	Sites G	Sites G	
8	All sites	H	H		All	As required	Sites H	Sites H	Sites H	
9	All sites	I	I		All	As required	Sites I	Sites I	Sites I	
10	All sites	J	J	Yes	All	As required	All sites	All sites	Sites J	All sites
11	All sites				All	As required				
12	All sites				All	As required				
13	All sites				All	As required				
15	All sites			Yes	All	All	All sites	All sites	All sites	All sites
20	All sites			Yes	All	All	All sites	All sites		All sites
25	All sites			Yes	All	All	All sites	All sites		All sites

30	All sites	Yes	All	All	All sites	All sites	All sites	All sites
35	All sites	Yes	All	All	All sites	All sites		All sites
40	All sites	Yes	All	All	All sites	All sites		All sites
45	All sites	Yes	All	All	All sites	All sites	All sites	All sites
50	All sites	Yes	All	All	All sites	All sites		All sites
55	All sites	Yes	All	All	All sites	All sites		All sites
60	All sites	Yes	All	All	All sites	All sites	All sites	All sites

Sites (x) refers to all monitoring plots within the specified set year's planting. In general, plots will now undergo initial monitoring until the year in which they will be planted, to ensure that the baseline is reliably captured.

Project planting will be undertaken according to the planting plan (Annex 17). Inclusion of additional project areas will be undertaken as they become available and eligible, and planting plans will be designed for each project area independently.

8 Ownership:

8.1 Proof of Title:

8.1.1 Addo Elephant National Park

Legal title: The land is owned by the Republic of South Africa.

Current land tenure: National Park – Protected Area

Land use: Conservation of the natural ecosystems.

Management: South African National Parks

South African National Parks are the managers of the land for the Addo Elephant National Park site of the proposed ARR project. Please see Annex 5 for a statement from SANParks explaining land ownership, reasons for restoration, benefits to the environment/local community and the necessity for carbon finance.

8.1.2 Baviaanskloof Nature Reserve

Legal title: The land is owned by the Republic of South Africa.

Current land tenure: Provincial Reserve – Protected Area

Land use: Conservation of the natural ecosystems.

Management: Eastern Cape Parks Board

The ECPTA manages the Baviaanskloof Nature Reserve, one site of the proposed ARR project. Please see Annex 5 for a statement from the ECPTA explaining land ownership, reasons for restoration, benefits to the environment/local community and the necessity for carbon finance.

8.1.3 Great Fish River Nature Reserve

Legal title: The land is owned by the Republic of South Africa.

Current land tenure: Provincial Reserve – Protected Area

Land use: Conservation of the natural ecosystems.

Management: Eastern Cape Parks Board

The ECPTA manages the Great Fish River Nature Reserve, one site of the proposed ARR project. Please see Annex 5 for a statement from the ECPTA explaining land ownership, reasons for restoration, benefits to the environment/local community and the necessity for carbon finance.

8.1.4 Ownership of VERs

After validation, a financial entity(e.g. a trust or not-for-profit company) will be formed with the main stakeholders (namely ECPTA, GIB, DWA, SANParks) being trustees or board members. This financial entity will own and trade the VERs generated by the project and will be managed by a management company assigned by the trustees or board members at a market-related rate. The distribution of income to stakeholders will be decided by the trustees or company board. Income will be used to reinvest in thicket restoration and planting of spekboom within the project. It would thus also be channelled back to communities around the reserves through increased employment of local contractors to do the work. (See Section 1.15.1 for more information)

8.2 Projects that reduce GHG emissions from activities that participate in an emissions trading program (if applicable):

Not applicable.

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10 Annexes

Annex 1 Institutional arrangements and contact details for project proponents

A 1.1 Memorandum of Agreement between project proponents

The signed Memorandum of Agreement between all project proponents is attached as a separate document.

A 1.2 Contact details for project proponents

Organization:	Department of Water (National Working for Water Programme)
Street/P.O. Box:	73 Hertzog Boulevard / Private Bag X4390
Building:	
City:	Cape Town
State/Region:	Western Cape
Postfix/ZIP:	8000
Country:	South Africa
Telephone:	+27 21 405 2200
FAX:	+27 21 425 7889
E-Mail:	chris@dwaf.gov.co.za
URL:	www.dwa.gov.za/wfw
Represented by:	Christo Marais (Operations Manager, WfW)
Title:	Dr

Organization:	Eastern Cape Parks Board
Street/P.O. Box:	PO Box 218
Building:	
City:	Patensie
State/Region:	Eastern Cape
Postfix/ZIP:	6335
Country:	South Africa
Telephone:	+27 42 283 0630
FAX:	+27 42 283 0636
E-Mail:	Wayne.Erlank@ecparks.co.za
URL:	www.ecparks.co.za
Represented by:	Wayne Erlank (Regional Manager)
Title:	Mr

Organization:	South African National Parks
Street/ P.O. Box:	P.O. Box 52
Building:	
City:	Addo
State/Region:	
Postfix/ZIP:	6105
Country:	
Telephone:	042-233-8602
FAX:	042-233-8643
E-Mail:	Normanj@sanparks.org

URL:	www.sanparks.org
Represented by:	Norman Johnston (Park Manager)
Title:	Mr

Organization:	Gamtoos Irrigation Board
Street/P.O. Box:	PO Box 237
Building:	
City:	Patensie
State/Region:	Eastern Cape
Postfix/ZIP:	6335
Country:	South Africa
Telephone:	+27 42 283 0329
FAX:	+27 42 283 0382
E-Mail:	
URL:	www.gamtooswater.net
Represented by:	Pierre Joubert
Title:	Mr

Organization:	Gamtoos Irrigation Board
Street/P.O. Box:	75 Warwick Street
Building:	
City:	Newton Park, Port Elizabeth
State/Region:	Eastern Cape
Postfix/ZIP:	
Country:	South Africa
Telephone:	041 365 3384 / 083 484 8086
FAX:	
E-Mail:	pedunes@isat.co.za
URL:	www.gamtooswater.net
Represented by:	Andrew Knipe
Title:	Mr

Organization:	Restoration Research Group
Street/P.O. Box:	Department of Environmental Science, Rhodes University
Building:	Bangor House
City:	Grahamstown
State/Region:	Eastern Cape
Postfix/ZIP:	6140
Country:	South Africa
Telephone:	
FAX:	
E-Mail:	scowling@kingsley.co.za
URL:	www.r3g.co.za
Represented by:	Shirley Pierce
Title:	Dr

Organization:	Conservation Support Services (CSS)
Street/P.O. Box:	61 New Street
Building:	

City:	Grahamstown
State/Region:	Eastern Cape
Postfix/ZIP:	6140
Country:	South Africa
Telephone:	+27 46 6224526
FAX:	+27 46 6224526
E-Mail:	mbekker@cssgis.co.za
URL:	http://www.cssgis.co.za
Represented by:	Martin Bekker
Title:	Mr

Organization:	C4 EcoSolutions
Street/P.O. Box:	9B Mohr Road, Tokai
Building:	
City:	Cape Town
State/Region:	Western Cape
Postfix/ZIP:	7945
Country:	South Africa
Telephone:	+27 21 7151560
FAX:	+27 21 7151560
E-Mail:	info@c4es.co.za
URL:	http://www.c4es.co.za
Represented by:	Anthony Mills
Title:	Dr

Annex 2 Information regarding public funding

Table A.2.1: Funding provided by the Department of Water Affairs (DWA)

Year	Sector	Amount (R)
2005	Research	574,000
	Management	275,882
	Operational	891,118
	Nursery	180,000
	Total	1,921,000
2006	Research	677,000
	Management	726,790
	Operational	1,537,510
	Nursery	1,545,062
	Total	4,486,362
2007	Research	1,030,000
	Management	973,898
	Operational	1,786,932
	Nursery	2,260,000
	Total	6,050,830
2008	Research	2,015,369
	Management	2,054,135
	Operational	1,930,505
	Nursery	1,745,392
	Total	7,745,401
2009	Research	
	Management	
	Operational	
	Nursery	
	Total	7,104,813

Operational budget is the budget for contractors; this includes equipment charge out, transport, wages and 20 % capacity building

Annex 3 Fulfilment of sustainable development criteria

Table A.3.1: Project impacts on and contribution towards the sustainable development criteria of South Africa (as defined by the DNA)

Criteria		Indicator	Project Contribution to Sustainable development
Environmental	Impact on local environmental quality	• Impact of the project on air quality.	• The project will sequester CO_2 by fixing carbon in plant biomass and soil.
		• Impact of the project on water pollution.	• By planting indigenous vegetation (*P. afra*), the project will improve water resource management through improved water quality and reduced erosion and siltation and sedimentation.
		• Impact of the project on the generation or disposal of solid waste.	• No major impact – small waste generation expected from plastic bags carrying plants.
		• Any other positive or negative environmental impacts of the project (such as impacts on noise, safety, visual impacts, or traffic).	• The project will not generate any negative impact on noise, safety or visual impact. Minor traffic increases may result from project worker's commuting to project areas and other stakeholder interest in the project. The project will enhance the visual and aesthetic appeal of the landscape through increased vegetation/land cover.
	Change in usage of natural resources	• Impact of the project on community access to natural resources.	• The project does not impact on community access to natural resources as all the project activities are within the boundary of lands managed by ECPTA or SANParks (protected nature reserves).
		• Impact of the project on the sustainability of use of water, minerals other non renewable natural resources.	• The project will improve water retention in the catchment thus aiding water management.
		• Impact of the project on the efficiency of resource utilisation.	• The project does not have an impact on the sustainability of use of minerals or other non renewable natural resources nor does it impact the efficiency of resources utilization.
			• Increased prevalence of wild resources may occur for local communities living adjacent to the reserve (and they may benefit from cross-boundary flows).

	Impacts on biodiversity and ecosystems	• Changes in local or regional biodiversity arising from the project.	• The project will increase biodiversity status; *P. afra*, as a keystone thicket species, will contribute to: improved soil quality; creating a favourable microclimate and habitat for the re-introduction of other native flora and fauna; nutrient cycling within the ecosystem; and stimulate increased pollination activity from bees/insects.
			• In addition to biodiversity gains, the project will also improve rainfall efficiency, ecosystem functioning and thereby meet national obligations within the Conventions of Biological Diversity and Desertification.
Economic	**Economic impacts**	• Impact of the project on foreign exchange requirements.	• The project will have limited impact on foreign exchange rate requirements.
		• Impact of the project on existing economic activity in the area.	• The proposed ARR activities will contribute to improving economic activity in the area through the creation of skilled and unskilled employment opportunities. The restored areas may also aid the success of nascent community programmes such as bee-keeping.
			• The proposed ARR project should encourage other local stakeholders to also implement the ARR project activities and thereby amplify expected project benefits.
		• Impact of the project on the cost of energy.	• The proposed ARR project will not impact upon the cost of energy.
		• Impact of the project on foreign direct investment.	• The proposed ARR project will not directly impact upon foreign direct investment but may encourage greater foreign investment in ARR projects throughout South Africa's Subtropical Thicket Biome.
	Appropriate technology transfer	• Positive or negative implications for the transfer of technology to South Africa arising from the project.	• The proposed ARR project has neither positive nor negative implications for the transfer of technology to South Africa.
		• Impact of the project on local skills development.	• The project will contribute to skills development of local employees related to carbon accounting.
		• Demonstration and replication potential of the project.	• The proposed ARR project has the potential to be replicated in other areas of the degraded Subtropical Thicket Biome and be used as an example for landowners and investors to develop a financially sustainable land use option.

Social	Alignment with national, provincial and local development priorities	• How the project is aligned with the provincial and national government objectives.	• The proposed ARR activities will contribute to the provincial and national objectives of (rural) poverty alleviation through the provision of jobs, skills transfer, capacity building and provision of micro-business opportunities. The project also aligns with important national commitments such as the National Environmental Management Act and the Biodiversity Act.
		• How the project is aligned with local development objectives.	• The restoration of the Subtropical Thicket Biome directly aids local development through skilled and unskilled employment opportunities. Adjacent to the reserve, the project is likely to stimulate tourism-derived economic opportunities as well as supporting emerging initiatives such as community bee-keeping and medicinal plant collection. It should be noted that no communities have been, or will be, relocated as a result of the proposed ARR project.
		• Impact of the project on the provision of, or access to, basic services to the area.	• The proposed ARR project will not impact on the local provision or access of services as it falls within protected areas.
		• Impact of the project on the relocation of communities if applicable.	• No communities or individuals will be relocated as a consequence of the proposed ARR project.
		• Contribution of the project to any specific sectoral objectives (for example, renewable energy targets).	• On a sectoral level, the proposed restoration activities will contribute to: i) local community employment; ii) the science and education base; iii) regional and national conservation and biodiversity targets; iv) tourism development; v) the aims of restoring critical ecosystem services such as water quality provisioning, soil retention, biodiversity, wildlife habitat and the wilderness appeal of the project areas.
	Social equity and poverty alleviation	• Impact of the project on employment levels? (specify the number of jobs created/lost; the duration of time employed, distribution of employment opportunities, types of employment, categories of employment changes in terms of skills levels and gender and racial equity).	• The proposed ARR activities will create employment of an estimated 300 jobs for local people on a seasonal basis. The employment will be on a contract basis and entails physical labour (planting of cuttings) for the majority of employees. Each team will have 13 labourers with a team leader who is trained to manage the contract, and earmarked to become a business person (carbon entrepreneur). An additional ten labourers will be trained to be field technicians, to be able to sample soils and plants, and enter data. A further 15 labourers will be employed in a nursery operated by DWA. The team composition will follow the National Government guidelines of the poverty relief principles (i.e. those taken up by the Department of Public Enterprises', "Expanded Public Works Programme") under which at least 60% of employees are required to be women and at least 25% of employees are required to be youth.

		• Impact of the project on community social structures.	• Other than the positive impacts described above, there are no foreseen negative impact on community social structures, social heritage and the provision of social amenities to the community as a result of the proposed ARR project. It is likely that these aspects will be enhanced during the course of the project.
		• Impact of the project on social heritage.	"
		• Impact of the project on the provision of social amenities to the community in which the project is situated.	"
		• Contribution of the project to the development of previously underdeveloped areas or specially designated development nodes.	• Future stages of the proposed ARR project are expected to have a positive impact on the development of previously underdeveloped areas or specially designated development nodes in rural areas at various scales.
General	**General project acceptability**	• Are the distribution of project benefits reasonable and fair?	• The project intends to fairly distribute expected benefits from the project between contributing stakeholder groups: reserve managers, project workers and project facilitators and in accordance with Government guidelines. The proposed ARR activities contribute to regional and national economic development.
			•The project conforms to the NEMA principles of sustainable development in that CO_2 emissions will be sequestered whilst there will be no negative impacts on natural resource requirements, the environment or local communities.
			• The project makes a tangible contribution towards the Millennium Development Goals.

Annex 4 GPS co-ordinates for ARR planting sites

Table A.4.1: GPS co-ordinates of bounding boxes for each planting site surveyed in the project areas.

Project Area	Contract Code*	Contract Size (ha)	Corner 1 (most North East)	Corner 2 (most North West)	Corner 3 (most South East)	Corner 4 (most South West)
Baviaanskloof Nature Reserve	92001083	6.2	24.409408, -33.652775	24.412102, -33.652475	24.410339, -33.654244,	24.413076, -33.654352
	92001077	5.9	24.414100, -33.654659,	24.416271, -33.654788,	24.414067, -33.657392	24.416239, -33.657384,
	92001074	5.9	24.413630, -33.654524,	24.417746, -33.654829	24.413437, -33.656754	24.419250, -33.657190
	92001041	7.8	24.404376, -33.665143	24.408190, -33.664312	24.405580, -33.666942,	24.407496, -33.666813
	92001133	3.9	24.380175, -33.671419	24.382091, -33.671055,	24.382160, -33.672833	24.383495, -33.672292
	92001134	4.9	24.379540, -33.666867	24.380941, -33.667417	24.377865, -33.668251	24.379542, -33.669519
	92001037	10.7	24.212589, -33.603307	24.213632, -33.603734	24.207271, -33.606264	24.208577, -33.608445
	92001048	5.4	24.214885, -33.604036	24.216547, -33.604525	24.213548, -33.605794	24.216154, -33.606243,
	92001044	9.5	24.208968, -33.600885	24.210114, -33.600848	24.209673, -33.603721,	24.210754, -33.604045
	92001036	2.3	24.324152, -33.640218	24.345393, -33.646107	24.332073, -33.646929,	24.345908, -33.646962
	92001067	5.0	24.303424, -33.639082	24.307303, -33.640806	24.303383, -33.640161	24.306498, -33.642996
	92001027	4.9	24.246527, -33.607902,	24.247397, -33.607158	24.245757, -33.609234	24.248864, -33.610124,
	92001056	5.4	24.290400, -33.631969,	24.294874, -33.629824	24.293086, -33.632293	24.294704, -33.631690
	92001062	4.4	24.292527, -33.632423	24.294680, -	24.290721, -33.633274	24.293284, -33.634866

			33.631697		
92001053	3.4	24.294748, -33.626031	24.295268, -33.626973	24.293270, -33.628848,	24.294758, -33.629567,
92001018	3.5	24.294609, -33.627500,	24.296157, -33.628080,	24.294963, -33.629609,	24.296937, -33.629383
92001022	3.5	24.266580, -33.624834	24.268415, -33.625777	24.265748, -33.626105	24.267806, -33.626996
92001028	2.8	24.265772, -33.626110	24.267789, -33.626987,	24.265046, -33.627127	24.267226, -33.628133
92001013	2.9	24.261496, -33.612755	24.262257, -33.612085	24.263774, -33.614405	24.264445, -33.613782
92001057	5.3	24.249814, -33.619762	24.251762, -33.619508	24.249091, -33.622380	24.250567, -33.622089
92001065	5.5	24.261811, -33.615895	24.264328, -33.616026	24.262734, -33.618023	24.265139, -33.618032,
92001014	2.8	24.260704, -33.613308	24.261495, -33.612771	24.263012, -33.615059	24.263748, -33.614400,
92001032	14.2	24.252595, -33.615545	24.255284, -33.615289	24.251960, -33.619211	24.256274, -33.619277
92001043	13.8	24.604448, -33.672081	24.608945, -33.669405	24.604672, -33.673624	24.611276, -33.671698
92001045	4.5	24.613874, -33.671675	24.614415, -33.671120	24.616251, -33.673926,	24.617833, -33.672638
92001061	4.4	24.616447, -33.671237	24.619801, -33.671060	24.616355, -33.672203	24.620954, -33.672727
92001005	5.7	24.573192, -33.680300	24.577803, -33.679187	24.572320, -33.681627	24.578148, -33.680735
92001011	4.8	24.578089, -33.680828	24.582218, -33.682288,	24.580877, -33.683709	24.583404, -33.683711,
92001015	4.5	24.580871, -33.683709	24.583408, -33.683726,	24.582168, -33.685528	24.584206, -33.685370
92001026	3.8	24.586216, -33.681103	24.586580, -33.680850	24.586606, -33.685161,	24.588661, -33.684551

Addo Elephant National Park	**0**	6.3	25.237854, -33.132351	25.233352, 33.132351	-	25.237854, -33.135064	25.233352, -33.135064
	1	5.5	25.236789, -33.133610	25.232374, 33.133610	-	25.236789, -33.136158	25.232374, -33.136158
	2	5.6	25.224289, -33.144618	25.220954, 33.144618	-	25.224289, -33.147662	25.220954, -33.147662
	3	5.7	25.212591, -33.181332	25.209949, 33.181332	-	25.212591, -33.184249	25.209949, -33.184249
	4	5.5	25.210223, -33.181793	25.207540, 33.181793	-	25.210223, -33.184617	25.207540, -33.184617
	5	3.3	25.204695, -33.199654	25.201695, 33.199654	-	25.204695, -33.201650	25.201695, -33.201650
	6	5.4	25.202400, -33.202102	25.198509, 33.202102	-	25.202400, -33.204637	25.198509, -33.204637
	7	3.1	25.235663, -33.174899	25.230106, 33.174899	-	25.235663, -33.177665	25.230106, -33.177665
	8	5.9	25.243247, -33.171555	25.240127, 33.171555	-	25.243247, -33.174474	25.240127, -33.174474
	9	2.3	25.235182, -33.175848	25.233077, 33.175848	-	25.235182, -33.178793	25.233077, -33.178793
	10	2.9	25.236177, -33.175508	25.234045, 33.175508	-	25.236177, -33.178476	25.234045, -33.178476
	11	2.9	25.236236, -33.172390	25.233540, 33.172390	-	25.236236, -33.173949	25.233540, -33.173949
	12	3.6	25.239154, -33.172661	25.236270, 33.172661	-	25.239154, -33.174550	25.236270, -33.174550
	13	2.3	25.289462, -33.190218	25.287936, 33.190218	-	25.289462, -33.192529	25.287936, -33.192529
	14	5.6	25.286754, -33.189503	25.283564, 33.189503	-	25.286754, -33.191913	25.283564, -33.191913
	15	5.8	25.247145, -33.173897	25.242910, 33.173897	-	25.247145, -33.175717	25.242910, -33.175717
	16	1.4	25.269455, -33.170154	25.267849, 33.170154	-	25.269455, -33.171176	25.267849, -33.171176

17	4.9	25.272998, -33.169277	25.269380, 33.169277	-	25.272998, -33.171114	25.269380, -33.171114
18	4.7	25.273875, -33.170491	25.270933, 33.170491	-	25.273875, -33.172660	25.270933, -33.172660
19	4.7	25.267033, -33.171273	25.263467, 33.171273	-	25.267033, -33.173222	25.263467, -33.173222
20	5.3	25.270156, -33.171324	25.266567, 33.171324	-	25.270156, -33.173310	25.266567, -33.173310
21	4.1	25.213769, -33.186824	25.208945, 33.186824	-	25.213769, -33.188196	25.208945, -33.188196
22	3.9	25.213775, -33.185774	25.209245, 33.185774	-	25.213775, -33.187562	25.209245, -33.187562
23	3.1	25.288503, -33.171278	25.285935, 33.171278	-	25.288503, -33.172999	25.285935, -33.172999
24	5.0	25.291236, -33.168778	25.286473, 33.168778	-	25.291236, -33.171668	25.286473, -33.171668
25	6.1	25.234150, -33.139324	25.229900, 33.139324	-	25.234150, -33.142723	25.229900, -33.142723
26	6.8	25.231123, -33.182604	25.220426, 33.182604	-	25.231123, -33.186364	25.220426, -33.186364
27	8.4	25.286397, -33.182467	25.280983, 33.182467	-	25.286397, -33.185439	25.280983, -33.185439
28	3.1	25.312980, -33.189794	25.309517, 33.189794	-	25.312980, -33.191452	25.309517, -33.191452
29	3.1	25.313583, -33.188336	25.310111, 33.188336	-	25.313583, -33.189997	25.310111, -33.189997
30	2.6	25.296953, -33.183566	25.293200, 33.183566	-	25.296953, -33.185018	25.293200, -33.185018
31	1.2	25.288440, -33.176466	25.287313, 33.176466	-	25.288440, -33.178249	25.287313, -33.178249
41	0.9	25.314143, -33.188180	25.312822, 33.188180	-	25.314143, -33.189105	25.312822, -33.189105
42	30.1	25.324957, -33.195126	25.316950, 33.195126	-	25.324957, -33.199851	25.316950, -33.199851

43	37.1	25.317396, -33.194390	25.306578, 33.194390	-	25.317396, -33.199491	25.306578, -33.199491
44	37.1	25.300193, -33.191524	25.290527, 33.191524	-	25.300193, -33.197998	25.290527, -33.197998
45	30.2	25.307655, -33.172805	25.295870, 33.172805	-	25.307655, -33.176157	25.295870, -33.176157
46	29.7	25.285108, -33.168745	25.277567, 33.168745	-	25.285108, -33.174573	25.277567, -33.174573
48	30.1	25.316385, -33.174427	25.304570, 33.174427	-	25.316385, -33.180910	25.304570, -33.180910
49	28.1	25.307995, -33.195635	25.298183, 33.195635	-	25.307995, -33.199627	25.298183, -33.199627
50	23.1	25.314229, -33.183276	25.306562, 33.183276	-	25.314229, -33.188325	25.306562, -33.188325
51	23.1	25.294577, -33.187110	25.287811, 33.187110	-	25.294577, -33.193012	25.287811, -33.193012
52	26.1	25.289768, -33.178621	25.285031, 33.178621	-	25.289768, -33.186927	25.285031, -33.186927
53	26.1	25.298531, -33.176487	25.288842, 33.176487	-	25.298531, -33.182366	25.288842, -33.182366
0	26.0	25.326233, -33.168342	25.313801, 33.168342	-	25.326233, -33.172194	25.313801, -33.172194
1	26.0	25.324933, -33.171895	25.311807, 33.171895	-	25.324933, -33.176052	25.311807, -33.176052
3	26.0	25.300708, -33.173512	25.289870, 33.173512	-	25.300708, -33.179533	25.289870, -33.179533
4	26.0	25.307027, -33.179772	25.298070, 33.179772	-	25.307027, -33.184923	25.298070, -33.184923
5	26.0	25.293290, -33.189762	25.284173, 33.189762	-	25.293290, -33.197976	25.284173, -33.197976
6	26.0	25.322021, -33.202504	25.312718, 33.202504	-	25.322021, -33.205310	25.312718, -33.205310
7	26.0	25.312575, -33.200869	25.303683, 33.200869	-	25.312575, -33.204810	25.303683, -33.204810

	8	1.9	25.285447, -33.188681	25.283153, 33.188681	-	25.285447, -33.190454	25.283153, -33.190454
	9	2.3	25.298903, -33.184377	25.296275, 33.184377	-	25.298903, -33.185699	25.296275, -33.185699
	10	8.7	25.303592, -33.190358	25.295522, 33.190358	-	25.303592, -33.195668	25.295522, -33.195668
Great Fish River Nature Reserve	0	1.3	26.637968, -33.094397	26.636213, 33.094397	-	26.637968, -33.095735	26.636213, -33.095735
	1	3.5	26.639313, -33.095281	26.635170, 33.095281	-	26.639313, -33.097353	26.635170, -33.097353
	2	8.2	26.634981, -33.095197	26.630487, 33.095197	-	26.634981, -33.098113	26.630487, -33.098113
	3	3.1	26.635350, -33.097383	26.630487, 33.097383	-	26.635350, -33.099674	26.630487, -33.099674
	4	6.9	26.632620, -33.097183	26.628856, 33.097183	-	26.632620, -33.100285	26.628856, -33.100285
	5	3.4	26.654550, -33.108213	26.650683, 33.108213	-	26.654550, -33.109429	26.650683, -33.109429
	6	3.2	26.656161, -33.104867	26.653639, 33.104867	-	26.656161, -33.108289	26.653639, -33.108289
	7	2.4	26.663955, -33.104452	26.661069, 33.104452	-	26.663955, -33.106111	26.661069, -33.106111
	8	2.9	26.667951, -33.105284	26.663907, 33.105284	-	26.667951, -33.106228	26.663907, -33.106228
	9	3.7	26.673744, -33.127602	26.672032, 33.127602	-	26.673744, -33.130919	26.672032, -33.130919
	10	4.3	26.675077, -33.127707	26.672954, 33.127707	-	26.675077, -33.130978	26.672954, -33.130978
	11	7.1	26.633890, -33.091500	26.629533, 33.091500	-	26.633890, -33.094322	26.629533, -33.094322
	12	5.2	26.628966, -33.098984	26.625106, 33.098984	-	26.628966, -33.102216	26.625106, -33.102216
	13	7.5	26.628249, -33.097553	26.624152,	-	26.628249, -33.101526	26.624152, -33.101526

			33.097553			
14	22.5	26.632680, -33.090963	26.624653, 33.090963	-	26.632680, -33.099654	26.624653, -33.099654
15	0.0	26.635088, -33.093360	26.635072, 33.093360	-	26.635088, -33.093375	26.635072, -33.093375
16	1.9	26.636350, -33.093317	26.634520, 33.093317	-	26.636350, -33.094937	26.634520, -33.094937
17	6.3	26.636111, -33.093659	26.631488, 33.093659	-	26.636111, -33.096292	26.631488, -33.096292
18	13.6	26.636414, -33.088633	26.630353, 33.088633	-	26.636414, -33.095219	26.630353, -33.095219

* Contract codes are not provided for the plantings in Addo Elephant National Park and GFRNR in this table, However they are available from the project implementer.

Table A.4.2: GPS coordinates of sample sites in the Baviaanskloof Nature Reserve used to collect field data on carbon sequestration in spekboom thicket.

	GPS coordinates (decimal degrees)			GPS coordinates (decimal degrees)	
Site Code	X	Y	Site Code	X	Y
RHST15	24.43172	-33.65266	RHOL24	24.41584	-33.65557
RHST13	24.43026	-33.65319	RHOL22	24.41567	-33.65557
RHST12	24.43009	-33.65347	RHOL13	24.41372	-33.65529
RHST11	24.42993	-33.65374	RHOL14	24.41388	-33.65516
RHST14	24.43074	-33.65388	RHOL15	24.41404	-33.65502
RHST21	24.40272	-33.65569	RHOL17	24.41454	-33.65490
RHST25	24.40402	-33.65542	RHOL18	24.41470	-33.65476
RHST23	24.40386	-33.65556	RHOL20	24.41485	-33.65476
RHST22	24.40370	-33.65583	RHOL25	24.41583	-33.65530
RHST24	24.40403	-33.65584	RHST3	24.36907	-33.66735
RHST16	24.42545	-33.65735	RHST1	24.36860	-33.66803
RHST17	24.42643	-33.65803	RHST2	24.36874	-33.66802
RHST18	24.42723	-33.65790	RHST4	24.36973	-33.66668
RHST19	24.42804	-33.65749	RHST5	24.37037	-33.66776
RHST20	24.42853	-33.65737	RHST7	24.35370	-33.65444
RHOL1	24.40992	-33.65287	RHST6	24.35352	-33.65538
RHOL3	24.41008	-33.65315	RHST10	24.35402	-33.65537
RHOL2	24.41007	-33.65328	RHST9	24.35384	-33.65551
RHOL4	24.41057	-33.65287	RHST8	24.35384	-33.65579
RHOL5	24.41088	-33.65329	KASS5	24.27587	-33.63557
RHOL6	24.41105	-33.65329	KASS1	24.27569	-33.63572
RHOL7	24.41138	-33.65288	KASS2	24.27649	-33.63640
RHOL8	24.41169	-33.65289	KASS3	24.27698	-33.63639
RHOL10	24.41218	-33.65316	KASS4	24.27732	-33.63532
RHOL9	24.41218	-33.65329	KRC3	24.20931	-33.60192
RHOL11	24.41234	-33.65397	KRC1	24.20897	-33.60315
RHOL12	24.41282	-33.65410	KRC2	24.20913	-33.60315
RHDST21	24.42462	-33.66636	KRC4	24.21043	-33.60275
RHDST22	24.42592	-33.66582	KRC5	24.21094	-33.60207
RHDST23	24.42624	-33.66570	KQ3	24.33339	-33.64716
RHDST24	24.42640	-33.66542	KQ1	24.33305	-33.64769
RHDST25	24.42722	-33.66529	KQ2	24.33340	-33.64770
RHDST16	24.41109	-33.66712	KQ4	24.33371	-33.64743
RHDST19	24.41190	-33.66780	KQ5	24.33451	-33.64757
RHDST18	24.41174	-33.66793	KKK1	24.21363	-33.61279
RHDST17	24.41139	-33.66820	KKK2	24.21377	-33.61320
RHDST20	24.41221	-33.66808	KKK3	24.21445	-33.61239
RHDST11	24.40286	-33.66854	KKK4	24.21476	-33.61211
RHDST13	24.40401	-33.66896	KKK5	24.21510	-33.61281
RHDST12	24.40319	-33.67044	KKO2	24.31440	-33.64283
RHDST14	24.40431	-33.67045	KKO1	24.31440	-33.64362
RHDST15	24.40529	-33.67004	KKO3	24.31537	-33.64350
RHDST6	24.37878	-33.66863	KKO4	24.31555	-33.64322
RHDST7	24.37926	-33.66877	KKO5	24.31586	-33.64404

RHDST8	24.37942	-33.66836	KAD5	24.29387	-33.63090
RHDST9	24.38040	-33.66810	KAD4	24.29371	-33.63118
RHDST10	24.38056	-33.66823	KAD7	24.29501	-33.63091
RHDST1	24.41431	-33.65649	KAD8	24.29566	-33.63118
RHDST3	24.41463	-33.65675	KAD10	24.29387	-33.63198
RHDST2	24.41445	-33.65689	KAD6	24.29436	-33.63213
RHDST4	24.41705	-33.65717	KAD9	24.29370	-33.63361
RHDST5	24.41785	-33.65758	KCAB5	24.24847	-33.63172
RHOL16	24.41452	-33.65557	KCAB3	24.24814	-33.63226
RHOL19	24.41485	-33.65598	KCAB2	24.24782	-33.63253
RHOL21	24.41533	-33.65597	KCAB1	24.24748	-33.63280
RHOL23	24.41583	-33.65586	KCAB4	24.24830	-33.63320
KAD1	24.29508	-33.62811	GHST15	24.62641	-33.66047
KAD2	24.29528	-33.62892	GHST10	24.62787	-33.66060
KAD3	24.29530	-33.62921	GHST6	24.62576	-33.66154
KGHB1	24.25313	-33.61595	GHST13	24.62593	-33.66182
KGHB2	24.25476	-33.61640	GHST7	24.62642	-33.66155
KGHB5	24.25447	-33.61709	GHST9	24.62788	-33.66101
KGHB3	24.25339	-33.61730	GHST4	24.60490	-33.67451
KGHB4	24.25393	-33.61798	GHST2	24.60382	-33.67473
KDH3	24.26670	-33.62531	GHST3	24.60461	-33.67563
KDH1	24.26649	-33.62562	GHST1	24.60381	-33.67675
KDH4	24.26724	-33.62572	GHST5	24.60652	-33.67611
KDH2	24.26664	-33.62621	GHOL2_1	24.62695	-33.65838
KDH5	24.26690	-33.62676	GHOL2_2	24.62711	-33.65866
KLK1	24.24637	-33.60917	GHOL2_3	24.62840	-33.65920
KLK3	24.24719	-33.60787	GHOL2_5	24.62970	-33.66003
KLK2	24.24718	-33.60808	GHOL2_4	24.62857	-33.66014
KLK6	24.24769	-33.60830	GHOL3_2	24.61526	-33.65708
KLK5	24.24771	-33.60852	GHOL3_3	24.61574	-33.65749
KLK4	24.24743	-33.60942	GHOL3_	24.61913	-33.65912
KLK7	24.24797	-33.60966	GHOL3_1	24.61429	-33.65708
KLK8	24.24851	-33.60964	GHOL3_4	24.61801	-33.65750
KLK9	24.24880	-33.60921	GHOL1_3	24.61460	-33.67079
KLK10	24.24879	-33.60898	GHOL1_1	24.61443	-33.67188
CNST1	24.57411	-33.68215	GHOL1_2	24.61459	-33.67242
CNST3	24.57526	-33.68126	GHOL1_4	24.61604	-33.67148
CNST5	24.57611	-33.68217	GHOL1_6	24.61733	-33.67162
CNST4	24.57580	-33.68269	GHOL1_7	24.61750	-33.67216
CNST2	24.57551	-33.68268	GHOL1_5	24.61669	-33.67311
CEST3	24.57865	-33.68270	GHOL1_8	24.61864	-33.67135
CEST4	24.57839	-33.68291	GHOL1_9	24.61944	-33.67203
CEST1	24.57803	-33.68334	GHOL1_10	24.61977	-33.67162
CEST2	24.57830	-33.68337	GHST12	24.62496	-33.65992
CEST5	24.57888	-33.68316	GHST8	24.62674	-33.65965
COLN6	24.57378	-33.68053			
COLN5	24.57397	-33.68026			
COLN4	24.57427	-33.68038			
COLN3	24.57488	-33.68009			

COLN2	24.57574	-33.68005			
COLE1	24.58092	-33.68311			
COLE4	24.58229	-33.68269			
COLE5	24.58282	-33.68317			
COLE3	24.58192	-33.68406			
COLE2	24.58133	-33.68431			
GHST11	24.62448	-33.65882			
GHST16	24.62529	-33.65938			
GHST14	24.62611	-33.65911			

Annex 5 Letters of A/R Project approval from stakeholders

Figure A.5.1: Letter from the Department of Environmental Affairs

environmental affairs

Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Private Bag X4390· CAPE TOWN · 8000· 14 Loop Street · Cape Town · 8001
Tel (+ 27 21) 441 2700 · Fax (+ 27 21) 441 2751

Enquiries: Dr. Christo Marais
Reference: ECRP/PDD/09/06/2011
Tel: +27(0)21 441 2727
Email: chris@dwa.gov.za
Date: 9th June 2011

To whom it may concern

Statement on the Addo Elephant National Park, Baviaanskloof Nature Reserve and Great Fish River Nature Reserve Restoration Project (ABFRP)

1) The ABFRP is taking place within the confines of the Addo Elephant National Park, with potential to expand to Great Fish River Nature Reserve and Baviaanskloof Nature Reserve.

2) The project land is owned by the Republic of South Africa.

3) The project is being implemented by Gamtoos Irrigation Board and South African National Parks on behalf of the Department of Environmental Affairs.

4) The open degraded landscapes that are being restored by planting spekboom (*Portulcaria afra*) were cleared in the past, prior to a protected area being proclaimed, and were formed either through goat pastoralism or intensive agriculture.

5) These landscapes are no longer used for agriculture, and are being managed as conservation land (as defined under the Protected Areas Act).

6) The land-owner (i.e. government) would like to restore these open degraded landscapes back to the original vegetation; however, unless costs are recouped from carbon credits, such an initiative would not happen. This is because restoration on such a large scale is prohibitively expensive and unaffordable to government biodiversity budgets. In other words: without carbon finance, these landscapes would remain in a degraded condition as it has been since the proclamation of the protected areas. In part this is evident because at the moment there are no other large-scale replanting projects taking place on conservation land within the Eastern Cape or indeed South Africa.

7) The benefits of restoration include rural development through job creation, reduced silt loads in dams and rivers, greater ecosystem productivity, improved aesthetics,

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Private Bag X4390· CAPE TOWN · 8000· 14 Loop Street · Cape Town · 8001
Tel (+ 27 21) 441 2700 · Fax (+ 27 21) 441 2751

improved habitat for many forms of biodiversity, improved tourism potential and improved biodiversity in terms of shrubs and trees.

8) The ABFRP is a *Verified Carbon Standard* project based on a *Clean Development Mechanism* methodology. A significant proportion of the funds received from *Verified Emission Reductions* will be channelled back to local communities that live adjacent to or within the project sites. This will be through the employment of local people to conduct the work.

9) The ABFRP started in 2004 and was developed primarily to catalyse large scale restoration of degraded thicket using carbon finance.

Please feel free to contact me if you have any queries.

Yours sincerely

Dr. Christo Marais
Head Operations: Natural Resource Management Programmes (NRMP)

Figure A.5.2: Letter from the Eastern Cape Parks Board (EPCB)

EASTERN CAPE
PARKS

STATEMENT ON THE SUBTROPICAL THICKET RESTORATION PROJECT

1) The Subtropical Thicket Restoration Project is taking place within the confines of the Baviaanskloof Nature Reserve and the Great Fish River Nature Reserve.
2) Project land is owned by the Republic of South Africa and managed by the Eastern Cape Parks Board.
3) The open degraded landscapes that are being restored by planting spekboom (*Portulcaria afra*) were cleared in the past, prior to a protected area being proclaimed, and were formed either through goat pastoralism or intensive agriculture.
4) These landscapes are no longer used for agriculture, and are being managed as nature reserve land.
5) The Eastern Cape Parks Board would like to restore these open degraded landscapes back to the original vegetation; however, unless costs are recouped from carbon credits, such an initiative would not happen. This is because restoration on such a large scale is prohibitively expensive for government biodiversity budgets. In other words: without carbon finance, these landscapes would remain in a degraded condition. In part this is evident because there are no other large-scale restoration projects taking place on conservation land within the Eastern Cape or indeed South Africa.
6) The benefits of restoration include job creation, reduced silt loads in dams and rivers, greater ecosystem productivity, improved aesthetics, improved habitat for many forms of biodiversity, and improved biodiversity in terms of shrubs and trees.
7) The Subtropical Thicket Restoration Project is a VSC project based on a small-scale CDM methodology; consequently a significant proportion of the funds received from VER's will be channelled back to local communities that live adjacent to or within the Baviaanskloof and Great Fish River Nature Reserves. This will be through the employment of local contractors to conduct the work.

07/06/2010

D. Balfour
Acting Director: Conservation
Eastern Cape Parks Board

07/06/2010

N. Raygee
Acting CEO
Eastern Cape Parks Board

WE PROMISE THE EARTH

6 St Marks Road | Southernwood East London | 5213 | P.O.Box 11235 | Southernwood East London | 5213 | Tel: + 27 (0) 43 705 4400 | www.ecparks.co.za

Eastern Cape Parks Board trading as Eastern Cape Parks

Figure A.5.3: Letter from the Gamtoos Irrigation Board (GIB)

GAMTOOS-BESPROEIINGSRAAD
Posbus 237 P.O.Box
6335 Patensie

GAMTOOS IRRIGATION BOARD
Telefoon/Telephone: (042) 283 0329
Faks/Fax:: (086) 675 0113
E-pos/E-mail: gamtoos@lantic.net

2008 National award winner: Water Conservation and Water Demand Management
Implementing Agent for Working for Water and Working for Wetlands projects

29 July 2010

To whom it may consern

The Gamtoos Irrigation Board (GIB) is responsible for implementation of the VCS ARR project entitled "Spekboom Thicket Restoration Project". GIB is directly responsible for the following:

- Selecting sites for planting;
- Appointing contractors;
- Harvesting and planting of *Portulacaria afra* cuttings.
- Sampling of soils and biomass for carbon accounting;
- Monitoring the project in accordance with the procedures set out in the project document.
- Ensuring the safe keeping of any data or methodology in their possession.

GIB approves of the project and extends its full support towards the VCS ARR approval process.

Yours sincerely,

Rienette Colesky
Aministration Manager

Figure A.5.4: Letter from Restoration Research Group (R3G)

R3G
Restoration Research Group

Restoration Research Group (R3G)

28 July 2010

<u>Spekboom Thicket Restoration Project</u>

Restoration Research Group (R3G) will act as scientific advisors and managers of the baseline measurements and monitoring activities on the VCS Spekboom Thicket Restoration Project.

A soil scientist and an ecologist in the research group R3G will give the Gamtoos Irrigation Board (GIB) advice regarding the required methodology to monitor actual GHG removals by sinks and leakage generated by the proposed ARR project activity. A technical team supervised by GIB will use this methodology to collect soil and plant data.

R3G comprises a group of scientists whose strength lies in a unique partnership between their scientific expertise based at Rhodes University, Stellenbosch University and Nelson Mandela Metropolitan University, with the funding and practical implementation provided by the South African Government's Expanded Public Works Programme (EPWP).

R3G's primary partner is the Department of Water Affairs (DWA), in particular, its Working for Water Programme (DWAF/WfWater) and its Working for Woodlands Programme (DWAF/WfWoodlands). It also works with South African National Biodiversity Institute's (SANBI) Working for Wetlands Programme, and the World Wide Fund-South Africa (WWF). The implementing agency for all of this work is the Gamtoos Irrigation Board, which has an excellent track record for managing this challenging work. R3G is also working in collaboration with Wageningen University & Research Centre (WUR) and Participatory Restoration of Ecosystem Services and Natural Capital (PRESENCE). This list of partners will undoubtedly grow in the future.

R3G approves of the project and extends its full support towards the VCS ARR approval process.

Dr Anthony Mills

Figure A. 5.5: Letter from CSS

CSS Geographical Information Specialists

PO Box 504 · Grahamstown · 6140
61 New Street · Grahamstown · 6139
Tel: +27 (46) 6224526
Fax: +27 (46) 6227931
info@cssgis.co.za

8 October 2010

To Whom It May Concern:

Conservation Support Services (CSS) has been contracted by Gamtoos Irrigation Board (GIB) as the mapping and GIS service provider for the Spekboom Thicket Restoration Project. CSS will conduct all the spatial development work for the project, as well as house and maintain the database and archive the data spatial, attribute and social (worker) data. CSS has been contracted as the mapping and GIS service provider by GIB for various projects over the last 8 years.

CSS approves and commits itself to the project and its contract with GIB, and extends its full support towards the VCS ARR approval process.

Yours sincerely

Martin Bekker
Director

Reg number: 2006/027716/07, Vat number 4290184110
Directors: M. Bekker; B. Cobbing, C Hlope, Acacia Karoo Trust
www.cssgis.co.za

Figure A. 5.6: Letter from the Eastern Cape provincial Department of Economic Development and Environmental Affairs (DEDEA): NEMA EIA Waiver

From: Andries Struwig [mailto:Andries.Struwig@deaet.ecape.gov.za]
Sent: 24 July 2008 14:30
To: Dr A.M. Sigwela
Cc: Dayalan Govender; mills@sun.ac.za
Subject: RE: EIA exemption request

Dr. Sigwela

It is hereby confirmed that the rehabilitation of degraded land in order to attempt to restore naturally functioning plant communities and ecosystems, is not a specific listed activity as contemplated in the NEMA EIA Regulations and therefore would not require authorisation from this department. You are however advised to take cognizance of specific listed activities that may be relevant depending on the scope of individual projects e.g. any rehabilitation that may take place within a river course/wetland or rehabilitation that takes place within 100m from the high water mark of the sea etc.

I trust that this answers your query.

Regards.

Andries Struwig
Assistant Director: EIM
Western Region
Department of Economic Development & Environmental Affairs
Private Bag X5001
Greenacres
6057
Tel: +27 41 5085844
Fax: +27 41 5851958
email: andries.struwig@deaet.ecape.gov.za

Figure A. 5.7:Statement on the modalities of communication with the UNFCCC secretariat .

January 21, 2008

STATEMENT ON THE MODALITIES OF COMMUNICATING WITH THE CDM EXECUTIVE BOARD AND THE UNFCCC SECRETARIAT

Further to the proposed registration of the South African government's Department of Water Affairs and Forestry (DWAF) Thicket Restoration Project, please note that:

- The Rhodes Restoration Group, a project participant, will be responsible for all communication with the CDM Executive Board and UNFCCC secretariat.
- The individual contact will be Dr. Anthony Mills who has been authorized, by all project participants, to communicate with the Executive Board and UNFCCC Secretariat.

Dr. Anthony Mills shall be authorized to instruct the Executive Board and UNFCCC Secretariat regarding allocations and/or distribution of CERs upon issuance of the same. The project participants confirm that they shall, on request, without demur, provide such letter, document, paper, writing or instrument required, and such form as requested, for the above purpose.

This statement shall be valid until a new statement, superseding this statement, is signed by the project participants and has been submitted to the Executive Board and UNFCCC Secretariat.

Dr Anthony Mills *signature*
Rhodes Restoration Research Group

Authorized Signatory Specimen Signatures

Name *signature*
Department of Water Affairs and Forestry (National Working for Water Programme)

Name *signature*
Eastern Cape Parks Board
W. M. ERLANK

Name *signature*
Gamtoos Irrigation Board

Figure A. 5.8: Indication of support for the A/R project from the GIB contract workers.

GAMTOOS BESPROEIINGSRAAD
Posbus 237 P.O. Box
6335 Patensie

GAMTOOS IRRIGATION BOARD
Telefoon/Telephone: (042) 283-0329
Faks/Fax: (042) 283-0382
E-Pos/E-Mail: water@eastcape.net

Implementing agent for working for water projects

MINUTES OF THE WORKERS SUPPORT MEETING
SUBTROPICAL THICKET RESTORATION PROJECT
11th OF JUNE 2007

Location: Gamtoos Irrigation Board Hall

Time: 10h00 to 11h00

Present: Mike Powell (Technical Advisor), Yolande Vermaak (Project Manager), all project contractors and their workers (see Appendix I)

Aim of meeting: to inform workers on the Subtropical Thicket Restoration Project goals and objectives; and to ascertain whether the workers support the project.

Minutes

Mike opened by giving the group a brief overview of what the meeting was about. To increase funding for future projects, there are certain guidelines that must be followed including ensuring that the workers are well informed of the project that they are working on.

Mike: Where does petrol come from?

Yolande: From oil

Mike: Oil comes from deep underground where dead trees sank to the bottom of the sea and combined with minerals to form oil. This happened slowly over millions of years and it is now very valuable as a source of energy. When we drive a car, the gases that come from the exhaust pipe build up in the Earth's atmosphere and work like a greenhouse – the gases let the sun's rays come through but they trap the heat inside. The more fuel we use, the more gases in the atmosphere and the warmer the Earth is going to become. This is a very significant issue for everyone because the temperatures everywhere will become hotter; however, we still rely heavily on burning oil for fuel and electricity.

To solve this problem, countries have to reduce their use of fuel. In 1997, many countries around the world came together and signed an agreement called the Kyoto Protocol where they agreed to reduce their country's carbon levels in the air.

What can developing countries do? Planting trees is a very effective way of working towards lowering the levels of carbon in the atmosphere as well as employing large numbers of local people. Trees need carbon to grow so they use their leaves to take carbon from the air which then reduces carbon in the atmosphere. That is why Kiewiet's team did soil surveys to find out the level of carbon in the soil and Johanna's team did the allometry work to find out the level of carbon in the trees. Spekboom has been found to absorb large amounts of carbon when it grows, more than most plants. If we can prove that by planting spekboom we can harvest a large amount of carbon per hectare, we can sell that carbon to companies and larger countries to balance out all the carbon that they are burning and releasing into the air. On the carbon market, 1 tonne of carbon is worth up to 20 Euro (200 Rand).

To continue this research and create more jobs in the future, we need to apply for more funding from overseas. To apply, we need a letter from the workers who are conducting the work on the ground which says that they understand what they are doing and what the project is focused on.

Mike used both English and Afrikaans so that everyone was able to follow what was being said. The workers confirmed that they supported the project and only had questions about logistical issues. These included:

i) Cedric had a problem with the carrying out of the spekboom cuttings.
ii) Loretta wanted to know why they cannot fence off the area where they have planted, to prevent the baboons from causing damage.

Mike responded as follows:

i) Perhaps they should cut fewer truncheons during the stockpiling phase. It is, however, important that the truncheons do not lie more than five days before planting.
ii) Cost wise it is not feasible, the teams will have to come up with a proposal.

The contractors and workers were then asked whether they understood and supported the project to which all responded positively. The register (Appendix I) was signed to indicate their support.

Signed:

Date:

Yolande Vermaak

Edwill Moore

Project Manager

Finance Manager

SUBTROPICAL THICKET RESTORATION PROJECT WORKERS MEETING

Attendance Register **Date:** 11/6/07

Name & Surname	Designation	ID number	Signature
Sherelene Tarentaal	G.Worker-Nursery	8702100112088	Tarentaal
Kaaitjie Tarentaal	G.Worker-Nursery	5602240164085	Klarentaal
Charand Swarts	^	8508250160086	Swarts
Suné Magielies	^	8605190224087	S.Magielies
Lenelia Boardman	^	7107070263084	Boardman
Angela Windvoël	^	6907071220081	A. Windvoël
Siena Mapoe	^	6906150260083	S Mapoe
Ragel Pietersen	Contractor-Nursery	6704210554086	R. Pietersen
Thandluxolo Anton	G.Worker-Nursery	8004045340084	T.Anton
Brian Prins	Stock Controller Nursery	8306105266087	B Prins
Franchwa Zana	G.Worker-Nursery	8512115247088	Zana
Enrico Zana	Herbicide App. Nursery	8008175227086	[illegible]
Ryno Zana	G.Worker-Nursery	8809205164086	Zana
Elroy Swarts	Herbicide App. Nursery	8404145318081	Swarts
Malin Jafta	G.Worker-Nursery	8910305235089	M Jafta
Edwin Malgas	G.Worker-Nursery	8612215177084	Malgas
Christopher Stefaans	^	8907105333087	T Stefaans
Cedric Kleinbooi	Contractor	6905195246081	[illegible]
Michael Ruka	Contractor	7504215352083	[illegible]
Michelle Human	G Worker	8311160228082	M Human
Hermia Baes	G.Worker	7607100157085	Baes
Marelene Rautenbach	^	8304020281083	M.Rautenbach
Jolene Prins	^	8110080168080	J Prins
Dina Pietersen	^	6206180150085	Petersen
Brunhilda Magielies	^	7807100177089	B Magielies
Elmarie Umstang	^	8009241066086	E. Umstang
Desmond Coetzee	^	5802265224083	D Coetzee
Jonathan Kietas	^	8008315001086	J. Kietas
Hendry Witbooi	^	8003015302084	Witbooi
Henry Ruiters	^	7412025239088	H Ruiters
Jonathan Plaatjies	Driver	7803165099086	Plaatjies
Mthetheleli Mhlabasi	G.Worker	8102026714085	[illegible]
Xolile Wagesa	^	8407185775086	[illegible]
Richard Dlamini	^	7004075653084	MR. Dlamini
Elias Mandeta	^	6701255514082	E Mandela
Jim Sali	^	7106295606089	J Sali
Douglas Gungulu	^	5709085746080	GUNGULU
K Matebese	^	6910305636080	K.MATEBESE
Charlton Malgas	Technician	8404175282082	C Malgas
Pieter Rossouw	^	7903165253087	[illegible]
Koos Dlomo	Driver	3510215187084	N K DLOMO
Henrico Prins	Technician	8601135214085	Henrico
Victoria Nolokwe	G.Worker	6412240603085	V Nolokwe

Annex 6 Climate, Community and Biodiversity Association Validation

The proposed ARR project will be validated against the Climate, Community and Biodiversity (CCB) Standards, and subsequently verified should the design of the proposed ARR project meet the required criteria, as determined by an independent auditor. The proposed ARR project is detailed below according to the sections stipulated in the Climate, Community and Biodiversity Project Design Standards Second Edition (CCBA, 2008). The background and context of the proposed ARR project are provided in the main report.

SECTION G: GENERAL SECTION

G1. Original Conditions in the Project Area

G1.1. The location of the project and basic physical parameters (e.g., soil, geology, climate).

The location of the proposed ARR project and basic physical parameters of each project area are described in Annex 12.

G1.2. The types and condition of vegetation within the project area.

The types and condition of vegetation within each project area are described in Annex 12.

G1.3. The boundaries of the project area and the project zone.

The boundaries of the project areas are described in Section 1.5 and Annex 12. The surrounding communities within the project zone are listed in Section 1.5.
Concept
G1.4. Current carbon stocks within the project area(s), using stratification by land use or vegetation type and methods of carbon calculation (such as biomass plots, formulae, default values) from the Intergovernmental Panel on Climate Change's 2006 Guidelines for National GHG Inventories for Agriculture, Forestry and Other Land Use (IPCC 2006 GL for AFOLU) or a more robust and detailed methodology.

The baseline stratification is described in Section 3.2.4a. The method of carbon calculation and baseline GHG scenario are described in Sections 4.1 and 4.2, respectively.

G1.5. A description of communities located in the project zone, including basic socio-economic and cultural information that describes the social, economic and cultural diversity within communities (wealth, gender, age, ethnicity etc.), identifies specific groups such as Indigenous Peoples and describes any community characteristics.

The communities living within the project zone are poor. Unemployment rates are high and there are limited economic opportunities available to community members. The unemployment rate for the Eastern Cape is 39.5 %, the second highest for any province in South Africa (StatsSA, 2007). The high unemployment rate is in part due to habitat degradation, which has resulted in a decline of the agricultural sector in this region (Kerley, Boshoff, & Knight, Ecosystem integrity and sustainable landuse in the Thicket Biome, South Africa., 1999).

G1.6. A description of current land use and customary and legal property rights including community property in the project zone, identifying any ongoing or

unresolved conflicts or disputes and identifying and describing any disputes over land tenure that were resolved during the last ten years (see also G5).

The current land use ofthe project area and all potential grouped areas is conservation, as described in Sections 1.5, 2.5 and 8. The current project site is a state-owned national park with no community rights of use or property rights. No disputes over the land have been registered through the formal land claims process, nor have there been any informal disputes reported. Any additional project area can only be included within the grouped project once all land tenure and land claims issues have been resolved..

G1.7. A description of current biodiversity within the project zone (diversity of species andecosystems) and threats to that biodiversity, using appropriate methodologies, substantiated where possible with appropriate reference material.

A description of the biodiversity of the project areas is provided in Annex 12, which details the vegetation and rare and endangered flora and fauna. All areas to be restored are currently considered to be moderately or severely degraded (see Section 1.4). Current environmental conditions do not permit natural recovery of thicket within these areas, due to the high soil temperatures as a result of the lack of canopy, reduced soil quality and reduced soil moisture content of degraded landscapes (Mills & Fey, Transformation of thicket to savanna reduces soil quality in the Eastern Cape, South Africa., 2004b). This represents a continued threat to the biodiversity of the degraded areas.

G1.8. An evaluation of whether the project zone includes any of the following High Conservation Values (HCVs) and a description of the qualifying attributes:

1.8.1. Globally, regionally or nationally significant concentrations of biodiversity values;

a. protected areas; b. threatened species; c. endemic species; and d. areas that support significant concentrations of a species during any time in their lifecycle (e.g. migrations, feeding grounds, breeding areas).

The project area and all potential grouped areas are Protected Areas under the protected Areas Act of 2004. In addition, the Baviaanskloof Nature Reserve is World Heritage Site under the World Heritage Convention Act (49 of 1999). The rare and endangered species of each of the project areas (including a number of endemic species i.e. *Aloe pictifolia, Gasteria ellaphieae, Gasteria glomerata* and *Gasteria rawlinsonii*) are listed in Annex 12.

1.8.2. Globally, regionally or nationally significant large landscape-level areas where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance;

All three project areas are in biodiversity hotspots[33], first defined by Myers[34]. The Addo National Elephant Park and Great Fish River Nature Reserve project areas are in the Maputaland-Pondoland-Albany biodiversity hotspot, as well as in the Albany Centre of Floristic Endemism (Victor & Dold, 2003). The Baviaanskloof Nature Reserve project area falls within the Cape Floristic Region biodiversity hotspot (Myers, The Biodiversity Challenge: Expanded Hot-Spots Analysis, 1990). These areas are characterized both by exceptional

[33] See http://www.biodiversityhotspots.org/Pages/default.aspx.
[34] (Myers, 1988)

levels of plant endemism and by serious levels of habitat loss, and are thus regionally, nationally and globally significant.

1.8.3. Threatened or rare ecosystems;

The project areas fall within the planning domain of Subtropical Thicket Ecosystem Project (STEP; Vlok & Euston-Brown, 2002). STEP defines the following biodiversity priority classifications (a measure of ecosystem status)[35]:

- Least threatened: Ecosystems which cover most of their original extent and which are mostly intact, healthy and functioning.
- Vulnerable: Ecosystems which cover much of their original extent but where further disturbance or destruction could harm their health and functioning.
- Endangered: Ecosystems whose original extent has been severely reduced, and whose health, functioning and existence is endangered.
- Critically endangered: Ecosystems whose original extent has been so reduced that they are under threat of collapse or disappearance.

All four categories are represented in the project areas. In addition, all selected planting sites in the planting areas are classified as moderately or severely degraded by the landscape-level transformation study undertaken by Lloyd *et al.* in 2002.

1.8.4. Areas that provide critical ecosystem services (e.g., hydrological services, erosion control, fire control);

The project areas are important water catchments for downstream and surrounding communities and towns. A restoration of the ecosystem through the planting of *P.afra* will result in improved water retention and increased and regulated water flow and supply from the project areas. This will result in improved water security for the local communities as well as the farms surrounding the project areas. The economic benefit from improved water supplies is significant in the drought-prone region, and may reduce the number of expensive engineering solutions required for increasing water supply. The value of the benefits of restoring the water regulation services of thicket is detailed in Annex 11, as is the surrounding communities' dependence on thicket. Whilst communities cannot harvest resources from the project areas (as they are in two nature reserves and a national park), cross boundary flow from the restored thicket to surrounding areas will benefit local communities through the ecosystem services provided.

1.8.5. Areas that are fundamental for meeting the basic needs of local communities (e.g., for essential food, fuel, fodder, medicines or building materials without readily available alternatives); and

The project areas are situated within two nature reserves and a national park and thus no consumptive use by the local communities is permitted within the project areas. Cross boundary flow from the restored thicket to surrounding areas, however, will benefit local communities who rely on thicket to meet some of their basic needs. This reliance is detailed in Annex 11.

1.8.6. Areas that are critical for the traditional cultural identity of communities (e.g., areas of cultural, ecological, economic or religious significance identified in collaboration with the communities).

[35] See http://bgis.sanbi.org/STEP/project.asp.

The socio-cultural value of thicket and economic importance to surrounding communities is detailed in Annex 11. Whilst there are no religious or culturally important sites in the specific planting sites within the project areas, as they were excluded during site selection, the cross boundary flow from the restored areas will improve the quality of lives of the surrounding communities.

G2. Baseline Projections

G2.1. Describe the most likely land use scenario in the absence of the project following IPCC 2006 GL for AFOLU or a more robust and detailed methodology, describing the range of potential land use scenarios and the associated drivers of GHG emissions and justifying why the land use scenario selected is most likely.

The most likely land use scenario in the absence of the proposed ARR project activities is described in Section 2.5.

G2.2. Document that project benefits would not have occurred in the absence of the project, explaining how existing laws or regulations would likely affect land use and justifying that the benefits being claimed by the project are truly 'additional' and would be unlikely to occur without the project.18

The assessment and demonstration of additionality of the proposed ARR project is undertaken in Section 2.5.

G2.3. Calculate the estimated carbon stock changes associated with the 'without project' reference scenario described above. This requires estimation of carbon stocks for each of the land use classes of concern and a definition of the carbon pools included, among the classes defined in the IPCC 2006 GL for AFOLU. The timeframe for this analysis can be either the project lifetime (see G3) or the project GHG accounting period, whichever is more appropriate. Estimate the net change in the emissions of non-CO2 GHG emissions such as CH4 and N2O in the 'without project' scenario. Non-CO2 gases must be included if they are likely to account for more than 5% (in terms of CO2-equivalent) of the project's overall GHG impact over each monitoring period. Projects whose activities are designed to avoid GHG emissions (such as those reducing emissions from deforestation and forest degradation (REDD), avoiding conversion of non-forest land, or certain improved forest management projects) must include an analysis of the relevant drivers and rates of deforestation and/or degradation and a description and justification of the approaches, assumptions and data used to perform this analysis. Regional-level estimates can be used at the project's planning stage as long as there is a commitment to evaluate locally-specific carbon stocks and to develop a project-specific spatial analysis of deforestation and/or degradation using an appropriately robust and detailed carbon accounting methodology before the start of the project.

The baseline scenario is calculated for isolated *P. afra* trees in the project area, as detailed in Section 4.2.1 and 4.2.3.

G2.4. Describe how the 'without project' reference scenario would affect communities in the project zone, including the impact of likely changes in water, soil and other locally important ecosystem services.

The dependence of the communities on thicket surrounding the project areas is described in Section 6 and Annex 11. In a degraded state, the communities are not able to utilize the thicket.

G2.5. Describe how the 'without project' reference scenario would affect biodiversity in the project zone (e.g., habitat availability, landscape connectivity and threatened species).

In the absence of the proposed ARR project activities, the landscape to be restored would remain degraded. Current environmental conditions would not permit natural recovery of thicket within these areas, due to the high soil temperatures as a result of the lack of canopy, reduced soil quality and reduced soil moisture content of degraded landscapes (Mills & Fey, Transformation of thicket to savanna reduces soil quality in the Eastern Cape, South Africa., 2004b). There would be no increase in the biodiversity of the project areas and none of the benefits of the proposed ARR project (see Sections 1.16.2 and 5) would be realised.

G3. Project Design and Goals

G3.1. Provide a summary of the project's major climate, community and biodiversity objectives.

The objectives of the proposed ARR project include:

- Planting approximately 48,086 ha of moderately and severely degraded thicket with *P. afra* cuttings.
- Removing approximately 19.29 million t CO_2e from the atmosphere.
- Creating an estimated 300 jobs in a province of 39.5 % unemployment.
- Resulting in the return of ecosystem carbon (in above ground biomass, below ground biomass, deadwood, litter and SOC).
- Increasing biodiversity in the project areas, by:
  - increasing soil quality and SOM content, through the addition of leaf litter;
  - reducing soil temperatures due to an improved canopy cover;
  - increasing water retention through improved infiltration into soils;
  - attracting (indigenous) flora and fauna to the previously degraded areas due a favourable environment; and
  - dispersing trees and shrubs through the project area by browsers, birds and insects (see section 1.8).
- Improving ecosystem services in surrounding areas through cross boundary flows from the restored thicket ecosystems, and through improved water retention in the restored areas.

G3.2. Describe each project activity with expected climate, community and biodiversity impacts and its relevance to achieving the project's objectives.

The proposed ARR project activities include:

- The planting of the *P. afra* cuttings, which involves the following actions (see Section 1.8 for details on each point);
- selection of planting sites;
- appointment of contractors;
- harvesting of *P. afra* cuttings from within the project area;
- planting of *P. afra* cuttings within the planting sites; and
- supplemental planting of *P. afra* cuttings where required.

- Monitoring after planting (see Section 3).

The planting of the *P.afra* cuttings is the principle activity of the proposed ARR project, and its subsequent growth and expected dispersal will realise the objectives listed in G3.1.

G3.3. Provide a map identifying the project location and boundaries of the project area(s), where the project activities will occur, of the project zone and of additional surrounding locations that are predicted to be impacted by project activities (e.g. through leakage).

Maps outlining the project areas are provided in Annex 12.

G3.4. Define the project lifetime and GHG accounting period and explain and justify any differences between them. Define an implementation schedule, indicating key dates and milestones in the project's development.

The proposed ARR project lifetime will be 60 years. The project schedule is detailed in Section 7.

G3.5. Identify likely natural and human-induced risks to the expected climate, community and biodiversity benefits during the project lifetime and outline measures adopted to mitigate these risks.

The risks to the proposed ARR project are detailed in Section 1.11.

G3.6. Demonstrate that the project design includes specific measures to ensure the maintenance or enhancement of the High Conservation Value attributes identified in G1 consistent with the precautionary principle.

All proposed ARR project activities will take place within two nature reserves and a national park, and in keeping with the relevant management plans. The proposed ARR project activities will therefore not be to the detriment of the identified High Conservation Value attributes.

G3.7. Describe the measures that will be taken to maintain and enhance the climate, community and biodiversity benefits beyond the project lifetime.

The restored thicket will be within the boundaries of two nature reserves and a national park, and therefore protected by the relevant legislation (see Section 2.5) for the duration of the proposed ARR project and beyond.

G3.8. Document and defend how communities and other stakeholders potentially affected by the project activities have been identified and have been involved in project design through effective consultation, particularly with a view to optimizing community and stakeholder benefits, respecting local customs and values and maintaining high conservation values. Project developers must document stakeholder dialogues and indicate if and how the project proposal was revised based on such input. A plan must be developed to continue communication and consultation between project managers and all community groups about the project and its impacts to facilitate adaptive management throughout the life of the project.

The stakeholder engagement process is detailed in Section 6 as well as Annex 11.

G3.9. Describe what specific steps have been taken, and communications methods used, to publicize the CCBA public comment period to communities and other stakeholders and to facilitate their submission of comments to CCBA. Project proponents must play an active role in distributing key project documents to affected communities and stakeholders and hold widely publicized information meetings in relevant local or regional languages.

GIB will ensure that the CCBA public comment period is publicized and understood by the communities listed in Section 1.5. This will be through verbal communication, through the contractors and workers already working for GIB, as well as through direct engagement with the relevant communities.

G3.10. Formalize a clear process for handling unresolved conflicts and grievances that arise during project planning and implementation. The project design must include a process for hearing, responding to and resolving community and other stakeholder grievances within a reasonable time period. This grievance process must be publicized to communities and other stakeholders and must be managed by a third party or mediator to prevent any conflict of interest. Project management must attempt to resolve all reasonable grievances raised, and provide a written response to grievances within 30 days. Grievances and project responses must be documented.

The mechanism for on-going communication is described in Section 6.3.

G3.11. Demonstrate that financial mechanisms adopted, including projected revenues from emissions reductions and other sources, are likely to provide an adequate flow of funds for project implementation and to achieve the anticipated climate, community and biodiversity benefits.

Public funding information is provided in Annex 2. Management of VERs and generated funds will be undertaken according to the system described in Section 1.15.1.

G4. Management Capacity and Best Practices

Concept

G4.1. Identify a single project proponent which is responsible for the project's design and implementation. If multiple organizations or individuals are involved in the project's development and implementation the governance structure, roles and responsibilities of each of the organizations or individuals involved must also be described.

The roles and responsibilities of all project proponents are listed in Section 1.15. The proposed ARR project will be implemented by the GIB, a well-established organisation that is based in the region.

G4.2. Document key technical skills that will be required to implement the project successfully, including community engagement, biodiversity assessment and carbon measurement and monitoring skills. Document the management team's expertise and prior experience implementing land management projects at the scale of this project. If relevant experience is lacking, the proponents must either demonstrate how other organizations will be partnered with to support the project or have a recruitment strategy to fill the gaps.

GIB will manage the activities listed in Section 1.8. The technical requirements for the project are relatively simple, and have been proved in the field. Field managers have been trained in monitoring operations, and collected data is housed in a custom-built spatial database that is regularly backed up. Subsequent to planting, the management requirements of the proposed ARR project are minimal due to the resilience of the *P. afra* plantings. With regard to prior experience, GIB has a long track record of successful projects, which is highlighted by the following awards:

- In 2007, GIB was awarded the Water Conservation and Demand Management Trophy (the only award in the agricultural sector on a national basis).
- In 2007, the GIB-run Sand/Bulk Alien Vegetation Clearing Project was awarded winner of the National Project Flagship Competition.
- In 2006, the Working for Water Project in Port Elizabeth (run by GIB) won the Airport Managers Award for Excellence.

G4.3. Include a plan to provide orientation and training for the project's employees and relevant people from the communities with an objective of building locally useful skills and knowledge to increase local participation in project implementation. These capacity building efforts should target a wide range of people in the communities, including minority and underrepresented groups. Identify how training will be passed on to new workers when there is staff turnover, so that local capacity will not be lost.

The capacity building, skills transfer and poverty alleviation aspects of the proposed ARR project are discussed in Section 1.16.2.

G4.4. Show that people from the communities will be given an equal opportunity to fill all employment positions (including management) if the job requirements are met. Project proponents must explain how employees will be selected for positions and where relevant, must indicate how local community members, including women and other potentially underrepresented groups, will be given a fair chance to fill positions for which they can be trained.

The composition of the teams and principles of selection are explained in Section 1.16.2.

G4.5. Submit a list of all relevant laws and regulations covering worker's rights in the host country. Describe how the project will inform workers about their rights. Provide assurance that the project meets or exceeds all applicable laws and/or regulations covering worker rights and, where relevant, demonstrate how compliance is achieved.

South African labour legislation provides a substantial package of labour rights for workers. The principle statutes providing these protections are presented in the table below (Benjamin, 2008).

Statute	**Labour Protections**
Labour Relations Act 66 of 1995	Freedom of association, organisational rights, collective bargaining; right to strike; and protection against unfair dismissal
Basic Conditions of Employment Act 75 of 1997	Hours of work, annual leave, sick leave, maternity leave, severance pay, notice pay; sectoral determinations
Employment Equity Act 55 of 1998	Anti-discrimination and affirmative action
Unemployment Insurance Act of 2001	Skills development and training
Skills Development Act 97 of 1998	Unemployment and maternity benefits
Compensation for Occupational Diseases Act 130 of 1993	Compensation for work-related injuries and diseases

Occupational Safety and Health| Act 85 of 1993; Mine Health and Safety Act 29 of 1996	Health and safety in the workplace

GIB routinely informs all workers of their rights, when contracts are signed.

G4.6. Comprehensively assess situations and occupations that pose a substantial risk to worker safety. A plan must be in place to inform workers of risks and to explain how to minimize such risks. Where worker safety cannot be guaranteed, project proponents must show how the risks will be minimized using best work practices.

There is very little risk associated with the activities undertaken by the workers. Workers using the mechanical auger will be properly trained by the contractors to minimise risks.

G4.7. Document the financial health of the implementing organization(s) to demonstrate that financial resources budgeted will be adequate to implement the project.

Funding for the implementation of the proposed ARR project by GIB has been through the Department of Water Affairs (DWA, formerly the Department of Water Affairs and Forestry), as detailed in Section 1.6.

G5. Legal Status and Property Rights
Concept
G5.1. Submit a list of all relevant national and local laws and regulations in the host country and all applicable international treaties and agreements. Provide assurance that the project will comply with these and, where relevant, demonstrate how compliance is achieved.

The relevant environmental legislation for sustainable development and over-arching international and national treaties with which the proposed ARR project activities will comply are listed in Section 1.10.

G5.2. Document that the project has approval from the appropriate authorities, including the established formal and/or traditional authorities customarily required by the communities.

Letters of approval for the proposed ARR project are presented in Annex 5. Approval of proposed ARR the project by surrounding communities is documented in Section 6.

G5.3. Demonstrate with documented consultations and agreements that the project will not encroach uninvited on private property, community property, or government property and has obtained the free, prior, and informed consent of those whose rights will be affected by the project.

All proposed ARR project activities will be on state land (two nature reserves and a national park; see Section 8). Letters of approval for the proposed ARR project are presented in Annex 5.

G5.4. Demonstrate that the project does not require the involuntary relocation of people or of the activities important for the livelihoods and culture of the communities. If any relocation of habitation or activities is undertaken within the terms of an agreement, the project proponents must demonstrate that the agreement

was made with the free, prior, and informed consent of those concerned and includes provisions for just and fair compensation.

No communities or individuals have been or will be relocated as a consequence of the proposed ARR project.

G5.5. Identify any illegal activities that could affect the project's climate, community or biodiversity impacts (e.g., logging) taking place in the project zone and describe how the project will help to reduce these activities so that project benefits are not derived from illegal activities.

There are no such illegal activities taking place in the project areas, which are in two nature reserves and a national park.

G5.6. Demonstrate that the project proponents have clear, uncontested title to the carbon rights, or provide legal documentation demonstrating that the project is undertaken on behalf of the carbon owners with their full consent. Where local or national conditions preclude clear title to the carbon rights at the time of validation against the Standards, the project proponents must provide evidence that their ownership of carbon rights is likely to be established before they enter into any transactions concerning the project's carbon assets.

The management and ownership of the carbon rights is detailed in Section 1.15.1.

SECTION CL: CLIMATE SECTION

CL1. Net Positive Climate Impacts
Concept
CL1.1. Estimate the net change in carbon stocks due to the project activities using the methods of calculation, formulae and default values of the IPCC 2006 GL for AFOLU or using a more robust and detailed methodology. The net change is equal to carbon stock changes with the project minus carbon stock changes without the project (the latter having been estimated in G2). This estimate must be based on clearly defined and defendable assumptions about how project activities will alter GHG emissions or carbon stocks over the duration of the project or the project GHG accounting period..

The net change in carbon stock as a result of the proposed ARR project is summarized in Section 4.4.1. The method and calculations used are explained in Section 4.

CL1.2. Estimate the net change in the emissions of non-CO_2 GHG emissions such as CH_4 and N_2O in the with and without project scenarios if those gases are likely to account for more than a 5% increase or decrease (in terms of CO_2-equivalent) of the project's overall GHG emissions reductions or removals over each monitoring period.

The emission of non-CO_2 GHG will be less than 5 % of the overall GHG removal for the proposed ARR project, as detailed in Section 4.3.2.

CL1.3. Estimate any other GHG emissions resulting from project activities. Emissions sources include, but are not limited to, emissions from biomass burning during site preparation, emissions from fossil fuel combustion, direct emissions from the use of synthetic fertilizers, and emissions from the decomposition of N-fixing species.

Non-CO_2 GHG emissions are estimated in Section 4.3.2.

CL1.4. Demonstrate that the net climate impact of the project is positive. The net climate impact of the project is the net change in carbon stocks plus net change in non-CO_2 GHGs where appropriate minus any other GHG emissions resulting from project activities minus any likely project-related unmitigated negative offsite climate impacts (see CL2.3).

The net climate impact of the proposed ARR project is positive, as detailed in Section 4.4.1.

CL1.5. Specify how double counting of GHG emissions reductions or removals will be avoided, particularly for offsets sold on the voluntary market and generated in a country with an emissions cap.

Not applicable.

CL2. Offsite Climate Impacts ('Leakage')

CL2.1. Determine the types of leakage that are expected and estimate potential offsite increases in GHGs (increases in emissions or decreases in sequestration) due to project activities. Where relevant, define and justify where leakage is most likely to take place.

The project areas consist of severely degraded lands with low biomass levels, and the land use is unchanged. Consequently, the land should continue to provide the same services, and there is no anticipated leakage as a result of project activities (see Section 4.3.3).

CL2.2. Document how any leakage will be mitigated and estimate the extent to which such impacts will be reduced by these mitigation activities.

Not applicable.

CL2.3. Subtract any likely project-related unmitigated negative offsite climate impacts from the climate benefits being claimed by the project and demonstrate that this has been included in the evaluation of net climate impact of the project (as calculated in CL1.4).

Not applicable.

CL2.4. Non-CO_2 gases must be included if they are likely to account for more than a 5% increase or decrease (in terms of CO_2-equivalent) of the net change calculations (above) of the project's overall off-site GHG emissions reductions or removals over each monitoring period.

The emission of non-CO_2 GHG will be less than 5 % of the overall GHG removal of the overall project, as detailed in Section 4.3.2.

CL3. Climate Impact Monitoring

CL3.1. Develop an initial plan for selecting carbon pools and non-CO_2 GHGs to be monitored, and determine the frequency of monitoring. Potential pools include aboveground biomass, litter, dead wood, belowground biomass, wood products, soil carbon and peat. Pools to monitor must include any pools expected to decrease as a result of project activities, including those in the region outside the project

boundaries resulting from all types of leakage identified in CL2. A plan must be in place to continue leakage monitoring for at least five years after all activity displacement or other leakage causing activity has taken place. Individual GHG sources may be considered 'insignificant' and do not have to be accounted for if together such omitted decreases in carbon pools and increases in GHG emissions amount to less than 5% of the total CO_2-equivalent benefits generated by the project. Non-CO_2 gases must be included if they are likely to account for more than 5% (in terms of CO_2-equivalent) of the project's overall GHG impact over each monitoring period. Direct field measurements using scientifically robust sampling must be used to measure more significant elements of the project's carbon stocks. Other data must be suitable to the project site and specific forest type.

The monitoring plan, which includes details regarding the purpose of monitoring, responsibilities, carbon pools to be monitored, quality control/assurance procedures, parameters and frequency of monitoring is detailed in Section 3.

CL3.2. Commit to developing a full monitoring plan within six months of the project start date or within twelve months of validation against the Standards and to disseminate this plan and the results of monitoring, ensuring that they are made publicly available on the internet and are communicated to the communities and other stakeholders.

The monitoring plan presented in Section 3 will be finalised within 12 months of validation against the Standards, and make publically available on the appropriate internet website.

SECTION CM: COMMUNITY SECTION

CM1. Net Positive Community Impacts

CM1.1. Use appropriate methodologies to estimate the impacts on communities, including all constituent socio-economic or cultural groups such as indigenous peoples (defined in G1), resulting from planned project activities. A credible estimate of impacts must include changes in community well-being due to project activities and an evaluation of the impacts by the affected groups. This estimate must be based on clearly defined and defendable assumptions about how project activities will alter social and economic well-being41, including potential impacts of changes in natural resources and ecosystem services identified as important by the communities (including water and soil resources), over the duration of the project. The 'with project' scenario must then be compared with the 'without project' scenario of social and economic well-being in the absence of the project (completed in G2). The difference (i.e., the community benefit) must be positive for all community groups.

The community engagement methods used are described in Section 6, and the four MSc theses resulting from the community interaction are summarized in Annex 11. The major benefit of the proposed ARR project on surrounding communities will be the creation of an estimated 300 jobs and the resultant poverty alleviation. This is significant in a region of 39.5 % unemployment. Employment details and worker team composition and training are described in Section 1.16.2.

Adjacent to the project areas, the proposed ARR project is likely to stimulate tourism-derived economic opportunities as well as supporting emerging initiatives such as community bee-keeping and medicinal plant collection. Although utilization of the restored thicket is not permitted within the project areas because they are in two nature reserves and a national park, surrounding communities will benefit from cross-boundary flows as a result of the restored thicket ecosystem. The reliance of the surrounding communities on the ecosystem services provided by the thicket is detailed in Annex 11.

The project activities will generate net positive community benefits, when compared to the 'without project' scenario, most notably through the creation of jobs.

CM1.2. Demonstrate that no High Conservation Values identified in G1.8.4-6 will be negatively affected by the project.

The proposed ARR project will not negatively affect areas that provide critical ecosystem services, areas that are fundamental for the livelihoods of local communities, or areas that are critical for the traditional cultural identity of communities.

Whilst all proposed ARR project activities will be in two nature reserves and a national park which prohibits resource utilization within the project areas, cross boundary flows will result in improved thicket conditions outside of the project areas. Ecosystem services, such as access to clean drinking water, will therefore be improved outside of the project areas as a result of the restored thicket, thereby benefiting the surrounding communities (see Annex 11).

CM2. Offsite Stakeholder Impacts

CM2.1. Identify any potential negative offsite stakeholder impacts that the project activities are likely to cause.

The proposed ARR project will not cause any negative offsite stakeholder impacts.

CM2.2. Describe how the project plans to mitigate these negative offsite social and economic impacts.

Not applicable.

CM2.3. Demonstrate that the project is not likely to result in net negative impacts on the well-being of other stakeholder groups.

The proposed ARR project will not cause any negative impacts for any stakeholders in the project.

CM3. Community Impact Monitoring
Concept
CM3.1. Develop an initial plan for selecting community variables to be monitored and the frequency of monitoring and reporting to ensure that monitoring variables are directly linked to the project's community development objectives and to anticipated impacts (positive and negative).

A community impact monitoring plan is currently being developed by GIB to monitor the well-being of workers benefitting from the project activities. Monitoring will be in the form of a questionnaire/interview, designed to understand the changes in the workers' perception of their well-being as a result of the project activities, as well as their perception of the impact on the communities in which they live. Monitoring will be undertaken on an annual basis, and every labourer employed by GIB's contractors will be interviewed.

CM3.2. Develop an initial plan for how they will assess the effectiveness of measures used to maintain or enhance High Conservation Values related to community well-being (G1.8.4-6) present in the project zone.

The proposed ARR project will not negatively affect areas that provide critical ecosystem services, areas that are fundamental for the livelihoods of local communities, and areas that are critical for the traditional cultural identity of communities will not be negatively affected by the proposed ARR project. An assessment of the enhancement of these areas with respect to community well-being will be incorporated into the questionnaire.

CM3.3. Commit to developing a full monitoring plan within six months of the project start date or within twelve months of validation against the Standards and to disseminate this plan and the results of monitoring, ensuring that they are made publicly available on the internet and are communicated to the communities and other stakeholders.

An assessment of the effectiveness of the questionnaire will be undertaken after the first interview process, and a full monitoring plan will be developed within 12 months of validation against the CCB Standards. The plan and the results of the monitoring process will be made publically available on the appropriate internet website, and printed reports will be given to the workers to take back to their respective communities. Comments and suggestions received will be used to strengthen the effectiveness of the monitoring process.

BIODIVERSITY SECTION

B1. Net Positive Biodiversity Impacts

Indicators

B1.1. Use appropriate methodologies to estimate changes in biodiversity as a result of the project in the project zone and in the project lifetime. This estimate must be based on clearly defined and defendable assumptions. The 'with project' scenario should then be compared with the baseline 'without project' biodiversity scenario completed in G2. The difference (i.e., the net biodiversity benefit) must be positive.

The proposed ARR project will restore degraded thicket by planting cuttings of *P. afra*, which is able to re-establish from cuttings and grow rapidly into tall dense vegetation, without irrigation. *P. afra* is particularly suitable for restoring degraded thicket due to:

- the ability of *P.afra* to produce approximately 4.6 tonnes of litter per hectare per year, which is comparable to wet forest ecosystems and five to 35 times higher than that of other semi-arid ecosystems (Mills & Cowling, 2010);
- the dense canopy, which maintains a microclimate of cool and dry conditions, conducive to the slow decomposition of leaf mulch on the thicket floor and in the soil (Mills & Fey 2004a; 2004b); and
- the fact that *P.afra* is fire-resistant (see Section 1.4).

These factors enable large amounts of carbon to accumulate within the soil and consequently improve soil fertility. This will facilitate natural ecosystem recovery and increase shrub and tree recruitment and thus diversity. This increased diversity will induce grazing and browsing by game within the project areas, which will promote *P. afra* growth (see Section 1.8). The overall affect will be an increase in biodiversity of the previously degraded areas. Such an increase has been observed at several restoration sites (van der Vyver, 2011).

In the absence of the proposed ARR project activities, the landscape to be restored would remain degraded. Current environmental conditions would not permit natural recovery of thicket within these areas, due to the high soil temperatures as a result of the lack of canopy, reduced soil quality and reduced soil moisture content of degraded landscapes (Mills & Fey, Transformation of thicket to savanna reduces soil quality in the Eastern Cape, South Africa., 2004b). As a result, there would be no increase in the biodiversity and none of the benefits of the project (see Sections 1.16.2 and 5) would be realised.

The net biodiversity difference for the 'with project' scenario is thus positive, when compared to the 'without project' scenario.

B1.2. Demonstrate that no High Conservation Values identified in G1.8.1-3 will be negatively affected by the project.

The proposed ARR project will not negatively affect globally, regionally or nationally significant concentrations of biodiversity values, large landscape-level areas where viable populations of most if not all naturally occurring species exist in natural patterns of distribution and abundance, or threatened or rare ecosystems will not be negatively affected by the proposed ARR project.

The proposed ARR project activities will take place within two nature reserves and a national park (all Protected Areas), which were formed to protect biodiversity. The project activities will preserve and increase this biodiversity. The project areas contain several threatened species, including the Black Rhinoceros (*Diceros bicornis*). Thicket forms part of its diet and thus Black Rhinoceros populations will benefit from the project activities (Brown, 2008). The project areas contain a number of endemic species, including *inter alia*: *Aloe pictifolia, Gasteria ellaphieae, Gasteria glomerata* and *Gasteria rawlinsonii*, all of which are Red Data List species. Through the restoration of thicket in the project areas, the proposed ARR project will benefit these rare and vulnerable species. Full Red Data lists per project area are provided in Annex 12.

B1.3. Identify all species to be used by the project and show that no known invasive species will be introduced into any area affected by the project and that the population of any invasive species will not increase as a result of the project.

P. afra is the only species to be used in the proposed ARR project. *P. afra* is a native and often dominant species within the project areas (Mucina & Rutherford, 2006). The *P. afra* cuttings used in the proposed ARR project are obtained from wild plants within 50 km of each the project areas, in order to reduce risks of 'genetic pollution'. These cuttings are obtained through a sustainable harvesting process, thereby minimising the impacts of harvesting on wild plants.

B1.4. Describe possible adverse effects of non-native species used by the project on the region's environment, including impacts on native species and disease introduction or facilitation. Project proponents must justify any use of non-native species over native species.

Not applicable.

B1.5. Guarantee that no GMOs will be used to generate GHG emissions reductions or removals.

No GMOs will be used in the proposed ARR project.

B2. Offsite Biodiversity Impacts
Indicators
B2.1. Identify potential negative offsite biodiversity impacts that the project is likely to cause.

The proposed ARR project activities are not expected to result in any negative offsite biodiversity impacts. Through an increase in biodiversity within the project areas and the expected cross-boundary flow to surrounding areas, offsite biodiversity will be positively impacted by the proposed ARR project activities. Improved water retention of the restored areas will result in an increased and regulated flow to surrounding areas, further benefitting biodiversity (see Section 1.16.2).

B2.2. Document how the project plans to mitigate these negative offsite biodiversity impacts.

Not applicable.

B2.3. Evaluate likely unmitigated negative offsite biodiversity impacts against the biodiversity benefits of the project within the project boundaries. Justify and demonstrate that the net effect of the project on biodiversity is positive.

Not applicable.

B3. Biodiversity Impact Monitoring
Indicators
B3.1. Develop an initial plan for selecting biodiversity variables to be monitored and the frequency of monitoring and reporting to ensure that monitoring variables are directly linked to the project's biodiversity objectives and to anticipated impacts (positive and negative).49

A biodiversity monitoring plan is currently being developed by GIB, with input from thicket specialists. Species counts in transects through a selection of the sample plots (see Section 3.2.5i) will be undertaken by an ecologist. Plant species within the transects, and bird, mammal and reptile species within the sample plots will be recorded. Insect traps will be used to count the number of insects in each transect. Monitoring will occur every five years during the growth monitoring (Section 3) surveys. A baseline species count will be made for each biodiversity sample plot planted subsequent to validation against the CCB Standards. The results will be compared to counts every five years thereafter to gain an understanding of the expected increase in biodiversity in the project areas.

B3.2. Develop an initial plan for assessing the effectiveness of measures used to maintain or enhance High Conservation Values related to globally, regionally or nationally significant biodiversity (G1.8.1-3) present in the project zone.

The above monitoring plan will assess the effectiveness of restored thicket in enhancing the biodiversity of the project areas, which qualify as High Conservation Value areas.

B3.3. Commit to developing a full monitoring plan within six months of the project start date or within twelve months of validation against the Standards and to disseminate this plan and the results of monitoring, ensuring that they are made publicly available on the internet and are communicated to the communities and other stakeholders.

The biodiversity monitoring plan currently being developed will be reviewed after implementation in the field and a full biodiversity monitoring plan will be developed within 12 months of validation against the CCB Standards. The plan and results will be made publically available on the appropriate internet website, and printed copies will be provided to stakeholders upon specific request.

GOLD LEVEL SECTION

GL1. Climate Change Adaptation Benefits

The proposed ARR project is not applying for Gold Level Climate Change Adaptation Benefits validation at this stage.

GL2. Exceptional Community Benefits
Concept
The proposed ARR project is not applying for Gold Level Exceptional Community Benefits validation at this stage.

GL3. Exceptional Biodiversity Benefits

GL3.1. Vulnerability
Regular occurrence of a globally threatened species (according to the IUCN Red List) at the site:
3.1.1. Critically Endangered (CR) and Endangered (EN) species - presence of at least a single individual; or
3.1.2. Vulnerable species (VU) - presence of at least 30 individuals or 10 pairs.

The project areas (collectively) contain:

- 2 Critically Endangered (CR) species;
- 6 Endangered (EN) species; and
- 41 Vulnerable (VU) species.

Red Data Lists for flora and fauna for each project area are provided in Annex 12.

Or,

GL3.2. Irreplaceability
A minimum proportion of a species' global population present at the site at any stage of the species' lifecycle according to the following thresholds:
3.2.1. Restricted-range species - species with a global range less than 50,000 km2 and 5% of global population at the site; or
3.2.2. Species with large but clumped distributions - 5% of the global population at the site; or
3.2.3. Globally significant congregations - 1% of the global population seasonally at the site; or
3.2.4. Globally significant source populations - 1% of the global population at the site;

The proposed ARR project is applying for Gold Level Exceptional Biodiversity Benefits validation based on GL3.1 only at this stage.

Annex 7 Carbon stocks meta-analysis from literature sources

There has been considerable research in the field of carbon sequestration potential in the Subtropical Thicket Biome, and particularly in terms of spekboom, over the last ten years. A meta-analysis of these sequestration rates was undertaken to obtain realistic estimates of the rate of carbon accumulation from degraded lands to intact thicket, over a 50-year period. An overview of this literature review is presented here. Final (50 year) carbon stock figures are taken from analyses of both old *P. afra* planting sites and pristine spekboom thicket. The gradient of the slopes is used as an estimate of the annual carbon accumulation rate in each of the carbon pools, and for the *ex ante* calculations.

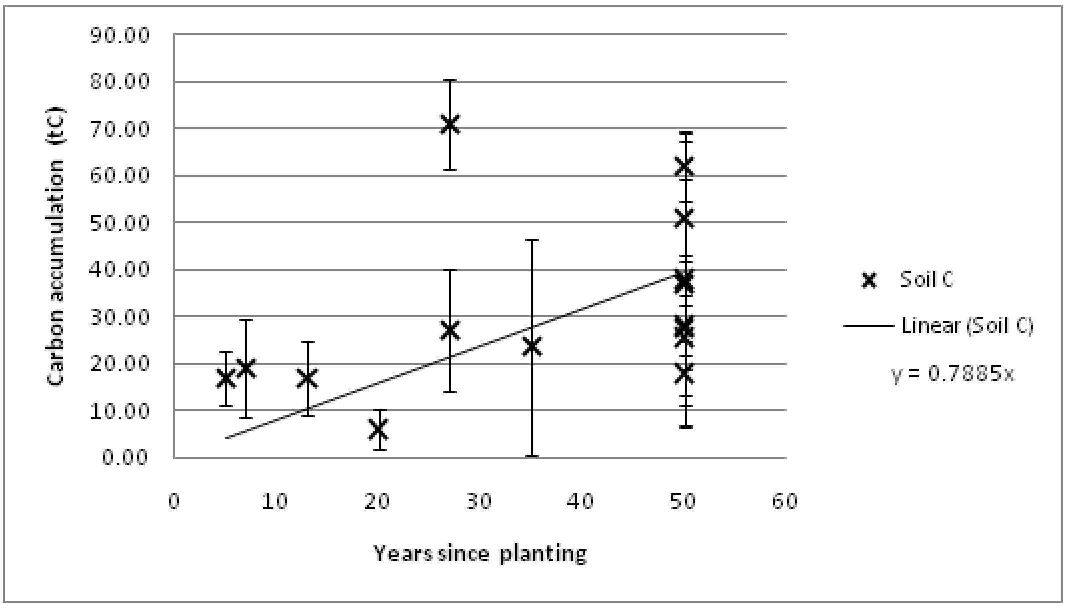


Figure A. 7.1: The rate of accumulation of carbon in the soil of degraded or bare land replanted with *P. afra* (obtained from multiple literature sources, see Table A.7.1).

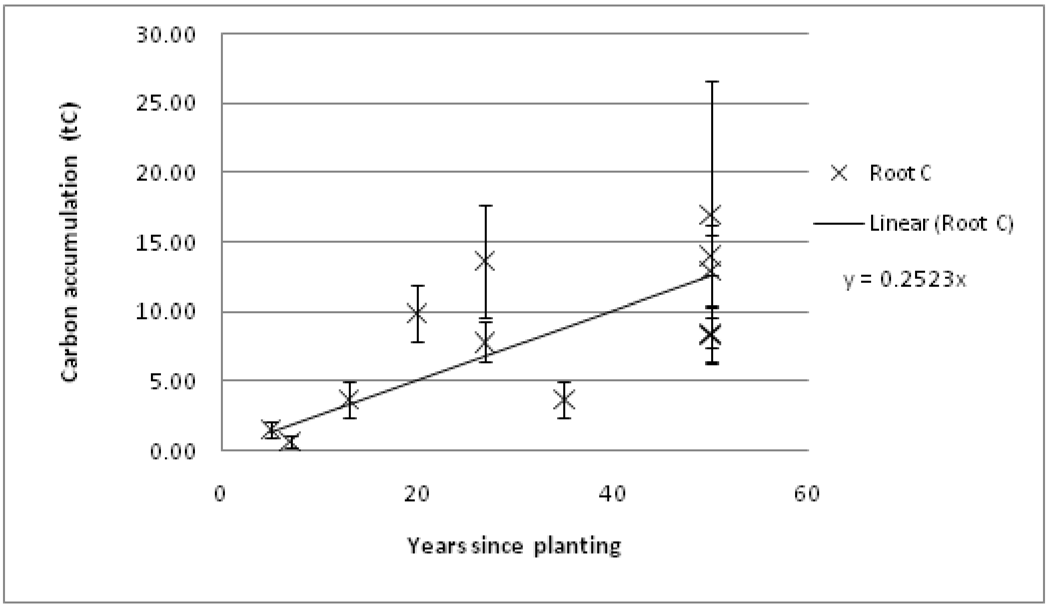


Figure A. 7.2: The rate of carbon accumulation in the roots of *P. afra* planted on degraded land (obtained from multiple literature sources, see Table A.7.1).

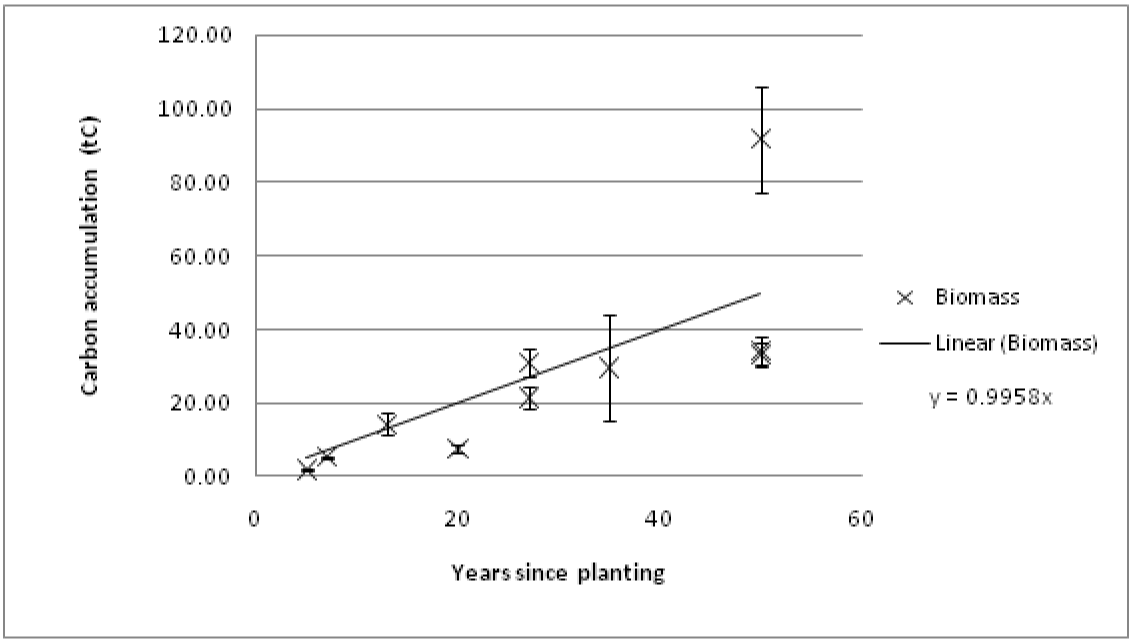


Figure A. 7.3: The rate of carbon accumulation in the above ground biomass of *P. afra* planted on degraded land (obtained from multiple literature sources, see Table A.7.1).

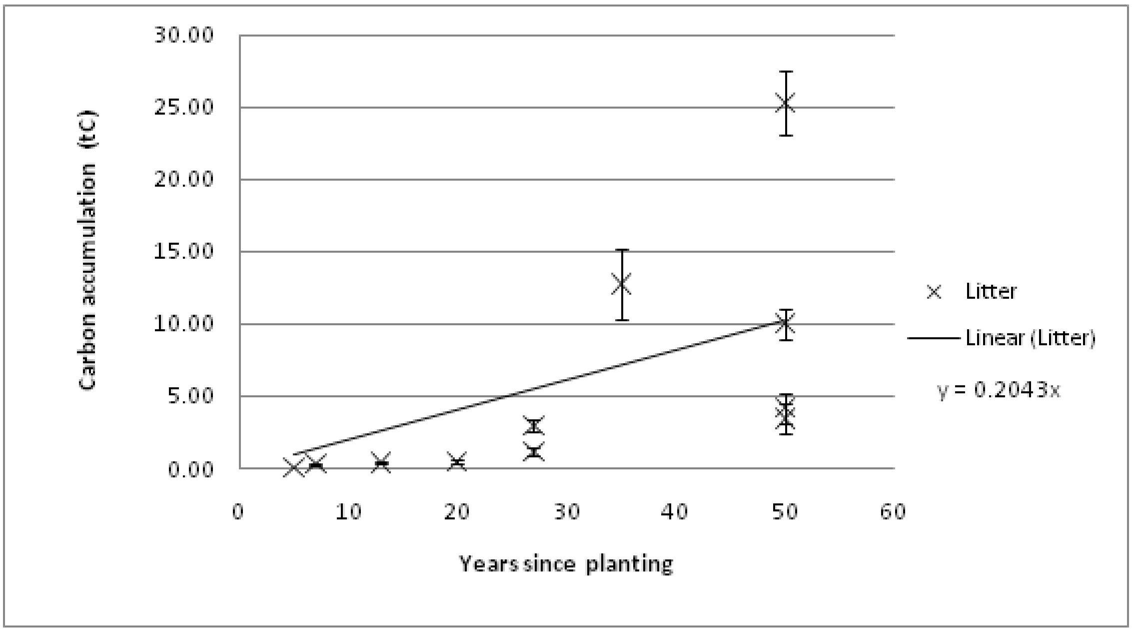


Figure A. 7.4: The rate of carbon accumulation in litter generated by *P. afra* planted on degraded land (obtained from multiple literature sources, see Table A.7.1).

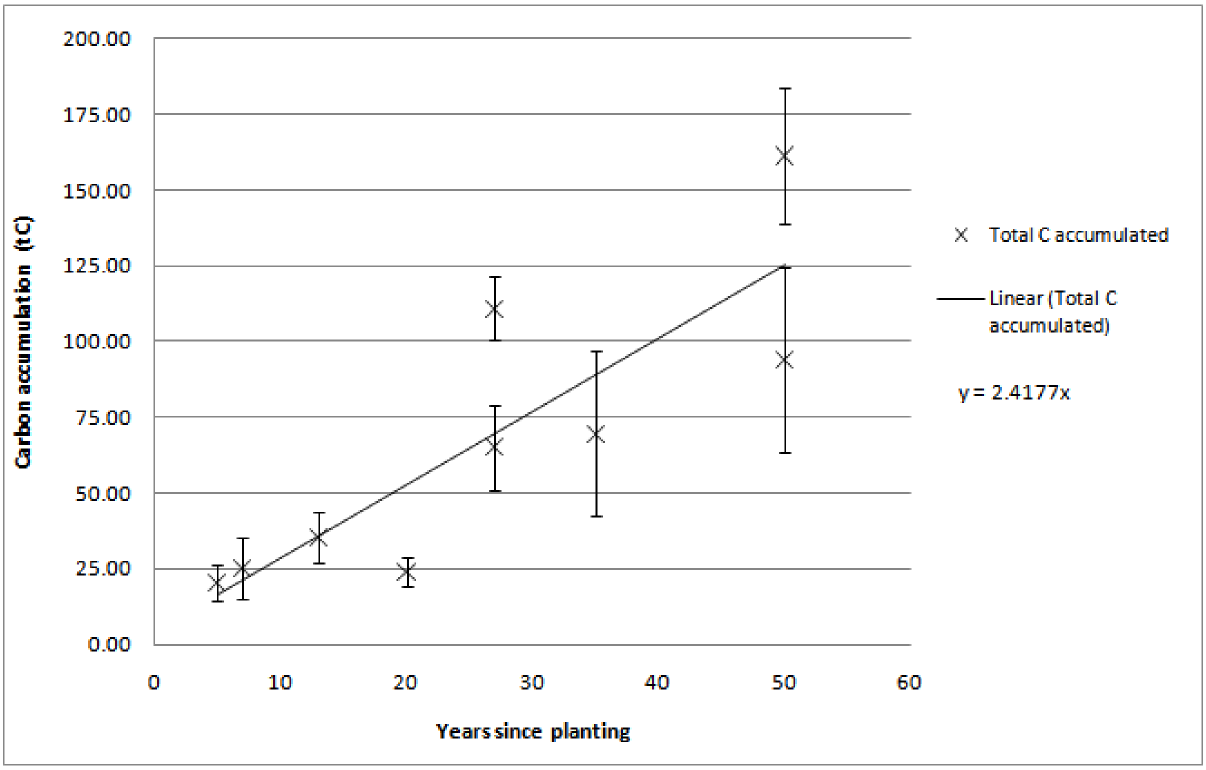


Figure A. 7.5: Total carbon accumulation rate by *P. afra* planted on degraded land (obtained from multiple literature sources, see Table A.7.1).

The actual calculations and sources of data are available in Annex 14.

Table A. 7.1: Literature review of carbon stocks in multiple thicket sites in the Eastern Cape.

Site	Comments	GPS coordinates	Soil (t C ha^{-1})	Depth (cm)	Roots (t C ha^{-1})	AGB (t C ha^{-1})	Litter (t C ha^{-1})	Reference
Rhinosterhoek (Warren Rudman)	50 year old restored site		100.55 ±10.9	60	17.33 ±9.59	107.63 ±10.7	25.29 ±2.2	(van der Vyver, 2011)
	35 year old restored site		96.75 ±20.95	60	4.07 ±1.33	45.41 ±10.58	12.76 ±2.41	
	Degraded land adjacent to restored site		73.1 ±9.3	60	0.38 ±0.08	15.89 ±9.81	0.03 ±0.01	
Baviaanskloof (Baviaans Spekboom Thicket)	Intact thicket		93 ±7	100	11 ±2	–	–	Mills & Cowling, 2010
	Degraded thicket		31 ±2	100	2.7 ±0.3	–	–	
	Old lands		42 ±4	100	2.6 ±0.3	–	–	
Xeric Succulent Thicket (8 Kirkwood sites)	Intact		168 ±26	50	25 ±1.3	–	–	(Mills, et al., 2005b)
	Degraded		131 ±16	50	11 ±0.6	–	–	
	Intact		133 ±27	30	–	40 ±3	11 ±1	(Mills A. J., et al., 2005a)
	Degraded		95 ±15	30	–	7 ±1	1 ±0.4	
Krompoort	27 year old restored site (berg spekboom)		118 ±8	100	9.3 ±1.4	30.9 ±4	1.2 ±0.3	(Mills & Cowling, Rate of carbon sequestration at two thicket restoration sites in the Eastern Cape, South Africa, 2006)
	27 year old restored site (local spekboom)		74 ±12	100	15.1 ±4	21.5 ±3	3 ±0.4	
	13 year old restored site		64 ±6	100	5.2 ±1.3	14.2 ±3	0.4 ±0.01	
	7 year old restored site		66 ±9	100	2.1 ±0.3	5.3 ±0.2	0.3 ±0.1	
	5 year old restored site		64 ±3	100	3 ±0.5	1.9 ±0.2	0.03 ±	
	Degraded		47 ±5	100	1.5 ±0.3	–	–	
Fish River Reserve	Intact thicket		69 ±6	100	16.3 ±3.3	34.2 ±4	–	(Mills & Cowling, Rate of carbon sequestration at two thicket restoration
	Open bare land		51 ±3	100	3.4 ±0.3	–	–	
	20 year old restored site		57 ±3	100	13.3 ±2	7.7 ±1	0.5 ±0.1	

							sites in the Eastern Cape, South Africa, 2006)
Baviaanskloof (Baviaans Spekboom Thicket)	Intact thicket	49.68 ±6.21	25	3.6 ±0.58	29 ±3.32	4.85 ±0.99	(Powell M. J., 2009)
	Degraded thicket	21.56 ±1.67	25	2.62 ±0.63	4 ±0.72	1.39 ±0.31	
	Old lands	24.06 ±2.34	25	3.34 ±0.78	5.4 ±1.58	0.66 ±0.25	

Annex 8 Carbon stocks field analysis

Although the chosen methodology does not require quantification of GHG emissions for the baseline scenario; the effects of degradation on carbon pools in thicket ecosystems have been explored by this project. This afforded GIB the opportunity to develop a project specific root-shoot ratio and calculate annual increases in SOC. Carbon baselines (above ground biomass, below ground biomass and SOM to a depth of 110 cm) were measured in permanent plots in intact thicket (n=76), old fields (n=66) and degraded lands (n=100) in the Baviaanskloof Nature Reserve. The baseline carbon pools were measured in permanent, unplanted plots during the period 2004-2007. The measurements were taken according to the methodologies from the IPCC Good Practice Guidance for LULUCF (2003). GPS co-ordinates and soil data for each of the planting sites sampled for the baseline can be found in Annex 4 and Annex 8, respectively. The baseline study was completed on the 1st December 2007. The consultants used to establish this baseline were Mike Powell (Department of Environmental Science, Rhodes University, Grahamstown) and Dr Anthony Mills (Department of Soil Science, Stellenbosch University, Stellenbosch).

Baseline carbon pools collected were for:

- Above ground biomass;
- Below ground biomass; and
- Soil organic carbon.

Above ground tree biomass

Changes in tree biomass are calculated from monitoring data on individual trees in the permanent sampling plots. These plots were randomly selected in the different strata. The geographic coordinates of each plot were archived and the plots were marked with metal pegs in the field.

Nested plots, comprising small plots within larger plots, were used for monitoring the changes in stem diameter and tree density. Large plots were used for stem diameters greater than 10 cm, and small plots were used for stem diameters less than 10 cm. A minimum sample size of 10 large stem diameters and 10 small stem diameters in each plot was achieved. In the first ten years of the project there were very few trees with stem diameters greater than 10 cm in the restored planting sites. To achieve a minimum sample size of ten stems per plot, the sizes of permanent monitoring plots in some sites were increased.

Allometric equations that relate stem diameter at ground level to total carbon storage have been developed for *P. afra*. These equations were developed over the period 2004-2007 using at least 40 individual trees across a wide stem diameter range. AR-AM0002 (V3) uses allometric equations for determining carbon stocks based on tree diameter at breast height. The proposed ARR project allometric equations were parameterised on stem diameter at ground level. This is because stands of *P. afra* are multi-stemmed and a ground-level measurement is consequently more practical.

The allometric equation developed for *P. afra* is as follows:

$$Log_{10}y(C) = 1.1043(Log_{10}CBSA) + 2.4464$$

where:

$CBSA$ Combined basal stem area of plants (m^2).

The carbon stock in above ground tree biomass in the permanent monitoring plots was then calculated according to the following equation:

$$C_{AB,i,sp,j,t} = \sum_{l=1}^{N_{j,sp}} CF_j \cdot f_j(DBH) \qquad (8)$$

where:

$C_{AB,i,sp,j,t}$ Carbon stock in above ground biomass of trees of species j on sample plot *sp* for stratum I at time t; t C

CF_j Carbon fraction of dry matter for species or group of species type j, t C $(t.d.m.)^{-1}$; IPCC default value = 0.5

$f_j(DBH, H)$ An allometric equation linking above ground biomass of living trees (t d.m $tree^{-1}$) to mean diameter at breast height (DBH) and possibly tree height (H) for species j, at time t; t.d.m. $tree^{-1}$

i 1, 2, 3, ... M_{PS} strata in the project scenario

j 1, ... S_{PS} tree species in the project scenario; *P. afra* is the only species planted, therefore S_{PS} =1

l 1, 2, 3, ... $N_{j,sp}$ sequence number of individual trees of species j in sample plot sp

t 1, 2, 3, ... t^* years elapsed since the start of the A/R project activity

The average carbon stock of above ground biomass for each stratum was calculated by averaging across the plots in a stratum.

Below ground biomass

Most of the below ground biomass gain from the proposed ARR project has accrued from the planted *P. afra* cuttings. This carbon gain was measured directly using destructive sampling.

The destructive sampling was divided into two substrata: i) sample pits under the planted *P. afra* canopy; and ii) sample pits outside of the *P. afra* canopy. Samples were taken to a depth of 1 m from 10 cm x 10 cm holes. Roots were separated from soil using wet-sieving and were dried in an oven at 65 ^{o}C until constant mass was achieved. The roots were then weighed and the following equation[36] was used to calculate the root carbon stock:

$$C_{BB,i,sp,j,t} = \sum_{l=1}^{N_{j,sp}} CF_j \cdot W_j$$

where:

$C_{BB,i,sp,j,t}$ Carbon stock in below ground biomass of trees of species j on sample plot sp for stratum I at time t; t C

W_j Weight of the roots an individual tree of species j; kg C

The average carbon stock of below ground biomass for each stratum was calculated by averaging across the plots in a stratum.

Soil organic carbon

Soil samples were collected from a depth of 1 m in 10 cm x 10 cm holes from under and outside of the *P. afra* canopy for purposes of bulk density measurement. The volume of each

[36] This equation was derived independently using the mathematical principles in equation (8).

of these sample holes was determined using river sand of known bulk density. The mass of the rock fraction (i.e. > 2 mm) in each sample was removed by wet sieving and subsequently dried in an oven at 65 °C. The volume of the rock fraction was determined by placing the rock fraction into water within a measuring cylinder. Mean bulk density values for each land use category (as opposed to bulk density values in each soil pit) were used to calculate total soil C stocks at different soil depths.

The mass of carbon per unit volume was calculated by multiplying the carbon concentration (percentage mass) and bulk density. SOC on an equal volume basis was calculated using equation 4.3.3 from the IPCC Good Practice Guidance for LULUCF. The equation is as follows:

$$SOC = [SOC] \cdot Bulk\ Density \cdot Depth \cdot CoarseFragments \cdot M \qquad (4.3.3)$$

where:

SOC	Soil organic carbon in for soil of interest; t C ha^{-1}
$[SOC]$	Soil organic carbon (percentage mass) of the sample determined in the laboratory; g C (kg soil)$^{-1}$
$Bulk\ Density$	Bulk density (soil mass/volume of sample); Mg m^{-3}
$Depth$	Sampling depth of soil profile; m
$CoarseFragments$	Factor to adjust the fraction of sample occupied by coarse fragments (>2 mm) [1-(% volume of coarse fragments/100)] to area of sampling frame; m^{-2}
M	Multiplier to convert units into t C ha^{-1}

The average soil organic carbon accumulation for each stratum was calculated by averaging across the plots in a stratum.

Root-shoot ratio

Calculations for the root-shoot ratio were done using the above and below ground biomass results from intact sample sites. Values for the average above and below ground biomass per hectare were used as above and below ground measurements were not correlated to individual plants. Below ground biomass for root carbon stocks were taken from the 0-25 cm soil layer as this soil layer contains 97 % of the below ground root carbon stock. The equation used is as follows:

$$R_j = \frac{C_{AB,i,sp,j,t}}{C_{BB,i,sp,j,t}}$$

where:

R_j	Root-shoot ratio for species j; dimensionless
$C_{AB,i,sp,j,t}$	Carbon stock in above ground biomass of trees of species j on sample plot sp for stratum I at time t; t C
$C_{BB,i,sp,j,t}$	Carbon stock in below ground biomass of trees of species j on sample plot sp for stratum i at time t; t C

The above ground biomass carbon stock value was calculated by averaging the 2nd column of Table A.8.5, Table A.8.15 and Table A.8.10 and multiplying by 12/44. The below ground biomass carbon stock value was calculated by averaging the 5th column of Table A.8.3, Table A.8.4, Table A.8.8, Table A.8.9, Table A.8.13 and Table A.8.14, and multiplying by 12/44. The root-shoot ratio was thus calculated as:

$$\boldsymbol{R_j = 0.35}$$

Annual changes in soil organic carbon

The average annual SOC change in degraded planting sites was calculated by dividing the difference between degraded and intact SOC by the time to reach equilibrium (50 years). The SOC change in old fields was calculated in the same manner. Values for degraded, old and intact SOC were taken from the 0-25 cm soil layer as this soil layer contains 65 %, 46 % and 59 % respectively, of the total SOC.

The degraded SOC value was calculated by averaging the 5th column of Table A.8.1 and Table A.8.2 and multiplying by 12/44. The old land SOC value was calculated by averaging the 5th column of Table A.8.6 and Table A.8.7 and multiplying by 12/44. The intact land SOC value was calculated by averaging the 5th column of Table A.8.11 and Table A.8.12 and multiplying by 12/44. The average annual SOC change in degraded and old fields was calculated as 0.89 and 0.76 t C ha^{-1} yr^{-1} respectively.

Table A.8.1: Degraded lands soil carbon stocks (0-25 cm).

	Soil carbon stock (t CO_2 ha^{-1})			
Code	Depth A (0-3 cm)	Depth B (3-10 cm)	Depth C (10-25cm)	Total (0-25 cm)
KAD1	10	13	19	42
KAD2	22	38	33	93
KAD4	17	87	71	176
KAD5	26	32	58	117
KAD6	21	22	56	99
KAD7	23	37	12	71
KAD8	16	13	53	83
KAD9	24	31	50	105
KAD10	18	17	23	58
KDH1	11	16	21	48
KDH2	8	18	26	53
KDH3	9	18	26	54
KDH4	8	12	23	43
KDH5	13	24	49	86
KGHB1	16	10	24	51
KGHB2	6	6	18	30
KGHB3	7	15	21	43
KGHB4	8	11	10	29
KGHB5	11	15	18	44
KRC1	9	27	60	96
KRC2	4	9	21	34
KRC4	8	22	26	55
KRC5	2.6	10	4	16
RHDST1	10	13	38	61
RHDST2	12	10	19	41
RHDST3	13	32	27	72
RHDST4	14	5	16	34
RHDST5	17	17	54	87
RHDST6	5	12	17	35

RHDST7	13	32	35	80
RHDST9	10	23	35	68
RHDST10	12	42	17	71
RHDST11	15	27	48	90
RHDST13	20	39	44	104
RHDST14	18	30	77	125
RHDST15	15	52	76	143
RHDST16	5	1.8	12	18
RHDST17	8	8	11	27
RHDST18	4	2	4	10
RHDST19	5	8	16	29
RHDST20	8	6	13	27
RHDST22	8	17	31	56
RHDST23	14	25	39	78
RHDST24	8	8	26	42
RHDST25	10	27	42	80

Table A.8.2: Degraded lands soil carbon stocks (25- 110 cm).

	Soil carbon stock (t CO_2 ha^{-1})				
	Depth D (38-42 cm)	Depth E (58-62 cm)	Depth F (78-82 cm)	Depth G (98-102 cm)	Total
RHDST6	33.0	21.5	14.8	16.4	85.7
RHDST7	16.2	8.6	12.9	16.4	54.1
RHDST8	37.8	4.8	11.0	4.8	58.4
RHDST9	19.2	5.3	11.0	5.3	40.7
RHDST10	16.2	16.7	7.6	23.6	64.2
RHDST11	16.2	11.0	4.8	5.3	37.3
RHDST12	15.6	5.7	5.2	8.7	35.3
RHDST13	24.0	10.0	5.2	5.3	44.6
RHDST14	18.6	4.8	12.9	5.3	41.6
RHDST15	30.0	4.8	13.8	5.3	53.9
KDH1	4.2	4.3	3.3	19.3	31.1
KDH3	12.0	3.3	3.3	3.4	22.1
KGHB3	34.2	4.8	6.7	8.2	53.9
KGHB4	8.4	16.7	6.2	5.3	36.6

Table A.8.3: Degraded lands root carbon stocks (0-25 cm).

	Root carbon stock (t CO_2 ha^{-1})			
Code	Depth A (0-3 cm)	Depth B (3-10 cm)	Depth C (10-25 cm)	Total (0-25 cm)
KAD1	0.02	0.04	0.01	0.07
KAD3	0.02	0.42	0.13	0.57
KAD4	0.15	2	0.88	2.80
KAD5	0.07	0.06	0.03	0.16
KAD6	0.10	0.09	0.24	0.44

KAD7	0.25	0.08	0.04	0.37
KAD8	0.02	0.03	0.13	0.18
KAD9	0.03	0.03	0.03	0.08
KAD10	0.17	0.05	0.10	0.32
KDH1	0.38	1	1	3
KDH2	1	0.71	2.80	5
KDH3	2	4	3	9
KDH4	1	0.03	4	5
KDH5	0.00	0.00	3	3
KGH1	6	5	8	18
KGH2	0.01	4	6	11
KGH3	0.47	25	2	28
KGH4	0.00	0.66	2	3
KRC1	0.13	6	1	7
KRC2	0.07	1	2	3
KRC3	0.04	2	0.57	3
KRC4	0.09	0.05	0.07	0.21
RHDST2	2	2	2	7
RHDST3	1	3	1	6
RHDST4	2	2	3	6
RHDST5	3	2	8	13
RHDST6	0.76	1	1	3
RHDST7	3	4	2	9
RHDST8	0.20	0.41	1	2
RHDST9	3	5	3	11
RHDST10	0.07	4	3	7
RHDST11	0.01	0.72	0.42	1
RHDST12	1	0.70	0.72	2
RHDST13	0.23	1.28	3	5
RHDST14	0.11	0.64	3	4
RHDST15	5	0.78	2	7
RHDST16	0.05	0.63	0.68	1
RHDST17	0.05	0.41	3	4
RHDST18	0.53	0.38	6	7
RHDST19	0.81	1	2	4
RHDST20	0.01	0.14	0.29	0.44
RHDST21	0.20	0.41	0.42	1

Table A.8.4: Degraded lands root carbon stocks (25-110 cm).

	Root carbon stock (t CO_2 ha^{-1})				
	Depth D (38-42 cm)	Depth E (58-62 cm)	Depth F (78-82 cm)	Depth G (98-102 cm)	Total
KDH1	0.49	0.35	0.23	0.21	1.29
KDH3	0.48	0.02	0.11	0.10	0.72
KGH3	0.28	0.22	0.15	0.10	0.75
KGH4	0.42	0.20	0.15	0.07	0.84
KRC3	0.15	0.20	0.41	0.02	0.79
KRC4	0.32	0.10	0.08	0.16	0.66

RHDST6	0.24	0.13	0.11	0.02	0.50
RHDST7	0.87	0.15	0.28	0.04	1.34
RHDST8	0.05	0.02	0.03	0.42	0.52
RHDST9	0.08	0.02	0.02	0.02	0.14
RHDST10	1.07	0.27	0.03	0.02	1.38
RHDST16	15.24	0.02	0.06	0.04	15.37
RHDST17	0.32	0.09	0.26	0.17	0.85
RHDST18	0.77	0.68	0.41	0.68	2.54
RHDST19	2.51	0.70	0.14	0.09	3.44
RHDST20	0.09	0.23	0.36	2.77	3.45

Table A.8.5: Degraded land above ground, deadwood and litter carbon.

Code	Above ground (t CO_2 ha^{-1})	Deadwood (t CO_2 ha^{-1})	Litter (t CO_2 ha^{-1})
0KAD1	13	0	0.58
KAD2	10	0	2
KAD3	10	0	5
KAD4	29	0	10
KAD5	63	0	6
KAD6	34	0	7
KAD7	56	0	4
KAD8	10	0	6
KAD9	8	0	2
KAD10	134	0	9
KDH1	5	0	0.80
KDH2	4	0	0.70
KDH3	20	0	1
KDH4	7	0	4
KDH5	7	0	4
KGHB1	9	0	2
KGHB2	7	0	1
KGHB3	18	0	3
KGHB4	8	0	0.59
KGHB5	7	0	2
KRC1	6	0	14
KRC2	49	0	6
KRC3	9	0	1
KRC4	8	0	18
KRC5b	42	0	0.44
RHDST1	4	0	2
RHDST2	33	0	6
RHDST3	24	0	3
RHDST4	14	0	3
RHDST5	18	0	0.83
RHDST6	6	0	43
RHDST7	2	0	1
RHDST8	4	0	3
RHDST9	0.18	0	2
RHDST10	0.18	0	0.16

RHDST11	7	0	0.70
RHDST12	12	0	2
RHDST13	57	0	12
RHDST14	14	0	9
RHDST15	11	0	0.93
RHDST16	4	0	1
RHDST17	6	0	0.94
RHDST18	17	0	0.47
RHDST19	24	0	3
RHDST20	0.94	0	2
RHDST21	10	0	2
RHDST22	7	0	2
RHDST23	85	0	22
RHDST24	1	0	0.37
RHDST25	9	0	3

Table A.8.6: Old fields soil carbon stocks (0-25 cm).

	Soil carbon stock (t CO_2 ha^{-1})			
Code	Depth A (0-3 cm)	Depth B (3-10 cm)	Depth C (10-25 cm)	Total (0-25 cm)
RHOL1	8	73	161	242
RHOL2	18	41	42	101
RHOL3	12	38	48	99
RHOL4	16	28	83	127
RHOL5	10	14	26	50
RHOL6	14	14	22	50
RHOL7	13	4	14	31
RHOL8	12	9	8	30
RHOL9	14	11	32	57
RHOL10	18	27	47	92
RHOL11	23	40	51	114
RHOL12	21	48	84	153
RHOL13	19	25	58	102
RHOL14	15	24	44	82
RHOL15	13	16	43	72
RHOL16	17	10	7	35
RHOL17	10	12	20	42
RHOL18	13	14	51	78
RHOL19	8	35	42	85
RHOL20	13	14	12	39
RHOL21	8	22	18	49
RHOL22	8	19	39	66
RHOL23	10	5	31	46
RHOL24	8	6	19	34
RHOL25	7	11	10	28
GHOL2_1	12	18	35	65

GHOL2_2	16	22	35	73
GHOL2_4	11	19	44	73
GHOL2_5	4	13	29	46
KLK1	7	17	38	63
KLK2	6	13	24	43
KLK3	16	10	24	50
KLK4	12	23	36	70
KLK5	12	15	27	54
KLK6	5	8	19	32
KLK7	7	5	14	25
KLK8	9	22	47	77
KLK9	11	12	31	55
KLK10	8	10	27	45
COLE1	19	47	140	205
COLE2	27	62	77	167
COLE3	24	35	49	108
COLE4	32	28	40	100
COLE5	8	12	98	119
COLN1	35	48	71	154
COLN2	21	34	105	160
COLN3	34	34	66	133
COLN4	21	25	84	130
COLN5	29	44	126	198
COLN6	19	23	73	114
GHOL1_1	13	26	31	70
GHOL1_2	9	17	11	37
GHOL1_3	12	35	38	85
GHOL1_4	18	21	33	72
GHOL1_5	16	36	55	106
GHOL1_6	7	13	24	44
GHOL1_7	12	27	43	82
GHOL1_8	12	32	61	105
GHOL1_9	20	12	22	54
GHOL1_10	11	25	27	63

Table A.8.7: Old fields soil carbon stocks (25-110 cm).

	Soil carbon stock (t CO_2 ha^{-1})				
	Depth D (38-42 cm)	Depth E (58-62 cm)	Depth F (78-82 cm)	Depth G (98-102 cm)	Total
COLE4	24.9	8.5	12.3	8.7	54.4
COLE5	142.5	83.8	36.2	41.3	303.8
COLN4	123.4	9.2	21.6	13.5	167.7
COLN5	94.7	43.8	7.7	8.7	154.9
CSTN5	51.5	35.4	92.8	97.4	277.1
GHOL1_6	39.2	9.2	23.1	30.9	102.5
GHOL1_7	22.0	8.5	20.0	16.7	67.2

GHOL1_8	74.6	40.7	9.2	8.7	133.3
GHOL1_9	38.3	7.7	8.5	7.9	62.4
GHOL1_10	64.1	20.8	8.5	7.9	101.2
GHOL2_1	11.5	20.0	8.5	11.1	51.0
GHOL2_2	10.5	15.4	8.5	8.7	43.1
GHOL2_3	33.5	7.7	8.5	7.9	57.6
GHOL2_4	11.5	14.6	7.7	7.9	41.7
GHOL2_5	22.0	8.5	8.5	8.7	47.7
RHOL3	24.9	5.4	20.8	28.6	79.6
RHOl4	6.7	5.4	5.4	11.1	28.6
RHOL6	35.4	26.1	8.5	32.5	102.5
RHOL8	29.6	15.4	17.7	5.6	68.3
RHOL12	44.0	17.7	45.5	53.9	161.1
RHOL19	54.5	8.5	23.1	8.7	94.8
RHOL22	13.4	8.5	8.5	7.9	38.3
RHOL25	10.5	9.2	8.5	8.7	36.9

Table A.8.8: Old fields root carbon stocks (0-25 cm).

	Root carbon stock (t CO_2 ha^{-1})			
Code	Depth A (0-3 cm)	Depth B (3-10 cm)	Depth C (10-25 cm)	Total (0-25 cm)
RHOL1	2	3	7	12
RHOL2	0.91	2	0.36	3
RHOL3	7	3	2	12
RHOL4	0.50	2	3	6
RHOL5	0.95	0.84	0.78	3
RHOL6	0.19	0.26	1	2
RHOL7	6	3	4	13
RHOL8	3	0.18	1	4
RHOL9	1	0.28	1	3
RHOL10	2	2	3	7
RHOL11	0.40	3	4	7
RHOL12	3	5	10	17
RHOL13	4	3	4	11
RHOL14	2	3	3	8
RHOL15	4	4	3	11
RHOL16	0.96	7	1	9
RHOL17	2	2	2	6
RHOL18	2	4	5	11
RHOL19	3	1	1	5
RHOL20	0.88	2	1	4
RHOL21	0.52	0.65	2	3
RHOL22	2	1	1	5
RHOL23	0.70	2	2	4
RHOL24	1	1	2	4
RHOL25	4	2	1	8
GHOL2_1	0.86	1	2	4
GHOL2_2	0.26	0.77	0.84	2

GHOL2_3	5.50	0.76	0.61	7
GHOL2_4	0.65	2	2	5
KLK1	0.09	0.05	0.07	0.21
KLK2	0.00	0.02	0.02	0.04
KLK3	0.33	0.13	0.07	0.53
KLK4	0.01	0.06	0.04	0.11
KLK5	0.02	0.00	0.01	0.03
KLK6	0.04	0.05	0.05	0.14
KLK7	0.06	0.11	0.03	0.20
KLK8	0.08	0.05	0.23	0.36
KLK9	0.06	0.06	0.02	0.14
KLK10	0.06	0.02	0.04	0.12
GHOL3_1	1	0.57	1	3
GHOL3_2	0.51	1	1	3
GHOL3_3	0.21	1	2	3
GHOL3_4	0.50	2	1	4
GHOL3_5	0.18	1	1	2
COLN1	3	1	2	6
COLN4	1	0.42	0.83	2
COLN5	0.41	0.45	0.59	1
COLN6	1	2	3	5
GHOL1_5	5	3	3	11
GHOL1_6	0.93	0.51	0.69	2
GHOL1_8	0.89	0.48	1	3
GHOL1_9	0.29	1	0.69	2
GHOL1_10	1	1	1	4

Table A.8.9: Old fields root carbon stocks (25-110 cm).

	Root carbon stock (t CO_2 ha^{-1})				
	Depth D (38-42 cm)	Depth E (58-62 cm)	Depth F (78-82 cm)	Depth G (98-102 cm)	Total
KCAB1	0.84	0.99	0.36	0.77	2.97
KCAB4	0.98	0.06	0.37	0.21	1.62
KKK1	0.38	0.19	0.12	7.20	7.89
KKK2	0.51	0.18	0.17	0.66	1.51
RHST2	0.39	0.70	0.23	0.05	1.37
RHST4	0.75	0.23	0.00	0.00	0.98
RHST6	0.41	0.51	0.32	0.04	1.29
RHST8	13.13	0.08	0.12	0.16	13.49
RHST11	0.13	8.65	0.37	6.29	15.44
RHST13	3.22	1.18	0.11	0.17	4.68
RHST15	3.58	0.51	0.22	1.24	5.55
RHST19	0.30	0.20	0.29	0.82	1.61
RHSR22	1.74	0.50	2.14	4.88	9.26
RHST25	1.38	0.05	0.00	0.09	1.52
GHST8	1.30	0.17	0.02	0.02	1.51
GHST9	1.09	0.85	0.05	0.05	2.03
GHST10	0.50	0.05	0.02	0.08	0.65

GHST11	0.03	0.51	0.07	0.19	0.79
GHST14	0.89	0.26	0.05	0.02	1.22
CSTN1	1.00	2.20	0.60	0.22	4.02
CSTN2	0.13	0.25	0.08	0.18	0.64
CSTN3	8.93	0.74	0.05	0.08	9.79
CSTN4	0.18	0.80	0.54	0.09	1.61
CSTN5	0.56	0.03	0.09	0.18	0.86

Table A.8.10: Old fields above ground, deadwood and litter carbon.

Code	Above ground ($t\ CO_2\ ha^{-1}$)	Deadwood ($t\ CO_2\ ha^{-1}$)	Litter ($t\ CO_2\ ha^{-1}$)
GHOL1_1	4	0	3
GHOL1_2	2	0	7
GHOL1_3	2	0	16
GHOL1_4	3	0	10
GHOL1_5	3	0	1
GHOL1_6	7	0	36
GHOL1_7	4	0	1
GHOL1_8	8	0	0.25
GHOL1_9	13	0	0.68
GHOL1_10	3	0	0.38
GHOL2_1	12	0	1
GHOL2_2	49	0	8
GHOL2_3	2	0	3
GHOL2_4	5	0	1
GHOL2_5	3	0	0.52
GHOL3_1	2	0	1
GHOL3_2	0.84	0	0.00
GHOL3_3	0.46	0	0.44
GHOL3_4	10	0	2
GHOL3_5	2	0	1
COLE1	9	0	1
COLE2	16	0	1
COLE3	5	0	0.76
COLE4	11	0	5
COLE5	23	0	0.87
COLN2	5	0	0.39
COLN3	7	0	0.34
COLN4	2	0	1
COLN5	4	0	0.41
COLN6	3	0	0
KLK1	101	0	2
KLK2	5	0	3
KLK3	3	0	4
KLK4	1	0	4
KLK5	2	0	6
KLK6	1	0	2
KLK7	0.70	0	2
KLK8	1	0	0.85
KLK9	0.42	0	5

KLK10	0.19	0	2
RHOL1	15	0	2
RHOL2	5	0	0.73
RHOL3	0.92	0	0.52
RHOL4	9	0	0.87
RHOL5	12	0	1
RHOL6	7	0	0.41
RHOL7	25	0	15
RHOL8	41	0	0.46
RHOL9	8	0	0.37
RHOL10	56	0	6
RHOL11	14	0	4
RHOL12	1	0	0.23
RHOL13	34	0	0.51
RHOL14	8	0	0.25
RHOL15	60	0	18
RHOL16	1	0	1
RHOL17	2	0	0.11
RHOL18	25	0	0.28
RHOL19	3	0	0.23
RHOL20	11	0	0.66
RHOL21	39	0	2
RHOL22	1	0	1
RHOL23	9	0	3
RHOL24	5	0	0.16
RHOL25	2	0	0.28

Table A.8.11: Intact thicket soil carbon stocks (under bush) (0-25 cm).

	Soil carbon stock (t CO_2 ha^{-1})			
Code	Depth A (0-3 cm)	Depth B (3-10 cm)	Depth C (10-25 cm)	Total (0-25 cm)
KADSS1	62.7	273.7	406.1	742.5
KADSS2	67.0	292.1	537.1	896.3
KADSS3	69.4	173.6	187.8	430.8
KADSS4	59.4	138.3	322.3	520.0
KADSS5	31.2	94.2	114.6	240.0
KCAB1	15.6	33.1	94.9	143.6
KCAB2	5.0	65.3	52.7	123.0
KCAB3	18.4	64.8	135.0	218.2
KCAB4	15.8	24.8	78.2	118.8
KCAB5	63.2	104.2	419.6	586.9
KKO2	68.7	120.7	293.8	483.2
KKO3	25.1	38.5	71.0	134.6
KKO4	21.1	40.1	48.1	109.2
KKO5	27.3	32.8	88.6	148.6
KKK1	22.9	75.8	137.9	236.6
KK2	10.8	42.3	88.6	141.7

KKK2	13.1	37.9	101.1	152.2
KK3	10.8	32.8	81.9	125.5
KKK3	21.8	38.6	70.6	131.0
KQ1	14.5	39.6	61.9	115.9
KQ2	14.8	28.3	51.8	95.0
KQ3	14.5	41.6	41.8	97.8
KQ4	23.1	80.0	198.9	302.0
KQ5	22.5	42.3	89.4	154.2
RHST1	21.8	45.3	79.8	146.9
RHST2	13.4	44.5	29.7	87.6
RHST3	6.7	79.5	102.4	188.5
RHST4	21.5	44.7	165.5	231.7
RHST6	26.1	62.7	78.2	167.0
RHST7	17.3	63.5	181.4	262.2
RHST8	23.0	42.1	65.6	130.8
RHST9	25.3	43.4	107.4	176.1
RHST11	19.9	67.9	109.5	197.3
RHST12	23.8	54.3	91.9	170.1
RHST13	29.5	39.4	63.9	132.8
RHST14	23.6	88.3	93.6	205.5
RHST15	14.4	5.0	104.5	123.9
RHST16	32.1	74.3	170.5	277.0
RHST17	17.3	25.2	75.2	117.8
RHST18	17.1	38.3	102.4	157.8
RHST19	30.7	44.2	92.8	167.6
RHST20	35.6	65.3	100.3	201.2
RHST21	29.2	51.2	84.4	164.7
RHST22	32.9	75.4	106.6	214.9
RHST23	16.2	39.4	83.6	139.2
RHST24	37.7	50.1	91.1	178.9
RHST25	31.0	40.1	111.2	182.2
GHST6	14.9	31.2	58.4	104.6
GHST7	19.5	115.9	102.1	237.5
GHST8	13.7	36.6	58.0	108.3
GHST9	15.6	27.8	47.6	91.0
GHST10	13.5	36.3	87.8	137.6
GHST11	12.2	14.4	24.7	51.2
GHST12	16.6	34.9	51.8	103.3
GHST13	9.7	21.0	38.2	68.8
GHST14	8.8	44.5	92.2	145.5
GHST15	14.6	29.3	52.2	96.1
GHST16	15.7	37.0	55.7	108.5
CSTE1	12.5	3.7	58.5	74.7
CSTE3	5.1	1.8	83.6	90.6
CSTE5	25.7	63.0	129.7	218.4
CSTN1	20.6	58.5	122.9	202.0
CSTN3	22.0	63.0	97.5	182.5
CSTN4	13.9	9.2	37.6	60.8
GHST1	27.9	42.3	108.7	178.9
GHST2	26.4	51.5	104.5	182.4

GHST3	24.2	49.7	104.5	178.4
GHST4	27.2	12.9	125.4	165.4

Table A.8.12: Intact thicket soil carbon stocks (under bush) (25-110 cm).

	Soil carbon stock (t CO_2 ha^{-1})				
	Depth D (38-42 cm)	Depth E (58-62 cm)	Depth F (78-82 cm)	Depth G (98-102 cm)	Total
GHST8	24.8	4.4	7.1	5.2	41.5
GHST9	6.5	11.4	5.1	5.7	28.7
GHST10	33.9	7.9	5.1	5.7	52.6
GHST11	18.9	18.8	24.0	5.7	67.4
GHST14	110.9	37.1	58.6	15.6	222.3
KCAB1	200.9	85.2	14.3	13.5	313.9
KCAB4	63.9	28.4	5.6	5.7	103.6
KKK1	76.3	4.8	13.3	7.3	101.7
KKK2	58.0	30.6	24.0	14.1	126.7
KKK3	11.5	12.3	5.4	5.6	34.7
KKK5	6.7	5.4	5.4	5.6	23.0
KKR4	46.8	5.3	8.6	17.3	78.0
RHST2	37.2	21.0	8.2	27.6	93.9
RHST4	33.3	55.9	6.1	12.0	107.3
RHST6	101.7	81.3	69.4	35.4	287.8
RHST8	78.3	31.0	34.2	32.3	175.7
RHST11	70.4	28.8	16.3	5.7	121.3
RHST13	121.3	39.3	33.1	32.3	226.1
RHST15	102.4	76.9	55.1	25.5	259.9
RHST19	103.0	48.5	5.1	20.3	176.9
RHST22	82.8	24.0	5.6	6.8	119.2
RHST25	44.3	62.5	31.6	20.8	159.3

Table A.8.13: Intact thicket root carbon stocks (under bush) (0-25 cm).

	Root carbon stock (t CO_2 ha^{-1})			
Code	Depth A (0-3 cm)	Depth B (3-10 cm)	Depth C (10-25 cm)	Total (0-25 cm)
KADSS1	0.31	1	1	2
KADSS2	0.11	0.19	2	2
KADSS3	0.09	0.07	0.19	0.34
KADSS4	0.07	0.26	0.30	0.63
KADSS5	0.22	0.24	0.53	0.99
KCAB3	0.63	10	1	12
KCAB5	0.12	0.18	0.87	1
KKO2	26	3	3	31
KKO4	0.87	0.87	12	14
KKK1	1.6	12.0	9	22

KKK2	0.76	28	3	33
KKK3	2	16	14	32
KQ3	0.52	3	19	23
RHST1	1	2	4	7
RHST2	2	2	5	9
RHST3	1	4	4	9
RHST4	4	13	3	20
RHST5	4	2	4	9
RHST6	2	9	0.94	12
RHST7	2	32	3	36
RHST8	7	3	3	13
RHST11	25	0.68	2	28
RHST12	2	6	7	15
RHST13	3	6	4	13
RHST15	1	4	3	9
RHST16	3	1	3	7
RHST17	0.59	4	4	9
RHST18	2	0.71	63	66
RHST19	2	2	6	11
RHST20	0.83	0.76	24	26
RHST21	3	19	2	24
RHST22	0.55	5	3	8
RHST23	2	2	59	63
RHST24	2	7	3	12
RHST25	2	5	14	21
GHST6	0.81	4	20	24
GHST7	6	8	3	17
GHST8	2	2	22	26
GHST9	2	2	2	7
GHST11	0.60	18	6	24
GHST12	10	11	9	30
GHST13	2	3	44	49
GHST14	0.24	2	0.98	3
GHST16	4	11	6	21
CSTN1	2	2	1	5
CSTN3	1	0	14	16
CSTN4	2	1	23	26
CSTN5	2	3	3	8
GHST10	1	419	2	423
RHST14	1	112	27	141
KKO3	0.25	77	2	79
GHST15	3	21	156	180

Table A.8.14: Intact thicket root carbon stocks (In the open)* (25-110 cm).

	Root carbon stock (t CO_2 ha^{-1})				
	Depth D (38-42 cm)	Depth E (58-62 cm)	Depth F (78-82 cm)	Depth G (98-102 cm)	Total

RHOL3	1.04	0.43	0.14	0.09	1.71
RHOL4	0.24	0.10	0.01	0.06	0.41
RHOL6	0.35	0.24	0.05	0.05	0.69
THOL8	0.51	0.09	0.03	0.03	0.66
RHOL12	0.30	0.10	0.02	0.02	0.43
RHOL13	0.39	0.02	0.02	0.09	0.53
RHOL15	0.26	0.29	0.04	0.06	0.65
RHOL19	0.07	0.09	0.04	0.04	0.24
RHOL22	0.38	0.10	0.02	0.04	0.54
RHOL25	0.70	0.21	0.14	0.07	1.13
GHOL2_2	0.04	0.02	0.05	0.10	0.21
GHOL2_4	0.02	0.02	0.34	0.02	0.39
GHOL2_5	0.23	0.02	0.18	0.02	0.44
KLK3	0.81	0.59	0.24	0.26	1.89
KLK5	0.37	0.09	0.04	0.08	0.59
GHOL2_1	0.50	0.09	0.11	0.04	0.74
COLE1	0.77	0.21	0.15	0.02	1.15
COLE2	0.41	0.10	0.02	0.02	0.55
COLE4	0.20	0.02	0.02	0.02	0.27
COLE5	0.86	0.38	0.18	0.06	1.49
COLN2	2.43	0.15	0.43	0.01	3.03
COLn3	0.17	0.06	0.13	0.05	0.40
COLN4	0.61	0.12	0.08	0.06	0.87
COLN5	0.28	0.06	0.08	0.05	0.47
COLn6	0.47	0.29	0.07	0.30	1.13
GHOL1_6	0.10	0.10	0.02	0.03	0.26
GHOL1_7	0.91	0.41	0.02	0.11	1.45
GHOL1_8	0.16	0.06	0.16	0.04	0.42
GHOL1_9	0.73	0.20	0.09	0.04	1.06
GHOL1_10	1.55	0.34	0.30	0.13	2.33

Table A.8.15: Intact thicket above ground, deadwood and litter carbon.

Code	Above ground ($t\ CO_2\ ha^{-1}$)	Deadwood ($t\ CO_2\ ha^{-1}$)	Litter ($t\ CO_2\ ha^{-1}$)
CSTE1	24	0	15
CSTE2	48	0	3
CSTE3	13	0	1
CSTE4	33	0	3
CSTE5	290	0	25
CSTN1	52	0	0
CSTN2	101	0	4
CSTN3	34	0	12
CSTN4	13	0	4
CSTN5	84	0	5
GHST 16	103	0	2
GHST1	31	0	7
GHST10	9	0	1
GHST11	9	0	8

GHST12	23	0	4
GHST13	15	0	2
GHST14	50	0	9
GHST15	193	0	2
GHST2	25	0	7
GHST3	171	0	23
GHST4	71	0	0.85
GHST5	38	0	5
GHST6	892	0	15
GHST7	26	0	0.80
GHST8	19	0	0.32
GHST9	79	0	2
KADSS1	81	0	9
KADSS2	44	0	5
KADSS3	49	0	16
KADSS4	28	0	3
KADSS5	71	0	0.86
KCAB1	56	0	10
KCAB2	51	0	7
KCAB3	87	0	10
KCAB4	59	0	26
KCAB5	305	0	4
KKK1	329	0	36
KKK2	131	0	66
KKK3	205	0	6
KKK4	113	0	40
KKK5	145	0	16
KKO1	32	0	5
KKO2	23	0	5
KKO3	52	0	17
KKO4	28	0	0.93
KKO5	22	0	5
KQ1	79	0	18
KQ2	44	0	8
KQ3	57	0	2
KQ4	47	0	5
KQ5	44	0	1
RHST1	119	0	10
RHST10	40	0	39
RHST11	124	0	41
RHST12	158	0	34
RHST13	108	0	33
RHST14	55	0	17
RHST15	85	0	13
RHST16	16	0	4
RHST17	0.6	0	3
RHST18	78	0	4
RHST19	410	0	80
RHST2	58	0	10
RHST20	40	0	4

RHST21	197	0	11
RHST22	23	0	0.79
RHST23	58	0	10
RHST24	142	0	6
RHST25	78	0	1
RHST3	116	0	8
RHST4	131	0	37
RHST5	52	0	52
RHST6	61	1.19	5
RHST7	85	0	9
RHST8	50	0	28
RHST9	65	0	48

Table A.8.16: Intact thicket bulk density under the bush at Depth A.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
KASS3	0.7	RHST4	0.5	RHST22	1.9	CSTE5	0.8
KASS4	0.8	RHST5	0.7	RHST23	1.0	CSTN1	0.6
KCAB2	0.6	RHST6	1.0	RHST24	1.7	CSTN2	0.6
KCAB4	0.5	RHST7	0.5	RHST25	1.3	CSTN3	0.6
KKK2	0.5	RHST8	0.5	GHST6	0.7	CSTN4	0.6
KKK4	0.6	RHST9	1.1	GHST13	0.9	CSTN5	0.7
KKK5	0.5	RHST14	0.5	GHST16	1.2	GHST1	1.2
KQ3	0.5	RHST16	0.5	CSTE1	0.9	GHST2	0.9
RHST1	0.6	RHST17	0.7	CSTE2	0.7	GHST3	0.9
RHST2	0.7	RHST19	0.5	CSTE3	1.0	GHST5	0.6
RHST3	0.5	RHST20	0.6	CSTE4	0.8		

Table A.8.17: Intact thicket Root density under the bush at Depth A.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
KASS1	0.0006	KKK2	0.0014	RHST11	0.0458	GHST7	0.0114
KASS2	0.0002	KKK3	0.0032	RHST12	0.0037	GHST8	0.0038
KASS3	0.0002	KKK4	0.0008	RHST13	0.0048	GHST9	0.0041
KASS4	0.0001	KKK5	0.0006	RHST14	0.0026	GHST10	0.0026
KASS5	0.0004	KQ1	0.0024	RHST15	0.0025	GHST11	0.0011
KCAB1	0.0045	KQ2	0.0021	RHST16	0.0058	GHST12	0.0177
KCAB2	0.0017	KQ3	0.0009	RHST17	0.0011	GHST13	0.0037
KCAB3	0.0011	RHST1	0.0026	RHST18	0.0044	GHST14	0.0004
KCAB4	0.0018	RHST2	0.0033	RHST19	0.0044	GHST15	0.0057
KCAB5	0.0002	RHST3	0.0020	RHST20	0.0015	GHST16	0.0073
KKO1	0.0004	RHST4	0.0067	RHST21	0.0060	CSTN1	0.0039
KKO2	0.0465	RHST5	0.0068	RHST22	0.0010	CSTN2	0.0070
KKO3	0.0005	RHST6	0.0039	RHST23	0.0028	CSTN3	0.0024
KKO4	0.0016	RHST7	0.0038	RHST24	0.0028	CSTN4	0.0038
KKO5	0.0423	RHST8	0.0128	RHST25	0.0036	CSTN5	0.0039
KKK1	0.0029	RHST9	0.0043	GHST6	0.0015		

Table A.8.18: Intact thicket stone volume under the bush at Depth A

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
KASS1	10	KKK4	24	RHST17	11	GHST16	1
KASS2	6	KKK5	9	RHST18	16	CSTE1	7
KASS3	22	KQ3	28	RHST19	12	CSTE2	7
KASS4	55	KQ4	21	RHST20	35	CSTE3	17
KASS5	43	RHST1	11	RHST22	15	CSTE4	8
KCAB1	6	RHST2	12	RHST23	8	CSTE5	25
KCAB2	10	RHST3	9	RHST24	5	CSTN1	20
KCAB3	11	RHST4	7	RHST25	16	CSTN2	7
KCAB4	12	RHST5	2	GHST6	10	CSTN3	11
KCAB5	35	RHST6	10	GHST7	50	CSTN4	30
KKO1	19	RHST7	11	GHST8	4	CSTN5	6
KKO2	23	RHST8	12	GHST9	1	GHST1	27
KKO3	29	RHST9	13	GHST10	1	GHST2	0
KKO4	2	RHST11	2	GHST11	0.0	GHST3	0
KKO5	16	RHST12	3	GHST12	4	GHST5	2
KKK1	4	RHST13	2	GHST13	11		
KKK2	2	RHST14	11	GHST14	7		
KKK3	10	RHST16	39	GHST15	2		

Table A.8.19: Intact thicket mean organic carbon under the bush at Depth A.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
KASS1	9	KKK5	3	RHST15	2	GHST13	1
KASS2	9	KQ1	2	RHST16	4	GHST14	1
KASS3	9	KQ2	2	RHST17	2	GHST15	2
KASS4	8	KQ3	2	RHST18	2	GHST16	2
KASS5	4	KQ4	3	RHST19	4	CSTE1	2
KCAB1	2	KQ5	3	RHST20	5	CSTE3	0.7
KCAB2	0.7	RHST1	3	RHST21	4	CSTE5	4
KCAB3	3	RHST2	2	RHST22	4	CSTN1	3
KCAB4	2	RHST3	0.9	RHST23	2	CSTN2	2
KCAB5	9	RHST4	3	RHST24	5	CSTN3	3
KKO2	9	RHST6	4	RHST25	4	CSTN4	2
KKO3	3	RHST7	2	GHST6	2	GHST1	4
KKO4	3	RHST8	3	GHST7	3	GHST2	4
KKO5	4	RHST9	3	GHST8	2	GHST3	3
KKK1	3	RHST11	3	GHST9	2	GHST5	4
KKK2	1	RHST12	3	GHST10	2		
KKK3	2	RHST13	4	GHST11	2		
KKK4	1	RHST14	3	GHST12	2		

Table A.8.20: Intact thicket bulk density under the bush at Depth B.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
KASS1	0.6	RHST2	0.5	RHST19	0.7	GHST16	1.2

KASS2	0.5	RHST3	0.4	RHST20	1.0	CSTE1	1.0
KASS3	0.8	RHST4	0.7	RHST21	1.1	CSTE2	1.0
KASS5	0.8	RHST5	0.9	RHST23	0.6	CSTE3	0.9
KCAB1	0.7	RHST6	1.0	RHST24	1.8	CSTE4	1.0
KCAB2	0.6	RHST7	1.0	RHST25	0.9	CSTE5	0.8
KCAB3	0.7	RHST8	0.7	GHST6	0.4	CSTN1	0.9
KKO1	0.7	RHST10	0.8	GHST8	1.5	CSTN2	0.7
KKK3	0.6	RHST11	0.6	GHST9	1.5	CSTN3	0.6
KKK4	0.5	RHST13	0.6	GHST10	1.5	CSTN4	0.7
KKK5	0.6	RHST14	0.6	GHST11	1.5	CSTN5	0.9
KQ1	0.6	RHST15	0.5	GHST12	1.3	GHST1	1.1
KQ2	0.7	RHST16	1.0	GHST13	1.3	GHST2	1.2
KQ3	0.6	RHST17	1.0	GHST14	1.3	GHST3	0.9
KQ5	0.4	RHST18	1.1	GHST15	1.6	GHST5	0.7
RHST1	0.7						

Table A.8.21: Intact thicket bulk density under the bush at Depth B.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
KASS1	0.000830	KKK4	0.000578	RHST12	0.004759	GHST7	0.006456
KASS2	0.000145	KKK5	0.000031	RHST13	0.005059	GHST8	0.001469
KASS3	0.000054	KQ1	0.001317	RHST14	0.087474	GHST9	0.001784
KASS4	0.000201	KQ3	0.002172	RHST15	0.003485	GHST10	0.326350
KASS5	0.000190	RHST1	0.001582	RHST16	0.001049	GHST11	0.013683
KCAB2	0.000308	RHST2	0.001587	RHST17	0.003397	GHST12	0.008815
KCAB3	0.007842	RHST3	0.003112	RHST18	0.000552	GHST13	0.002525
KCAB5	0.000142	RHST4	0.010157	RHST19	0.001807	GHST14	0.001585
KKO1	0.000288	RHST5	0.001265	RHST20	0.000592	GHST15	0.016310
KKO2	0.001957	RHST6	0.007159	RHST21	0.014677	GHST16	0.008831
KKO3	0.059906	RHST7	0.024565	RHST22	0.003554	CSTN1	0.001741
KKO4	0.000677	RHST8	0.002519	RHST23	0.001802	CSTN2	0.004452
KKO5	0.000217	RHST9	0.006181	RHST24	0.005795	CSTN3	0.000114
KKK1	0.009374	RHST10	0.001526	RHST25	0.003779	CSTN4	0.001002
KKK2	0.022187	RHST11	0.000532	GHST6	0.003085	CSTN5	0.002064
KKK3	0.012525						

Table A.8.22: Intact thicket stone volume under the bush at Depth B.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
KASS1	45	KQ2	24	RHST16	15	GHST14	0.6
KASS2	35	KQ3	19	RHST17	51	GHST15	0
KASS3	50	KQ4	54	RHST18	6	GHST16	1
KASS5	37	KQ5	16	RHST19	11	CSTE1	8
KCAB1	48	RHST1	16	RHST20	15	CSTE2	10
KCAB2	12	RHST2	9	RHST21	9	CSTE3	21
KCAB3	20	RHST3	23	RHST22	0.0	CSTE4	7
KKO1	0	RHST4	17	RHST23	15	CSTE5	24
KKO2	83	RHST5	6	RHST24	43	CSTN1	15
KKO3	21	RHST6	14	RHST25	14	CSTN2	19

KKO4	59	RHST7	26	GHST6	47	CSTN3	8
KKO5	42	RHST8	6	GHST7	52	CSTN4	17
KKK1	4	RHST10	19	GHST8	0.5	CSTN5	5
KKK2	8	RHST11	6	GHST9	0.5	GHST1	7
KKK3	14	RHST12	22	GHST10	0.6	GHST2	0
KKK4	10	RHST13	8	GHST11	0.6	GHST3	9
KKK5	14	RHST14	6	GHST12	3	GHST5	5
KQ1	27	RHST15	18	GHST13	11		

Table A.8.23: Intact thicket mean organic carbon under the bush at Depth B

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
KASS1	15	KKK5	2	RHST14	5	GHST11	0.8
KASS2	16	KQ1	2	RHST15	0.3	GHST12	2
KASS3	9	KQ2	2	RHST16	4	GHST13	1
KASS4	8	KQ3	2	RHST17	1	GHST14	2
KASS5	5	KQ4	4	RHST18	2	GHST15	2
KCAB1	2	KQ5	2	RHST19	2	GHST16	2
KCAB2	4	RHST1	2	RHST20	4	CSTE1	0.2
KCAB3	4	RHST2	2	RHST21	3	CSTE3	0.1
KCAB4	1	RHST3	4	RHST22	4	CSTE5	3
KCAB5	6	RHST4	2	RHST23	2	CSTN1	3
KKO2	7	RHST6	3	RHST24	3	CSTN3	3
KKO3	2	RHST7	3	RHST25	2	CSTN4	0.5
KKO4	2	RHST8	2	GHST6	2	GHST1	2
KKO5	2	RHST9	2	GHST7	6	GHST2	3
KKK1	4	RHST11	4	GHST8	2	GHST3	3
KKK2	2	RHST12	3	GHST9	2	GHST5	0.7
KKK3	2	RHST13	2	GHST10	2		
KKK4	2						

Table A.8.24: Intact thicket bulk density under the bush at Depth C.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
KASS1	0.8	KQ3	0.8	RHST20	0.7	GHST16	1.7
KASS2	1.0	KQ5	0.7	RHST21	0.9	CSTE1	1.0
KASS3	1.1	RHST2	0.6	RHST22	0.9	CSTE2	0.6
KASS4	0.9	RHST3	1.1	RHST23	0.8	CSTE3	1.0
KASS5	1.1	RHST4	0.5	RHST24	1.1	CSTE4	1.1
KCAB1	0.6	RHST5	1.1	RHST25	0.8	CSTE5	1.0
KCAB2	0.9	RHST6	0.9	GHST6	1.0	CSTN1	0.7
KCAB3	0.5	RHST7	0.7	GHST7	1.0	CSTN2	0.7
KCAB4	0.8	RHST11	0.6	GHST8	1.7	CSTN3	0.9
KCAB5	0.7	RHST13	0.4	GHST9	1.1	CSTN4	1.0
KKO1	1.3	RHST14	0.6	GHST10	1.7	CSTN5	1.0
KKK1	0.9	RHST15	0.7	GHST11	1.2	GHST1	1.3
KKK2	0.9	RHST16	1.2	GHST12	1.5	GHST2	1.2
KKK3	1.0	RHST17	0.8	GHST13	1.2	GHST3	1.2

KQ1	0.8	RHST18	0.8	GHST14	1.4	GHST5	0.8
KQ2	0.9	RHST19	0.9				

Table A.8.25: Intact thicket root density under the bush at Depth C.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
KASS1	0.000379	KQ3	0.007062	RHST15	0.001015	GHST9	0.000803
KASS2	0.000566	RHST1	0.001382	RHST16	0.000973	GHST10	0.000810
KASS3	0.000069	RHST2	0.001845	RHST17	0.001506	GHST11	0.002050
KASS4	0.000108	RHST3	0.001534	RHST18	0.022957	GHST12	0.003151
KASS5	0.000192	RHST4	0.001217	RHST19	0.002145	GHST13	0.015897
KCAB3	0.000399	RHST5	0.001489	RHST20	0.008775	GHST14	0.000356
KCAB5	0.000316	RHST6	0.000340	RHST21	0.000682	GHST15	0.056519
KKO2	0.001130	RHST7	0.000916	RHST22	0.000925	GHST16	0.002203
KKO3	0.000626	RHST8	0.001076	RHST23	0.021539	CSTN1	0.000301
KKO4	0.004531	RHST10	0.009786	RHST24	0.000994	CSTN3	0.005192
KKK1	0.003092	RHST11	0.000835	RHST25	0.005141	CSTN4	0.008249
KKK2	0.001208	RHST12	0.002382	GHST6	0.007114	CSTN5	0.001065
KKK3	0.005063	RHST13	0.001288	GHST7	0.001032		
KQ2	0.001058	RHST14	0.009879	GHST8	0.007905		

Table A.8.26: Intact thicket stone volume under the bush at Depth C.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
KASS1	21	KQ2	45	RHST19	20	GHST15	0.4
KASS2	16	KQ3	29	RHST20	17	GHST16	4
KASS3	42	KQ5	23	RHST21	21	CSTE1	13
KASS4	43	RHST2	15	RHST22	27	CSTE2	11
KASS5	25	RHST3	21	RHST23	30	CSTE3	28
KCAB1	34	RHST4	27	RHST24	25	CSTE4	7
KCAB2	21	RHST5	10	RHST25	21	CSTE5	14
KCAB3	15	RHST6	23	GHST6	39	CSTN1	19
KCAB4	18	RHST7	15	GHST7	21	CSTN2	11
KCAB5	43	RHST11	6	GHST8	0.8	CSTN3	22
KKO2	22	RHST12	21	GHST9	0.3	CSTN4	16
KKO3	45	RHST13	20	GHST10	0.4	CSTN5	18
KKO4	49	RHST14	36	GHST11	23	GHST1	26
KKK1	2	RHST15	25	GHST12	36	GHST2	0
KKK2	5	RHST16	42	GHST13	2	GHST3	0
KKK3	14	RHST17	16	GHST14	13	GHST5	5
KQ1	22	RHST18	19				

Table A.8.27: Intact thicket mean organic carbon under the bush at Depth C.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
KASS1	10	KKK4	2	RHST13	2	GHST10	2
KASS2	13	KKK5	2	RHST14	2	GHST11	0.6

KASS3	4	KQ1	1	RHST15	3	GHST12	1
KASS4	8	KQ2	1	RHST16	4	GHST13	0.9
KASS5	3	KQ3	1	RHST17	2	GHST14	2
KCAB1	2	KQ4	5	RHST18	2	GHST15	1
KCAB2	1	KQ5	2	RHST19	2	GHST16	1
KCAB3	3	RHST1	2	RHST20	2	CSTE1	1.4
KCAB4	2	RHST2	0.7	RHST21	2	CSTE3	2.0
KCAB5	10	RHST3	2	RHST22	3	CSTE5	3
KKO2	7	RHST4	4	RHST23	2	CSTN1	3
KKO3	2	RHST6	2	RHST24	2	CSTN3	2
KKO4	1	RHST7	4	RHST25	3	CSTN4	0.9
KKO5	2	RHST8	2	GHST6	1	GHST1	3
KKK1	3	RHST9	3	GHST7	2	GHST2	3
KKK2	2	RHST11	3	GHST8	1	GHST3	3
KKK3	2	RHST12	2	GHST9	1	GHST5	3

Table A.8.28: Old lands bulk density at Depth A.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
RHOL1	0.6	RHOL13	0.6	RHOL23	1.1	COLE1	0.9
RHOL2	1.2	RHOL14	0.9	GHOL2_2	1.5	COLE2	0.9
RHOL3	1.3	RHOL15	0.9	KLK1	1.3	COLE3	1.2
RHOL4	1.1	RHOL16	0.9	KLK3	0.6	COLE4	0.7
RHOL6	1.4	RHOL17	1.2	KLK4	1.0	COLN1	1.0
RHOL7	0.7	RHOL18	1.1	KLK5	0.6	COLN2	1.1
RHOL8	1.7	RHOL19	1.3	KLK6	1.1	COLN3	1.1
RHOL9	1.1	RHOL20	1.1	KLK8	1.0	COLN4	1.2
RHOL11	1.2	RHOL21	1.7	KLK9	1.3	COLN6	1.1
RHOL12	1.1	RHOL22	1.0	KLK10	1.7		

Table A.8.29: Old lands root density at Depth A.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
RHOL1	0.003648	RHOL16	0.001747	KLK1	0.000160	COLN6	0.001234
RHOL2	0.001649	RHOL17	0.004067	KLK2	0.000009	GHOL1_1	0.001208
RHOL3	0.012468	RHOL18	0.003476	KLK3	0.000606	GHOL1_3	0.008133
RHOL4	0.000907	RHOL19	0.005491	KLK4	0.000021	GHOL1_4	0.001419
RHOL5	0.001733	RHOL20	0.001591	KLK5	0.000044	GHOL1_5	0.008258
RHOL6	0.000353	RHOL21	0.000937	KLK6	0.000071	GHOL1_6	0.001698
RHOL7	0.010820	RHOL22	0.003905	KLK7	0.000108	GHOL1_7	0.004070
RHOL8	0.005525	RHOL23	0.001278	KLK8	0.000150	GHOL1_8	0.001616
RHOL9	0.002167	RHOL24	0.002046	KLK9	0.000112	GHOL1_9	0.000532
RHOL10	0.002883	RHOL25	0.007962	KLK10	0.000115	GHOL1_10	0.001870
RHOL11	0.000730	GHOL2_1	0.001564	COLN1	0.005200	GHOL3_1	0.002174
RHOL12	0.005040	GHOL2_2	0.000472	COLN2	0.004862	GHOL2_2	0.000927
RHOL13	0.006604	GHOL2_3	0.000811	COLN3	0.002808	GHOL3_2	0.000389
RHOL14	0.003572	GHOL2_4	0.009988	COLN4	0.002199	GHOL2_3	0.000904
RHOL15	0.006950	GHOL2_5	0.001177	COLN5	0.000745	GHOL3_3	0.000323

Table A.8.30: Old lands stone volume at Depth A.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
RHOL1	3	RHOL16	9	KLK3	5	COLN3	24
RHOL2	4	RHOL17	5	KLK4	14	COLN4	31
RHOL3	8	RHOL18	2	KLK5	7	COLN5	0
RHOL4	5	RHOL19	8	KLK6	11	COLN6	22
RHOL5	0	RHOL20	1	KLK7	21	GHOL1_1	1
RHOL6	4	RHOL21	3	KLK8	4	GHOL1_2	0.7
RHOL7	1	RHOL22	35	KLK9	6	GHOL1_3	2
RHOL8	8	RHOL23	4	KLK10	8	GHOL1_4	1
RHOL9	7	RHOL24	2	COLE1	21	GHOL1_5	1
RHOL10	5	RHOL25	5	COLE2	2	GHOL1_6	23
RHOL11	43	GHOL2_1	3	COLE3	11	GHOL1_7	2
RHOL12	10	GHOL2_2	2	COLE4	13	GHOL1_8	1
RHOL13	15	GHOL2_3	0	COLE5	0	GHOL1_9	39
RHOL14	6	KLK1	5	COLN1	22	GHOL1_10	6
RHOL15	2	KLK2	3	COLN2	30		

Table A.8.31: Old lands mean organic carbon at Depth A.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
RHOL1	0.7	RHOL16	1.5	KLK2	0.5	COLN2	1.8
RHOL2	1.5	RHOL17	0.9	KLK3	1.3	COLN3	2.9
RHOL3	1.1	RHOL18	1.2	KLK4	1.0	COLN4	1.8
RHOL4	1.4	RHOL19	0.7	KLK5	1.0	COLN5	2.5
RHOL5	0.8	RHOL20	1.1	KLK6	0.4	COLN6	1.6
RHOL6	1.2	RHOL21	0.7	KLK7	0.6	GHOL1_1	1.1
RHOL7	1.1	RHOL22	0.7	KLK8	0.8	GHOL1_2	0.8
RHOL8	1.1	RHOL23	0.9	KLK9	1.0	GHOL1_3	1.0
RHOL9	1.2	RHOL24	0.7	KLK10	0.7	GHOL1_4	1.5
RHOL10	1.6	RHOL25	0.6	COLE1	1.6	GHOL1_5	1.4
RHOL11	1.9	GHOL2_1	1.0	COLE2	2.4	GHOL1_6	0.6
RHOL12	1.8	GHOL2_2	1.4	COLE3	2.1	GHOL1_7	1.0
RHOL13	1.6	GHOL2_3	0.9	COLE4	2.8	GHOL1_8	1.0
RHOL14	1.3	GHOL2_4	0.3	COLE5	0.7	GHOL1_9	1.7
RHOL15	1.1	KLK1	0.6	COLN1	3.0	GHOL1_10	1.0

Table A.8.32: Old lands bulk density at Depth B.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
RHOL1	0.9	RHOL14	1.3	RHOL25	1.4	COLE2	1.0
RHOL2	1.4	RHOL15	1.3	KLK1	1.6	COLE3	1.4
RHOL3	1.2	RHOL16	1.2	KLK2	1.5	COLE4	0.8
RHOL4	1.3	RHOL17	1.4	KLK3	1.2	COLE5	1.3
RHOL5	1.3	RHOL18	1.3	KLK4	1.3	COLN2	1.1
RHOL6	1.3	RHOL19	1.5	KLK5	1.1	COLN3	0.9

RHOL7	1.2	RHOL20	1.2	KLK6	1.4	COLN4	1.1
RHOL9	1.3	RHOL21	0.9	KLK7	1.5	COLN5	1.2
RHOL10	1.2	RHOL22	1.6	KLK8	1.3	COLN6	1.1
RHOL12	1.1	RHOL23	1.7	KLK9	1.5	GHOL1_7	1.7
RHOL13	0.8	RHOL24	1.7	COLE1	1.0		

Table A.8.33: Old lands root density at Depth B.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
RHOL1	0.002512	RHOL16	0.005335	KLK2	0.000015	GHOL1_1	0.000999
RHOL2	0.001691	RHOL17	0.001364	KLK3	0.000099	GHOL1_2	0.000938
RHOL3	0.002631	RHOL18	0.003166	KLK4	0.000047	GHOL1_3	0.005475
RHOL4	0.001253	RHOL19	0.000936	KLK5	0.000002	GHOL1_4	0.000690
RHOL5	0.000653	RHOL20	0.001359	KLK6	0.000039	GHOL1_5	0.002214
RHOL6	0.000204	RHOL21	0.000508	KLK7	0.000089	GHOL1_6	0.000394
RHOL7	0.002717	RHOL22	0.001066	KLK8	0.000036	GHOL1_8	0.000371
RHOL8	0.000140	RHOL23	0.001348	KLK9	0.000043	GHOL1_9	0.000988
RHOL9	0.000214	RHOL24	0.000835	KLK10	0.000015	GHOL1_10	0.001133
RHOL10	0.001459	RHOL25	0.001600	COLN1	0.000889	GHOL3_1	0.000441
RHOL11	0.002152	GHOL2_1	0.000970	COLN2	0.003740	GHOL2_2	0.000903
RHOL12	0.003506	GHOL2_2	0.000596	COLN3	0.001474	GHOL3_2	0.000980
RHOL13	0.002269	GHOL2_4	0.000589	COLN4	0.000328	GHOL2_3	0.001835
RHOL14	0.002010	GHOL2_5	0.001333	COLN5	0.000347	GHOL3_3	0.000788
RHOL15	0.003456	KLK1	0.000042	COLN6	0.001544		

Table A.8.34: Old lands stone volume at Depth B.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
RHOL1	8	RHOL15	4	KLK1	6	COLE5	10
RHOL2	7	RHOL16	17	KLK2	3	COLN2	24
RHOL3	5	RHOL17	4	KLK3	8	COLN3	15
RHOL4	4	RHOL18	4	KLK4	18	COLN4	35
RHOL5	11	RHOL19	13	KLK5	17	COLN5	8
RHOL6	7	RHOL20	2	KLK6	8	COLN6	15
RHOL7	5	RHOL21	4	KLK7	14	GHOL1_1	0.5
RHOL8	4	RHOL22	8	KLK8	4	GHOL1_3	26
RHOL9	10	RHOL23	6	KLK9	4	GHOL1_4	1
RHOL10	5	RHOL24	7	KLK10	13	GHOL1_5	24
RHOL11	30	RHOL25	4	COLE1	15	GHOL1_6	0.7
RHOL12	8	GHOL2_1	0	COLE2	20	GHOL1_7	2.4
RHOL13	26	GHOL2_2	1	COLE3	15	GHOL1_8	0.0
RHOL14	9	GHOL2_3	0	COLE4	44	GHOL1_10	0.8

Table A.8.35: Old lands mean organic carbon at Depth B.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
RHOL1	2.3	RHOL16	0.3	KLK2	0.4	COLN2	1.1

RHOL2	1.3	RHOL17	0.4	KLK3	0.3	COLN3	1.1
RHOL3	1.2	RHOL18	0.4	KLK4	0.7	COLN4	0.8
RHOL4	0.9	RHOL19	1.1	KLK5	0.5	COLN5	1.4
RHOL5	0.5	RHOL20	0.5	KLK6	0.3	COLN6	0.7
RHOL6	0.5	RHOL21	0.7	KLK7	0.2	GHOL1_1	0.8
RHOL7	0.1	RHOL22	0.6	KLK8	0.7	GHOL1_2	0.6
RHOL8	0.3	RHOL23	0.2	KLK9	0.4	GHOL1_3	1.1
RHOL9	0.4	RHOL24	0.2	KLK10	0.3	GHOL1_4	0.7
RHOL10	0.9	RHOL25	0.4	COLE1	1.5	GHOL1_5	1.2
RHOL11	1.3	GHOL2_1	0.6	COLE2	2.0	GHOL1_6	0.4
RHOL12	1.5	GHOL2_2	0.7	COLE3	1.1	GHOL1_7	0.9
RHOL13	0.8	GHOL2_3	0.6	COLE4	0.9	GHOL1_8	1.0
RHOL14	0.8	GHOL2_4	0.4	COLE5	0.4	GHOL1_9	0.4
RHOL15	0.5	KLK1	0.6	COLN1	1.5	GHOL1_10	0.8

Table A.8.36: Old lands bulk density at Depth C.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
RHOL1	1.0	RHOL14	1.6	KLK1	1.7	COLE5	1.2
RHOL2	1.5	RHOL15	0.6	KLK2	1.8	COLN1	1.4
RHOL3	1.6	RHOL16	1.8	KLK3	1.5	COLN2	1.9
RHOL4	1.3	RHOL17	1.6	KLK5	1.4	COLN3	0.9
RHOL5	1.3	RHOL18	1.5	KLK6	1.6	COLN4	1.1
RHOL6	1.6	RHOL19	1.5	KLK7	1.0	COLN5	1.2
RHOL7	1.6	RHOL20	1.5	KLK8	0.7	COLN6	1.1
RHOL8	1.6	RHOL21	1.2	KLK9	1.7	GHOL1_2	1.7
RHOL9	1.5	RHOL22	1.7	KLK10	1.6	GHOL1_3	1.5
RHOL10	1.3	RHOL23	0.5	COLE1	1.1	GHOL1_5	1.4
RHOL11	1.1	RHOL24	1.2	COLE3	1.5	GHOL1_6	1.7
RHOL12	1.1	RHOL25	1.8	COLE4	1.2	GHOL1_7	1.4
RHOL13	1.1						

Table A.8.37: Old lands root density at Depth C.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
RHOL1	0.002498	RHOL16	0.000392	KLK1	0.000025	GHOL1_5	0.001260
RHOL2	0.000132	RHOL17	0.000734	KLK2	0.000006	GHOL1_6	0.000250
RHOL3	0.000681	RHOL18	0.001883	KLK3	0.000025	GHOL1_8	0.000476
RHOL4	0.001235	RHOL19	0.000457	KLK4	0.000014	GHOL1_9	0.000251
RHOL5	0.000285	RHOL20	0.000402	KLK5	0.000003	GHOL1_10	0.000399
RHOL6	0.000412	RHOL21	0.000574	KLK6	0.000018	GHOL3_1	0.000391
RHOL7	0.001286	RHOL22	0.000495	KLK7	0.000010	GHOL2_2	0.000425

RHOL8	0.000423	RHOL23	0.000640	KLK8	0.000084	GHOL3_2	0.000678
RHOL9	0.000472	RHOL24	0.000682	KLK9	0.000008	GHOL2_3	0.000460
RHOL10	0.001142	RHOL25	0.000459	KLK10	0.000015	GHOL3_3	0.000436
RHOL11	0.001335	GHOL2_1	0.000855	COLN1	0.000552		
RHOL12	0.003566	GHOL2_2	0.000305	COLN4	0.000301		
RHOL13	0.001516	GHOL2_3	0.000447	COLN5	0.000214		
RHOL14	0.001177	GHOL2_4	0.000223	COLN6	0.001011		
RHOL15	0.000953	GHOL2_5	0.000891	GHOL1_2	0.000165		

Table A.8.38: Old lands stone volume at Depth C.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
RHOL1	30	RHOL16	16	KLK3	10	COLN4	28
RHOL2	8	RHOL17	5	KLK4	20	COLN5	22
RHOL3	7	RHOL18	3	KLK5	12	COLN6	19
RHOL4	3	RHOL19	8	KLK6	11	GHOL1_1	0.0
RHOL5	19	RHOL20	2	KLK7	4	GHOL1_2	0.3
RHOL6	4	RHOL21	14	KLK8	2	GHOL1_3	0.3
RHOL7	5	RHOL22	8	KLK9	15	GHOL1_4	1
RHOL8	7	RHOL23	4	KLK10	7	GHOL1_5	0.3
RHOL9	9	RHOL24	4	COLE1	15	GHOL1_6	12
RHOL10	16	RHOL25	3	COLE3	16	GHOL1_7	1
RHOL11	37	GHOL2_1	0	COLE4	31	GHOL1_8	1
RHOL12	12	GHOL2_2	0	COLE5	19	GHOL1_9	0.3
RHOL13	22	GHOL2_3	6	COLN1	8	GHOL1_10	14
RHOL14	12	KLK1	7	COLN2	7		
RHOL15	2	KLK2	5	COLN3	18		

Table A.8.39: Old lands mean organic carbon at Depth C.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
RHOL1	2.3	RHOL16	0.1	KLK2	0.3	COLN2	1.5
RHOL2	0.6	RHOL17	0.3	KLK3	0.3	COLN3	0.9
RHOL3	0.7	RHOL18	0.7	KLK4	0.5	COLN4	1.2
RHOL4	1.2	RHOL19	0.6	KLK5	0.4	COLN5	1.8
RHOL5	0.4	RHOL20	0.2	KLK6	0.3	COLN6	1.0
RHOL6	0.3	RHOL21	0.3	KLK7	0.2	GHOL1_1	0.5
RHOL7	0.2	RHOL22	0.6	KLK8	0.7	GHOL1_2	0.2
RHOL8	0.1	RHOL23	0.4	KLK9	0.4	GHOL1_3	0.5
RHOL9	0.5	RHOL24	0.3	KLK10	0.4	GHOL1_4	0.5

RHOL10	0.7	RHOL25	0.1	COLE1	2.0	GHOL1_5	0.8
RHOL11	0.7	GHOL2_1	0.5	COLE2	1.1	GHOL1_6	0.3
RHOL12	1.2	GHOL2_2	0.5	COLE3	0.7	GHOL1_7	0.6
RHOL13	0.8	GHOL2_3	0.6	COLE4	0.6	GHOL1_8	0.9
RHOL14	0.6	GHOL2_4	0.4	COLE5	1.4	GHOL1_9	0.3
RHOL15	0.6	KLK1	0.6	COLN1	1.0	GHOL1_10	0.4

Table A.8.40: Degraded bulk density carbon at Depth A.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
KAD1	0.6	KDH5	1.2	RHDST7	1.7
KAD2	1.7	KGHB1	1.5	RHDST11	1.0
KAD3	1.1	KGHB2	1.0	RHDST12	1.0
KAD4	0.7	KGHB3	1.2	RHDST13	0.9
KAD5	0.8	KGHB4	0.9	RHDST14	0.6
KAD6	0.5	KRC1	0.7	RHDST15	1.2
KAD7	0.6	KRC4	0.6	RHDST16	1.0
KAD8	0.5	KRC5	0.5	RHDST20	1.9
KAD10	1.2	RHDST2	1.1	RHDST24	0.5
KDH1	0.8	RHDST3	0.6	RHDST25	0.8
KDH2	1.8	RHDST4	0.9		
KDH3	0.8	RHDST5	0.8		
KDH4	1.5	RHDST6	0.8		

Table A.8.41: Degraded root density carbon at Depth A.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
KAD1	0.000030	KDH3	0.003417	RHDST1	0.008428	RHDST13	0.001131
KAD2	0.000011	KDH4	0.002033	RHDST2	0.003749	RHDST14	0.001855
KAD3	0.000038	KDH5	0.000008	RHDST3	0.002707	RHDST15	0.000416
KAD4	0.000277	KGHB1	0.010035	RHDST4	0.003508	RHDST16	0.000203
KAD5	0.000131	KGHB2	0.000012	RHDST5	0.005632	RHDST17	0.008702
KAD6	0.000184	KGHB3	0.000863	RHDST6	0.001373	RHDST18	0.000094
KAD7	0.000451	KGHB4	0.000005	RHDST7	0.003719	RHDST19	0.000096
KAD8	0.000040	KGHB5	0.000009	RHDST8	0.004876	RHDST20	0.000956
KAD9	0.000047	KRC1	0.000235	RHDST9	0.000371	RHDST22	0.000501
KAD10	0.000308	KRC2	0.000127	RHDST10	0.004814	RHDST23	0.001470
KDH1	0.000685	KRC4	0.000078	RHDST11	0.000126	RHDST24	0.000025
KDH2	0.002420	KRC5	0.000163	RHDST12	0.000027	RHDST25	0.000370

Table A.8.42: Degraded stone volume at Depth A.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
KAD1	17	KDH3	30	RHDST1	3	RHDST13	33
KAD2	33	KDH4	67	RHDST2	9	RHDST14	42
KAD3	26	KDH5	13	RHDST3	3	RHDST15	28
KAD4	9	KGHB1	5	RHDST4	14	RHDST16	15
KAD5	19	KGHB2	11	RHDST5	17	RHDST17	8

KAD6	23	KGHB3	24	RHDST6	3	RHDST18	7
KAD7	11	KGHB4	20	RHDST7	18	RHDST19	2
KAD8	30	KGHB5	44	RHDST8	19	RHDST20	3
KAD9	46	KRC1	24	RHDST9	7	RHDST22	12
KAD10	28	KRC2	13	RHDST10	46	RHDST23	15
KDH1	16	KRC4	21	RHDST11	33	RHDST24	43
KDH2	33	KRC5	41	RHDST12	26	RHDST25	13

Table A.8.43: Degraded mean organic carbon at Depth A.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
KAD1	1.2	KDH4	1.0	RHDST2	1.4	RHDST15	1.7
KAD2	2.6	KDH5	1.5	RHDST3	1.5	RHDST16	0.6
KAD3	1.6	KGHB1	1.9	RHDST4	1.6	RHDST17	0.9
KAD4	2.1	KGHB2	0.7	RHDST5	2.0	RHDST18	0.4
KAD5	3.0	KGHB3	0.8	RHDST6	0.6	RHDST19	0.6
KAD6	2.4	KGHB4	0.9	RHDST7	1.5	RHDST20	1.0
KAD7	2.7	KGHB5	1.3	RHDST8	1.5	RHDST22	1.0
KAD8	1.9	KRC1	1.0	RHDST9	1.2	RHDST23	1.6
KAD9	2.8	KRC2	0.5	RHDST10	1.4	RHDST24	0.9
KAD10	2.1	KRC4	0.9	RHDST11	1.8	RHDST25	1.2
KDH1	1.3	KRC5	0.3	RHDST13	2.4		
KDH2	1.0	RHDST1	1.2	RHDST14	2.2		
KDH3	1.1						

Table A.8.44: Degraded mean bulk density at Depth B.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
KAD1	0.6	KDH3	0.7	KRC5	0.6	RHDST13	0.9
KAD2	0.7	KDH4	0.8	RHDST2	0.9	RHDST14	0.5
KAD3	0.5	KGHB1	1.4	RHDST3	1.2	RHDST15	1.1
KAD4	0.9	KGHB2	0.8	RHDST4	1.1	RHDST16	1.6
KAD5	1.3	KGHB3	0.9	RHDST5	1.1	RHDST18	1.9
KAD6	1.2	KGHB4	0.9	RHDST6	1.8	RHDST19	1.4
KAD7	0.8	KGHB5	0.7	RHDST8	1.7	RHDST20	1.6
KAD8	1.0	KRC1	0.9	RHDST9	1.6	RHDST22	1.2
KAD10	1.0	KRC2	0.8	RHDST11	1.5	RHDST24	1.3
KDH2	1.4	KRC3	0.7	RHDST12	1.0	RHDST25	0.8

Table A.8.45: Degraded root density at Depth B.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
KAD1	0.000034	KDH4	0.000027	RHDST1	0.002519	RHDST14	0.000547
KAD3	0.000325	KDH5	0.000003	RHDST2	0.001918	RHDST15	0.000999
KAD4	0.001378	KGHB1	0.003795	RHDST3	0.002244	RHDST16	0.000495
KAD5	0.000047	KGHB2	0.003486	RHDST4	0.001452	RHDST18	0.000491
KAD6	0.000072	KGHB3	0.019776	RHDST5	0.001696	RHDST19	0.000316

KAD7	0.000061	KGHB4	0.000516	RHDST6	0.000822	RHDST20	0.000296
KAD8	0.000024	KGHB5	0.000619	RHDST8	0.003442	RHDST22	0.006278
KAD9	0.000026	KRC1	0.004681	RHDST9	0.000318	RHDST23	0.001002
KAD10	0.000037	KRC2	0.001024	RHDST10	0.003840	RHDST24	0.000106
KDH1	0.000983	KRC3	0.000235	RHDST11	0.002758	RHDST25	0.000316
KDH2	0.000551	KRC4	0.001875	RHDST12	0.000561		
KDH3	0.003395	KRC5	0.000038	RHDST13	0.002483		

Table A.8.46: Degraded stone volume at Depth B.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
KAD1	26	KDH4	34	RHDST1	9	RHDST14	28
KAD2	21	KDH5	28	RHDST2	26	RHDST15	20
KAD3	30	KGHB1	47	RHDST3	5	RHDST16	1
KAD4	8	KGHB2	56	RHDST4	15	RHDST18	5
KAD5	58	KGHB3	35	RHDST5	14	RHDST19	1
KAD6	45	KGHB4	52	RHDST6	28	RHDST20	3
KAD7	36	KGHB5	48	RHDST8	19	RHDST22	10
KAD8	28	KRC1	38	RHDST9	11	RHDST23	33
KAD10	21	KRC2	28	RHDST10	3	RHDST24	17
KDH1	19	KRC3	22	RHDST11	44	RHDST25	22
KDH2	48	KRC4	57	RHDST12	21		
KDH3	16	KRC5	36	RHDST13	26		

Table A.8.47: Degraded mean organic carbon at Depth B.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
KAD1	0.7	KDH4	0.6	RHDST2	0.5	RHDST15	2.6
KAD2	1.9	KDH5	1.2	RHDST3	1.6	RHDST16	0.1
KAD4	4.3	KGHB1	0.5	RHDST4	0.2	RHDST18	0.1
KAD5	1.6	KGHB2	0.3	RHDST5	0.8	RHDST19	0.4
KAD6	1.1	KGHB3	0.7	RHDST6	0.6	RHDST20	0.3
KAD7	1.8	KGHB4	0.6	RHDST7	1.6	RHDST22	0.8
KAD8	0.7	KGHB5	0.7	RHDST8	0.5	RHDST23	1.2
KAD9	1.5	KRC1	1.3	RHDST9	1.1	RHDST24	0.4
KAD10	0.8	KRC2	0.4	RHDST10	2.1	RHDST25	1.4
KDH1	0.8	KRC4	1.1	RHDST11	1.3		
KDH2	0.9	KRC5	0.5	RHDST13	1.9		
KDH3	0.9	RHDST1	0.6	RHDST14	1.5		

Table A.8.48: Degraded bulk density at Depth C.

Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)	Code	Bulk Density (g/cm^3)
KAD3	0.4	KRC1	0.8	RHDST13	0.8
KAD5	0.7	KRC3	0.7	RHDST14	0.5
KAD6	0.8	KRC4	0.5	RHDST15	1.6
KAD7	0.7	RHDST4	1.3	RHDST18	1.6

KAD8	0.9	RHDST5	1.2	RHDST19	1.4
KAD9	1.1	RHDST7	1.9	RHDST20	1.3
KAD10	0.6	RHDST8	1.0	RHDST23	1.3
KDH2	1.9	RHDST10	0.9	RHDST24	0.6
KDH4	1.3	RHDST11	0.9	RHDST25	0.8
KDH5	1.5	RHDST12	0.8		

Table A.8.49: Degraded root density at Depth C.

Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)	Code	Root Density (g/cm^3)
KAD1	0.000005	KDH3	0.000981	RHDST2	0.000885	RHDST15	0.001135
KAD2	0.000018	KDH4	0.001347	RHDST3	0.000524	RHDST16	0.001205
KAD3	0.000047	KDH5	0.000978	RHDST4	0.000911	RHDST17	0.000626
KAD4	0.000320	KGHB1	0.002744	RHDST5	0.002807	RHDST18	0.000248
KAD5	0.000010	KGHB2	0.002312	RHDST6	0.000419	RHDST19	0.001159
KAD6	0.000088	KGHB3	0.000605	RHDST7	0.005504	RHDST20	0.002078
KAD7	0.000014	KGHB4	0.000820	RHDST8	0.000801	RHDST23	0.000619
KAD8	0.000046	KRC1	0.000446	RHDST9	0.000379	RHDST24	0.000105
KAD9	0.000009	KRC2	0.000714	RHDST10	0.001270	RHDST25	0.000153
KAD10	0.000037	KRC3	0.000071	RHDST11	0.001085		
KDH1	0.000414	KRC4	0.000206	RHDST12	0.000153		
KDH2	0.001019	KRC5	0.000026	RHDST14	0.000260		

Table A.8.50: Degraded stone volume at Depth C.

Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)	Code	Stone Volume (%)
KAD1	35	KDH2	67	KRC5	17	RHDST12	12
KAD2	35	KDH3	45	RHDST1	5	RHDST13	29
KAD3	18	KDH4	54	RHDST2	58	RHDST14	20
KAD4	30	KDH5	15	RHDST3	46	RHDST15	32
KAD5	43	KGHB1	84	RHDST4	21	RHDST18	24
KAD6	5	KGHB2	67	RHDST5	18	RHDST19	1
KAD7	6	KGHB3	62	RHDST7	32	RHDST20	1
KAD8	45	KGHB4	52	RHDST8	13	RHDST22	20
KAD9	57	KRC1	30	RHDST9	35	RHDST23	24
KAD10	37	KRC3	38	RHDST10	24	RHDST24	26
KDH1	56	KRC4	30	RHDST11	26	RHDST25	45

Table A.8.51: Degraded mean organic carbon at Depth C.

Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)	Code	Mean Organic Carbon (%)
KAD1	0.5	KDH3	0.7	KRC5	0.1	RHDST13	1.1
KAD2	0.8	KDH4	0.6	RHDST1	1.0	RHDST14	2.0
KAD3	1.6	KDH5	1.2	RHDST2	0.5	RHDST15	2.0
KAD4	1.8	KGHB1	0.6	RHDST3	0.7	RHDST16	0.3
KAD5	1.5	KGHB2	0.5	RHDST4	0.4	RHDST18	0.1
KAD6	1.4	KGHB3	0.5	RHDST5	1.4	RHDST19	0.4

KAD7	0.3	KGHB4	0.3	RHDST6	0.4	RHDST20	0.3
KAD8	1.4	KGHB5	0.5	RHDST7	0.9	RHDST22	0.8
KAD9	1.3	KRC1	1.5	RHDST9	0.9	RHDST23	1.0
KAD10	0.6	KRC2	0.5	RHDST10	0.4	RHDST24	0.7
KDH1	0.5	KRC4	0.7	RHDST11	1.2	RHDST25	1.1
KDH2	0.7						

Table A.8.52: *Ex ante* carbon storage per hectare for degraded and old fields in the Baviaanskloof (based on the difference between intact and degraded/old fields).

	Ex ante (degraded) (t CO_2e ha^{-1})	Ex ante (old fields) (t CO_2e ha^{-1})
Root (0-25 cm)*	27.5	27.6
Root (25-110 cm)*	1.72	3.01
Soil (0-25 cm)*	130	112
Soil (25-110 cm)*	85.7	59.6
Deadwood	0.02	0.02
Litter	8.32	10.0
Above ground	72.9	80.5
Total mean	327	293
Combined Uncertainty	19	22

* Soil and root samples are split into two groups based on the two different sampling methodologies used (see Section 3.2: sampling).

Table A.8.53: Mean carbon storage per hectare in the Baviaanskloof.

	Mean (t CO_2eq ha^{-1})	Standard Deviation	N	Standard Error	95% confidence interval	Uncertainty (%)
Root (0-25 cm)*						
Degraded thicket	4.8	5.4	42	0.8	1.6	34
Old fields	4.7	4.0	53	0.6	1.1	23
Intact	32.3	63.9	52	9.0	17.5	54
Root (25-110 cm)*						
Degraded thicket	2.2	3.7	16	0.9	1.9	86
Old fields	0.9	0.7	30	0.1	0.2	28
Intact	3.9	4.2	24	0.9	1.7	45
Soil (0-25 cm)*						
Degraded thicket	64.5	35.2	45	5.3	10.4	16
Old fields	83.0	47.2	60	6.1	12.0	15
Intact	194.9	148.1	68	18.1	35.5	18
Soil (25-110 cm)*						
Degraded thicket	47.1	16.1	14	4.5	8.7	19
Old fields	73.2	36.3	23	7.7	15.1	21
Intact	132.8	85.4	22	18.6	36.5	27
Deadwood						
Degraded thicket	0	0	50	0	0	-
Old fields	0	0	65	0	0	-
Intact	0.02	0.14	76	0.02	0.03	197
Litter						
Degraded thicket	4.7	7.1	50	1.0	2.0	42

Old fields	3.0	5.5	65	0.7	1.4	45
Intact	13.0	15.9	76	1.8	3.6	28
Above ground						
Degraded thicket	18.8	24.6	50	3.5	6.9	37
Old fields	11.3	17.5	65	2.2	4.3	38
Intact	91.7	120.3	76	13.9	27.2	30

* Soil and root samples are split into two groups based on the two different sampling methodologies used for the two different depths (0-25 cm and 25-110 cm).

Annex 9 Calibration of bulk density measurements

Table A.9.1: Calibration of bulk density measurements between 60°C and 100°C.

	60°C			100°C			% change
N	4h	8h	10h	1h	12h	18h	
1	64.82	64.82	64.82	64.82	64.78	64.77	0.08
2	66.35	66.36	66.36	66.36	66.34	66.34	0.03
3	69.94	69.92	69.92	69.91	69.82	69.81	0.16
4	70.86	70.86	70.86	70.85	70.83	70.82	0.06
5	70.64	70.64	70.64	70.65	70.6	70.59	0.07
6	69.59	96.57	69.56	69.55	69.48	69.47	0.13
7	53.54	53.51	53.5	53.48	53.36	53.35	0.28
8	72.34	72.32	72.32	72.3	72.21	72.2	0.17
9	84.42	84.40	84.4	84.37	84.27	84.27	0.15
10	53.39	53.36	53.36	53.35	53.26	53.26	0.19
11	72.81	72.77	72.77	72.75	72.64	72.64	0.18
12	79.10	79.08	79.08	79.07	78.97	78.96	0.15
13	68.05	68.04	68.05	68.03	67.95	67.94	0.16
14	68.33	68.31	68.31	68.3	68.21	68.21	0.15
15	78.41	78.39	78.4	78.37	78.3	78.3	0.13
16	63.66	63.65	63.66	63.65	63.62	63.62	0.06
17	71.98	71.94	71.94	71.93	71.86	71.86	0.11
18	60.02	59.96	59.97	59.95	59.8	59.79	0.30
19	62.71	62.70	62.7	62.68	62.61	62.61	0.14
20	69.19	69.19	69.2	69.19	69.12	69.11	0.13
Average % change in mass							0.14

Annex 10 Contracts and business plan

The following documents are appended to indicate the nature of agreements entered into, as well as the start date of the project. The Business Plan for the "Eastern Cape Subtropical Thicket Rehabilitation Pilot Project" dated 5 August 2004 indicates that although the Kyoto Protocol had yet to be ratified, carbon trading was already happening at that stage. The Business Plan states that the aims of the pilot project were to assess carbon storage through rehabilitation of spekboom, and to study the economic, social and ecological impacts of the project. It was funded by DWAF specifically to assess and develop methods of thicket rehabilitation for carbon trading.

A 10.1 Initial business plan for thicket restoration in the Baviaanskloof.

Figure A. 10.1: Initial business plan for the thicket restoration project. The full plan is available on request from GIB.

PILOT PROJECT

Eastern Cape Subtropical Thicket Rehabilitation

REVISED BUSINESS PLAN
2004/5 – 2007

Initial Project Donors:

WORKING FOR WATER PROGRAMME (EASTERN CAPE)

Complied by: **Gamtoos Irrigation Board**
Date: **5 August 2004**

Approved by:
Date:

Department of Water Affairs and Forestry

List of Acronyms

BMR	Baviaanskloof Megareserve
CDM	Clean Development Mechanism
DEAET	Department of Economic Affairs, Environment and Tourism
DWAF	Department of Water Affairs and Forestry
GIB	Gamtoos Irrigation Board
KPI	Key Performance Indicators
STEP	Subtropical Thicket Ecosystem Planning
TA	Technical Advisor
TORs	Terms of reference
WF	Wilderness Foundation
WfW	Working for Water Programme

Executive Summary

This project aims to develop cost-effective mechanisms for rehabilitation of subtropical thicket across a number of land use classes within the Eastern Cape. Ultimately the pilot-project proposes to kick-start a larger, biome-level rehabilitation initiative and thereby meet a number of local, regional and national needs (Marais 2004). It is generally accepted that areas that have been degraded of biodiversity are more prone to invasion by alien species. Rehabilitation of degraded areas therefore acts as a preventative measure to the emergence of invader species, in this case with specific reference to invasive grasses and prickly pears, simultaneously developing exit strategy opportunities for the WfW programme in the region. It is structured to be a pilot project and has a secondary role to explore and better understand, as well as develop the potential economies of carbon sequestration, biodiversity conservation and combating desertification.
The rehabilitation project is part of a long-term holistic management strategy in the rehabilitation of the vegetation of the area. The economic factors and variables of the rehabilitation project will be rigorously measured and modelled.

Gamtoos Irrigation Board (GIB) will be responsible for the implementation of the pilot project. The Wilderness Foundation (WF), through the contractual responsibility of managing the Baviaanskloof Megareserve Project, will partner the GIB on the project and will assume responsibility for the development protocols for the project and related scientific and project management inputs into the rehabilitation sites.

Project Budgets:

The budget summary below indicates the total projected costs of this project. The EC WfW, the Cape Action for People and the Environment (CAPE) and The Wilderness Foundation (WF) contributed to the capacity building in 2003/2004.

1. Introduction

1.1 Historical Background

With the advent of increased mechanisation and industrialisation, it is becoming apparent that the excessive use of fossil fuels, primarily through combustion is creating unnaturally high concentrations of gases in the atmosphere. These gases, ozone, nitrogen-oxide and a few others, notably carbon dioxide, are causing a steady rise in mean global temperatures – in the form of a heat retaining "blanket". It is reported that there has been an accumulated 30% increase since the industrial revolution (Appenzeller 2004). This could have colossal impacts for the planet's climate, biodiversity and primary production. The greenhouse gases, especially carbon are becoming important economic and trade issues (Shea *et al.* 1998).

The seriousness of the situation is clearly evident in the stipulations of the United Nations Framework Convention for Climate Change (i.e. Kyoto Protocol). All signatories to the protocol are required to reduce emissions of these greenhouse gases to pre 1990 levels. Developed nations that are unable or reluctant to achieve these targets will be required to trade carbon penalties with developing nations who are able to capture carbon – mostly through sustainable forest management practices. Furthermore, article 12 of the Kyoto Protocol provides for the operation of Clean Development Mechanism (CDM). In essence it encourages developed nations to sponsor carbon emission reduction projects in developing countries. Carbon sequestration (long term) and carbon storage (shorter term), as well as rehabilitation could qualify accordingly. This effectively introduces a massive global carbon economy. The sequestration of carbon through the rehabilitation of natural woodlands and forests can make a relatively small but significant contribution to the carbon economy.

Although the Kyoto protocol has not been ratified (yet), carbon trading around the world is happening and increasing volumes are being traded. The Herald Sun (24 May 2004) indicates that Russia is very likely to sign – this will enforce the protocol

and drastically accelerate the carbon trading. South Africa can expect to face stiff competition from other developing nations – especially South America and the East.
A major benefit to the rehabilitation of subtropical thicket is the rehabilitation of biodiversity, ecosystem processes and improving the resilience of natural systems (Eastern Cape Sub Tropical Thicket in this case), while providing work opportunities, skills transfer and capacity building in the rural areas. This will help negate the influx of unemployed people into urban squalour and is in line with the STEP vision of "keeping people on the land in living landscapes" (Knight *et al.* 2003). The bioregional planning exercise conducted by the STEP Project is entering the implementation phase and will be infused into the Integrated Development Plans (IDPs) of numerous local municipalities within the Eastern Cape.

Concurrently international conventions on biodiversity and combating desertification have created the potential for the trade of biodiversity and soil conservation credits. The nature and dynamics of these budding economies are very unclear at this stage, but merit further investigation. It is worth noting that projects that have a focus on carbon storage/sequestration, but have secondary aims to conserve biodiversity, transfer skills and improve livelihoods are receiving favourable attention. It is very often being referred to as "carbon with a face". Even though the potential extent of sequestration might not be at the same level as the potential for a cut in emissions, it is being looked at favourably by the international markets.

South Africa is a signatory to the conventions on Biodiversity, Combating Desertification and Kyoto. This project has the potential to provide tangible deliverables on all three conventions

The thicket biome until relatively recently did not receive much attention from the scientific community (only being recognised as a biome in 1996), and was regarded by many farmers as less desirable than savanna or grassland. STEP vegetation scientists have identified 112 different thicket types (Vlok & Euston-Brown 2002).

A 10.2 Business plan for the ABFRP

Attached as a separate document

A 10.3 Example quotation contract with restoration contractor

Attached as separate document

A 10.4 Example completion document for contract with restoration contractor.

Attached as a separate document.

Annex 11 Socio-economic studies

A 11.1 PRESENCE thesis studies

The Subtropical Thicket Restoration Programme (STRP) collaborates with the PRESENCE project, which is coordinated by Earth Collective, to address key scientific issues in ecosystem restoration in the western Baviaanskloof Nature Reserve. Four theses conducted by MSc students have provided a major contribution to this project, as well as to this ARR Project Description submission. The theses use the concept of ecosystem services in an integrated assessment of opportunities for conservation and sustainable development. Whilst the focus of the work encompasses a wider area than just the Baviaanskloof Nature Reserve, the results are relevant to this ARR project. In particular, all the studies indicate considerable benefit to communities, through the restoration of natural vegetation and the consequent restoration and maintenance of ecosystem services. The communities in question live adjacent to and in close proximity to the Baviaanskloof Nature Reserve, and therefore reflect the opinions of local communities and the socio-economic impacts of the project activities on these communities. Some of the more pertinent findings are described below:

Thesis 1: Valuation of goods and services provided by the thicket ecosystem[37]:

This research answers the following questions:

1. What are the main services provided by the thicket ecosystem that have current and potential economic value?
2. What are the current and potential use levels of the selected services?
3. Who are the main stakeholders involved and how they depend on these thicket services?
4. What are the current economic (and monetary) benefits of selected ecosystem services?
5. What would be the potential economic (and monetary) benefits of ecosystem services in the study area?

In the western Baviaanskloof, local stakeholders' economies and livelihoods depend on ecosystem (thicket) services. The main services for local communities are fuelwood, construction material, medicinal plants, fodder, and water, representing 20 – 25 % of their monthly income. For farmers, fodder, water and tourism represents approximately 50 – 60 % of their gross annual income (Table A.11.1). However, not all of these services are used in a sustainable way, as appears to be the case of fodder and water, as well as fuelwood (in Zaaimanshoek), which may compromise the availability of other services.

Stakeholders depend differently on thicket ecosystem goods and services. For local communities, thicket services represent a 'safety net'. They depend mainly on fuelwood, construction material, medicinal plants, fodder, and water for daily subsistence. Farmers mainly depend on fodder, water and eco-tourism for commercial purposes.

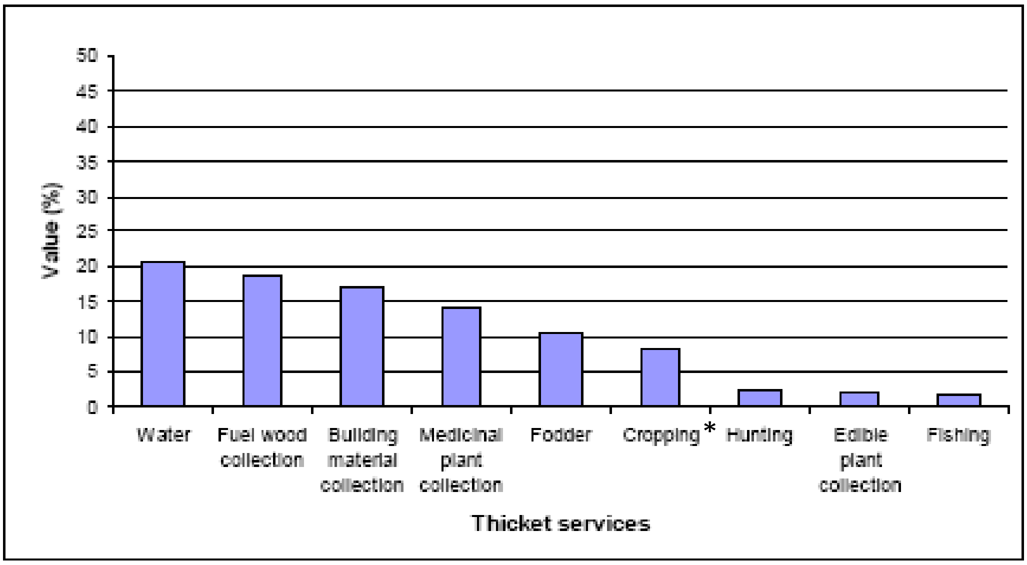
The dependence of local communities on thicket is high (Figure A.11.1). Therefore, the restoration of thicket may imply long-term livelihood assurance and a return of lost natural capital.

[37] De la Flor Tejero, I. 2008. Valuation of the goods and services provided by the thicket ecosystem in the western Baviaanskloof, South Africa. M.Sc. thesis. Wageningen University, The Netherlands.

Table A.11.1: Current total economic value and potential economic value of thicket services.

Current Total Economic Value								
Functions/ Services	**Quantity used/year**	**Employment workers**	**Gross Value year communities (R)**	**Gross value year farmers (R)**	**Total Gross Value year (R)**	**Gross value/ year-ha (R)**	**Potential Economic Value**	**Ecological impact**
Production								
Fuelwood	239 220 kg	1	63 154	-	63 154	1.26	Low	*
Construction material	14784 kg	-	1889	-	1889	0.04	Low	x
Medicinal plants	270 kg	-	3848	-	3848	0.077	Low	x
Fodder**	1730LSU	91 full-time /39seasonal	206 283	2 891 217	3 097 500	62	Low	xx
Hunting	?	-	?	?	?	?	High	x
Honey	180 kg	-	2250	2250	4500	0.09	High	x
Regulation								
Pollination	25	-	-	11 250	11 250	0.225	High	+
CO2 sequestration	-	-	-	-	-	-	High	+
Water supply & regulation	m3	?	?	?	?	?	High	xx
Information								
Recreation eco-tourism)***	11 000 tourist	?	-	4 484 400	4 484 400	90	High	x
TOTAL	-	91 full time/40 seasonal	277 424	7 389 117	**7 666 541** or US$999 717	**153** or US$20	-	-

x: Sustainable
xx: Non-sustainable
+: Positive impact
* Fuelwood collection in Sewefontein is sustainable, but not in Zaaimanshoek
** Workers working in livestock management account for the workers living in Zaaimanshoek and Sewefontein, but also for the community members living on the farmers' farms.
*** Workers in livestock management diversify their activities and collaborate with farmers in the tourism business. Current value of water was not estimated as no scientific data about the benefits that thicket vegetation has on water availability were available at the time of publication of this study.



*Cropping is not an ecosystem service but it has a large influence on the livelihoods of communities (Sewefontein). Water can be considered that the main input of cropping.

Figure A.11.1: Value of thicket ecosystem services according to the Pebble Distribution Method (PDM).

Thesis 2: The relevance of socio-cultural values of ecosystem services to restoration planning and implementation[38]:

The objective of this thesis was to perform a socio-cultural valuation of the thicket ecosystem for primary stakeholders and a preliminary Social Impact Assessment (SIA) of the STRP project.

Primary data collection methods in this study included semi-structured and qualitative interviews, focus group sessions, observation, desk research and several participatory research tools. Socio-cultural valuation, participatory rural appraisal (PRA; including the Pebble Distribution Method or PDM), SIA, participatory geographic information systems (PGIS) and stakeholder analysis were used to analyse the data.

The results show a broad range of socio-cultural values for both farmer and local communities in the western Baviaanskloof. The most important results are:

- Both communities appear to maintain strong 'sense of place' and cultural landscapes values; over 63 % of the farmers and over 95 % of the local inhabitants have lived in the Baviaanskloof valley most of their lives, and many even their whole lives.
- All communities refer to the importance of the suitability of thicket to support livestock and wild animals. All of the farmers and one local community keep livestock for commercial purposes and their own consumption (a cultural-traditional activity); game farming is practiced by 27 % of the farmers.
- For the local communities, the top four most important resources related to thicket to maintain their livelihoods and well-being are water (13.6 %), firewood (12.2 %), building material (11.2 %), and medicinal thicket resources (9.2 %). Whilst these resources are not directly available to the communities within the project areas, since they are

[38] Janssen, K. 2008. The relevance of socio-cultural planning and implementation in the Baviaanskloof. M.Sc. thesis. Wageningen University, The Netherlands.

protected areas, the project will restore the flow of water regionally, and act as a seed bank to promote the recruitment of thicket in adjacent areas.

This study shows that the implementation of STRP under voluntary carbon market regulation would have considerable impacts on socio-cultural values and quality of lives of both farmers and local communities (Figure A.11.2).

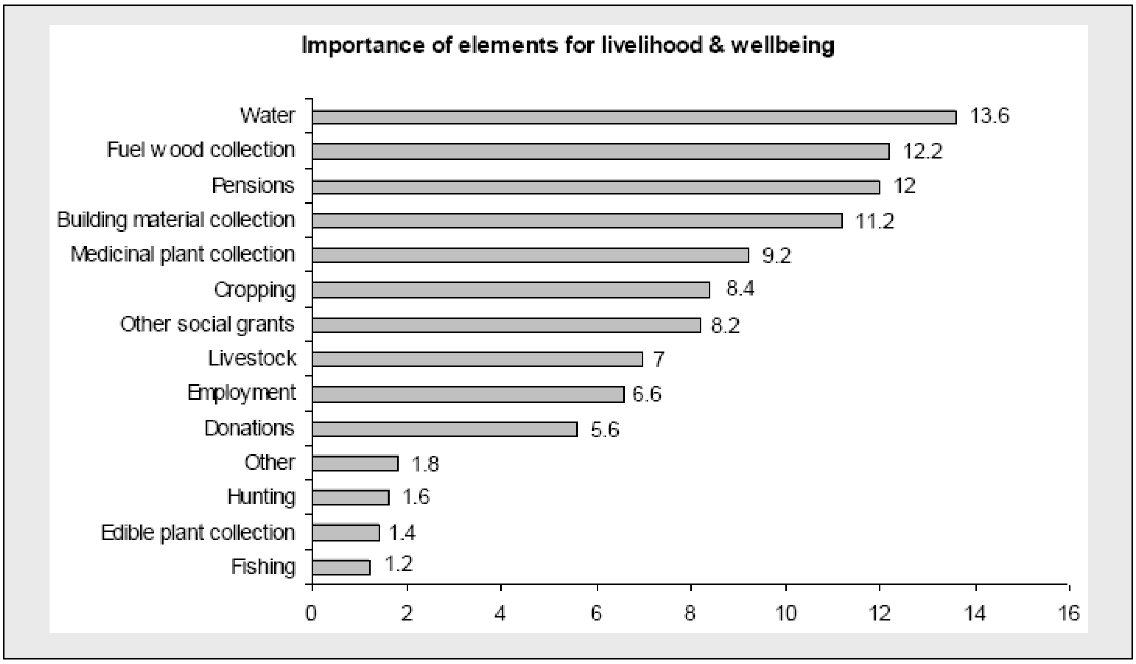


Figure A.11.2: Relative importance of socio-elements according to the local communities in the Western Baviaanskloof. Based on 10 PDM exercises with a total of 44 individual participants.

Thesis 3: Valuing the benefits of restoring water regulation services in the Subtropical Thicket Biome[39]:

This thesis focused on valuing the watershed services provided by thicket and wetland restoration and the insights into their relative importance for the local economy. The research focused on the water services provided by the Baviaanskloof watershed, to the downstream beneficiaries in the Gamtoos valley. The restoration of thicket in the Baviaanskloof Nature Reserve may increase water supply in the Gamtoos valley, and the outcomes of this ARR project are therefore linked to water supply and associated issues. The full thesis is not included in this document due to its size, but is available upon request.

Thesis 4: Willingness to restore land in the Baviaanskloof[40]:

The main objective of this thesis was to evaluate the involvement of stakeholders in land restoration in relation to the thicket ecosystem of the western Baviaanskloof. A general awareness about the necessity to restore the ecosystem was found to be developing amongst all the stakeholders. A number of different incentives may aid land owners in implementing restoration (Figure A.11.3) financial payment being one of the more

[39] Van der Burg, L. 2008. Valuing the benefits of restoring water regulation service in the Subtropical Thicket Biome. M.Sc. Thesis. Wageningen University, The Netherlands.
[40] Noirtin, E. 2008. Who is willing to restore and why? Stakeholder analysis in the Western Baviaanskloof, South Africa. M.Sc. Thesis. Wageningen University, The Netherlands.

acceptable and successful incentives. This finding indicates the role that VERs can play in this community in the future. The full thesis is not included in this document due to its size, but is available upon request.

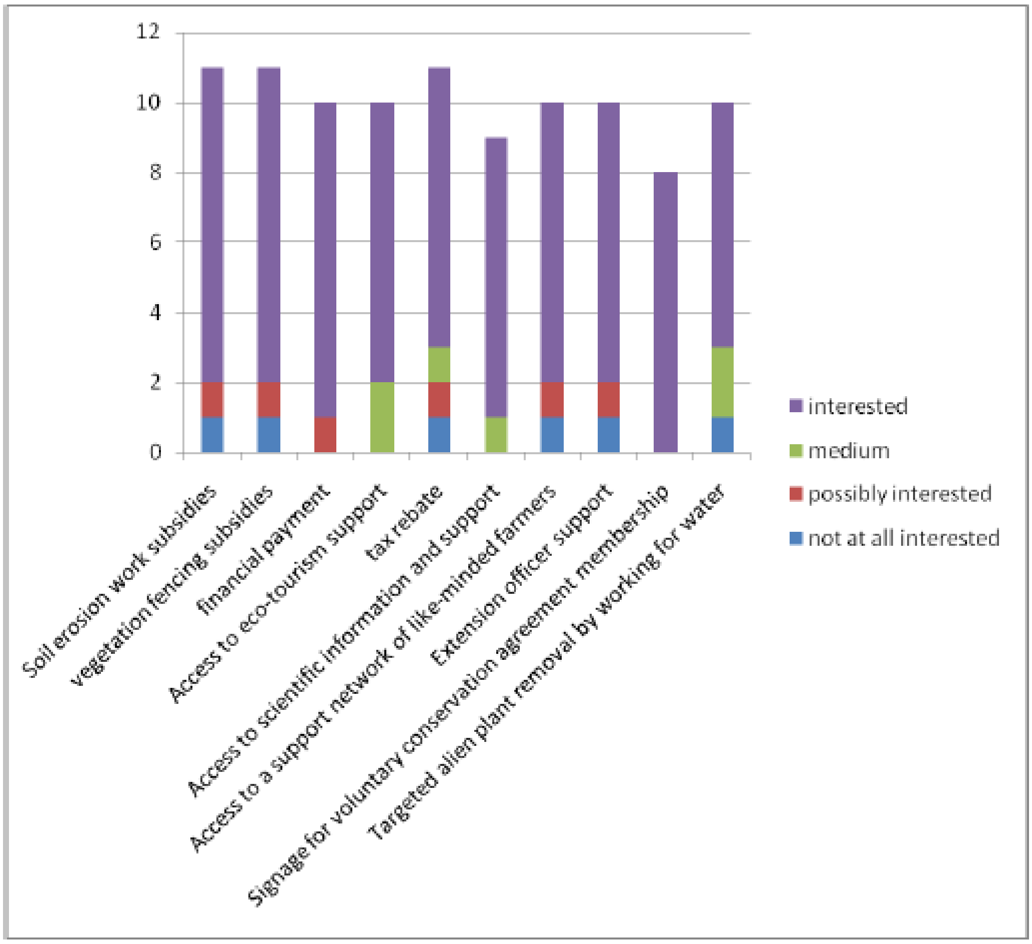


Figure A.11.3: Farmers' interest in various incentives.

A 11.2 Socioeconomic study analysing the impacts of the ABFRP project.

Attached as separate document.

Annex 12 Project area background information

Since the early 1900s, several million ha of semi-arid thicket vegetation in the Eastern Cape, South Africa, have been degraded by intensive goat farming (Lloyd, Palmer, van den Berg, van Wyk, & van der Merwe, 2002). Despite a long association with large, indigenous herbivores, the thicket is surprisingly sensitive to goat pastoralism. Unsustainable browsing of thicket by goats has transformed the vegetation in many areas in the selected nature reserves from a dense assemblage of trees and shrubs covering most of the landscape to an open 'pseudo-savanna' of thicket patches (Lechmere-Oertel, Kerley, & Cowling, Patterns and implications of transformation in semi-arid succulent thicket, South Africa., 2005a; Lechmere-Oertel, Kerley, & Cowling, Landscape dysfunction and reduced spatial heterogeneity in soil resources and fertility in semi-arid succulent thicket, South Africa., 2005b). In the case of extreme degradation, a depleted and dying canopy tree layer is the only remnant of the original perennial vegetation. This degradation results in reduction of species diversity, above and below ground carbon stocks, soil quality and plant productivity (and hence livestock and game stocking capacity). Restoration of thicket by planting cuttings of *P. afra* results in the return of ecosystem carbon (in above ground biomass, below ground biomass, litter and SOM).

Figure A.12.1: Fence line contrast, showing the extent of degradation (on the left) caused by goat pastoralism.

In 2003, the South African government's then Department of Water Affairs and Forestry (DWAF – now the Department of Water Affairs) recognised the opportunity to fund restoration of degraded thicket through the sale of accrued carbon credits. Consequently, DWAF funded an ARR project in 2004 in degraded thicket landscapes in the Eastern Cape, with the purpose of earning carbon credits in order to fund further ARR efforts (Annex 5, Figure A.5.1). Without this incentive to earn carbon credits, this project would not have been funded, as ARR of degraded thicket is costly (approximately US\$500 ha^{-1}).

Initial restoration efforts focused on three conservation areas. The current conservation area is the AENP. Background information for this area is provided below. Information has also been provided for the two provincial nature reserves (the Baviaanskloof Nature Reserve and the GFRNR) that may be included in the grouped project once the outstanding land claims on these areas have been resolved (see Figure A.12.2). The general project area is in the Subtropical Thicket Biome of the Eastern Cape of South Africa, in an area that is semi-arid and susceptible to frequent droughts.

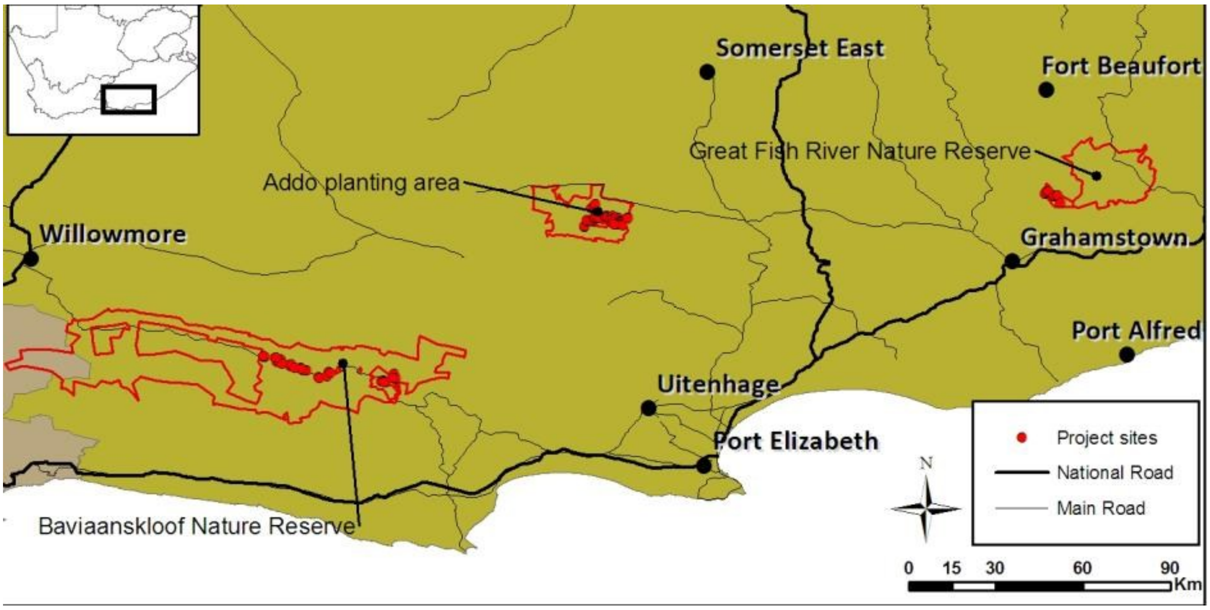


Figure A.12.2: Location of project areas in the Eastern Cape Province of South Africa.

A 12.1 Addo Elephant National Park (current project area)

History

The Addo Elephant National Park was first created in 1931, in response to the extensive culling of elephants by local landowners. The original 2,000 hectares was host to only 11 elephants, and in 1954 the park was expanded to 2,750 hectares and ringed with an elephant-proof fence. Since this time the park boundaries have been extended a number of times through purchase of private land, until it reached its current size of nearly 1,640 km^2.

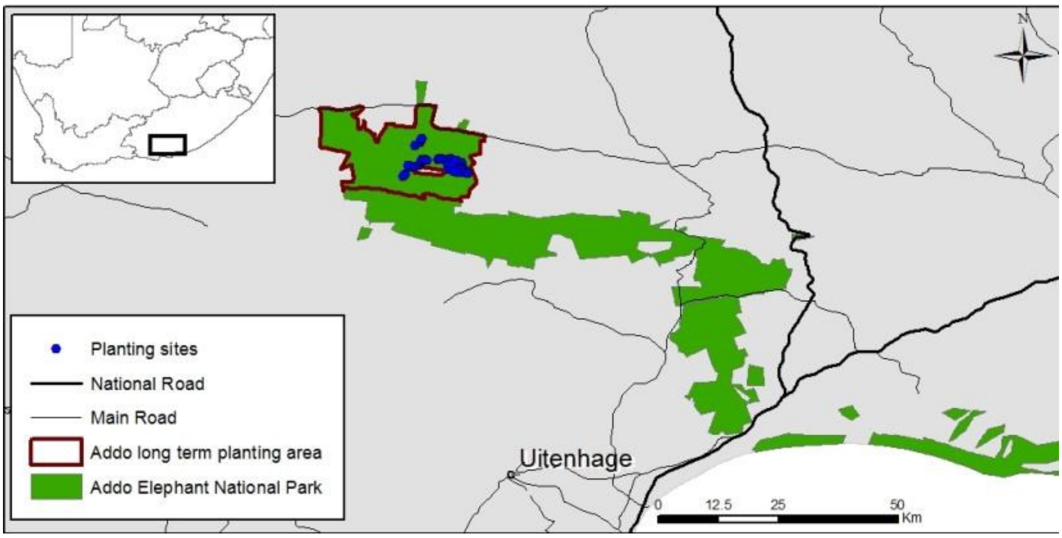


Figure A.12.3: Location of the Addo Elephant National Park and the planned long term planting area in the Eastern Cape of South Africa.

The long term planting (project) area is based in the Darlington Dam section of the northern Addo Elephant National Park. This area was purchased from private landowners over a period of years, in order to expand the area available for conservation, particularly of elephants. The purchased land had previously undergone severe degradation due to unsustainable land management practices over a long period of time. Consequently, at present, much of the selected project area is severely degraded (see Figure A.12.4 below).

As a consequence of this, no elephants are currently stocked in the project area, although as recovery progresses they may be introduced at low stocking rates.

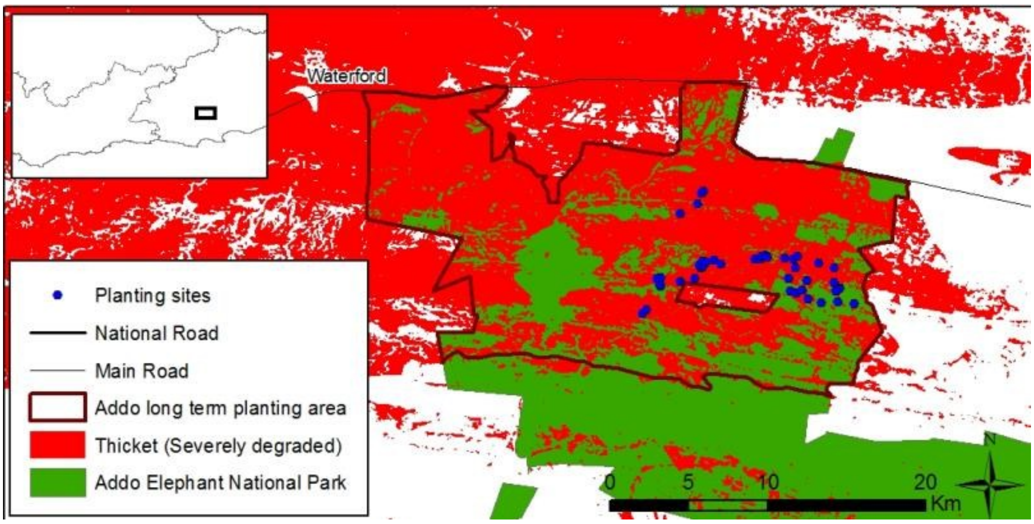


Figure A.12.4: Extent of land degradation within the northern region of the Addo Elephant National Park.

Despite the fact that the land is now protected as a conservation area under national legislation, no recovery of the natural vegetation has been observed (Annex 15). Herbivory is limited, since most large herbivores within the park are located in the southern sections, and consequently more localised factors must be responsible for the current slow rate of recovery.

Climate

The climate of the proposed ARR project area is semi-arid. Mean annual temperatures for the national park are between 16 °C and 19 °C (Figure A.12.8) modelled from rainfall station data and altitude (Schulze, et al., 2008). The mean annual precipitation (also modelled) is approximately 385 mm, varying between 242 mm and 429 mm within the long term planting area (Figure A.12.9). Rainfall is cyclonic and orographic, and has bimodal peaks in spring and autumn. Rainfall events often occur as thunder storms and prolonged droughts are not uncommon.

Geology and soils

The project area has a varied geology, although it is almost exclusively of sedimentary origin, comprising sandstones, shale, mudstone and tillites. The majority of the geological formations within the area fall under the Karoo supergroup, including the Waterford shales and arenites, the Beaufort mudstones and the Ecca and Fort Brown shales. The Witteberg Group (Lake Mentz and Witteberg subgroups) make up the Zuurberg mountain range in the south of the project area, and are comprised primarily of shale and arenite, with some diamictite. Sandwiched between these two groups is the Dwyka glacial sediment group, with its archetypical tillites. The soils in the area are primarily fine textured soils derived from the mudstones and shales, with occasional patches of sandstone- and conglomerate-derived sandy soils. The soils tend to be moderately fertile, and fall within the mid range of soil fertility strata (4 and 5) as defined by Fey (1993).

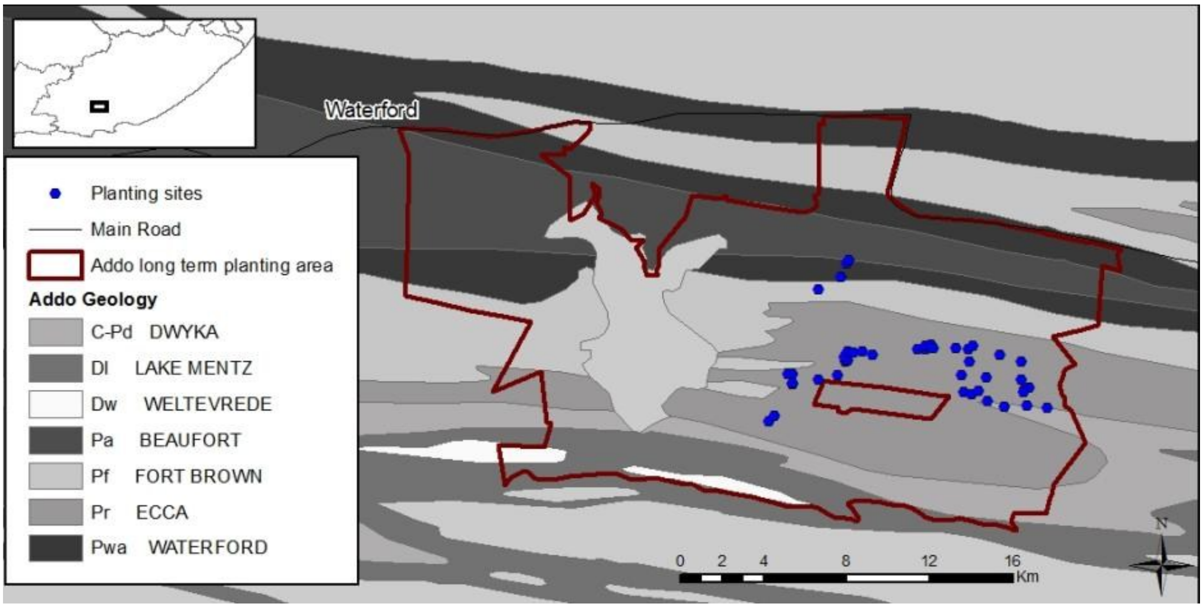


Figure A.12.5: Geology of the Addo Elephant National Park planting area.

Vegetation (Vlok & Euston-Brown, 2002)

The vegetation in the long-term planting (project) area within the Addo Elephant National Park is predominantly shrubby thicket typified by the Sundays Noorsveld and Sundays Spekboomveld. The Sundays Noorsveld is largely restricted to the arid zone within the Sundays River basin, typified by the heavy clays of the Ecca group rocks. It has sparse tree content (primarily *Pappea capensis, Boscia oleoides*, *Euclea undulata,* and *Rhus longispina*), with abundant woody shrubs (predominantly *Gymnosporia polyacantha* and *Rhigozum abovatum*, with occasional *Nymania capensis*) and a dominant *Euphorbia coerulescens*. Originally the pristine habitat boasted a number of perennial grasses (*Cenchrus ciliaris*, *Digitaria argyrograpta, Fingerhuthia africana* and *Panicum maximum*), but there are few areas that have not been overgrazed through goat farming. In degraded land, the open areas are typically filled by short-lived grasses such as *Aristida adscensionis, Aristida congesta, Cynodon dactylon* and *Enneapogon desvauxii*. Spekboom does occur in the Sundays Noorsveld, but tends not to be a major component of the pristine vegetation.

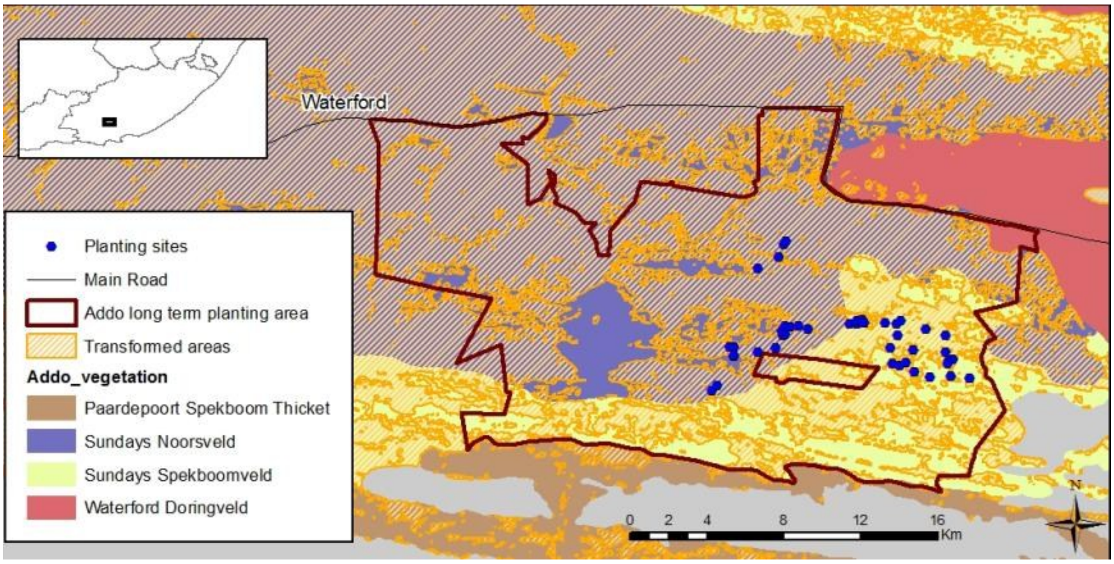


Figure A.12.6: Vegetation types of the Addo Elephant National Park.

In the Sundays Spekboomveld, the dominant *Euphorbia coerulescens* is replaced almost entirely by spekboom, which grows in thick stands. Apart from this notable difference, the Spekboomveld is structurally similar to the Noorsveld, with a slight shift in the makeup of the woody cover (*Pappea capensis* and *Schotia afra* usually more abundant, and *Acacia karoo* generally absent). The Spekboomveld occurs in the southern and eastern part of the project area. When degraded, Sundays Spekboomveld retains only a few woody trees in a matrix of karroid shrubs (*e.g. Pentzia incana* and the alien weed *Atriplex lindleyi*) and annual grasses, as well as the resilient herb *Sansevieria aethiopica*. The latter is generally considered a good indicator of where the Sundays Spekboomveld was once found.

Additional minor vegetation types in the long term planting area are the Pardepoort Spekboom Thicket found in the southernmost areas, and small areas of Waterford Doringveld in the northeast. The Doringveld is structurally similar to the Noorsveld, with the shrubby component largely replaced by short karroid shrubs (*Pentzia incana* is dominant). Typical tree species include *Euclea undulata*, *Gymnosporia polyacantha*, and *Rhus longispina*, with abundant *Acacia karoo* and *Rhus lancea* along the rivers. The Pardepoort Spekboom Thicket is dominated by *Portulacaria afra*, with a well-developed woody component (*Boscia oleoides*, *Pappea capensis, Schotia afra* and occasionally *Schotia latifolia)* and abundant succulents (primarily *Aloe speciosa* and *Crassula ovata*). The upper slopes of Pardepoort Spekboom Thicket tend to have localised endemics such as *Tromotriche longii*, and a different subset of species such as *Ficus burtt-davyi*.

Rare or Endangered species

The Addo Elephant National Park contains several rare and vulnerable species. Included in these are 1 critically endangered plant species, 3 endangered plant species, 6 vulnerable plant species, 6 rare animal species, 5 vulnerable animal species and 7 vulnerable bird species. Full lists of the rare and vulnerable species are given in Table A.12.2 and Table A.12.3. These rare and vulnerable species will benefit from the project activities. The restoration of spekboom thicket will improve habitat conditions for these species.

Table A.12.2: Addo Elephant National Park Red Data List species: flora.

Status	Species
Critically Endangered	*Aloe bowiea*
Endangered	*Adromischus mammillaris*
	Haworthia springbokvlakensis
	Senecio scaposus var. addoensis
Vulnerable	*Agathosma stenopetala*
	Anacampseros subnuda subsp. lubbersii
	Cotyledon tomentosa subsp. tomentosa
	Strelitzia juncea
	Trichodiadema aureum
	Trichodiadema pygmaeum

Table A.12.3: Addo Elephant National Park Red Data List species: fauna.

Status	Species
Rare	*Bitis albanica*

	Dendrohyrax arboreus
	Felis nigripes
	Hippopotamus amphibius
	Panthera pardus
	Proteles cristata
Vulnerable	*Anthropoides paradiseus*
	Ardeotis kori
	Circus ranivorus
	Diceros bicornis bicornis
	Equus zebra
	Falco naumanni
	Felis lybica
	Mellivora capensis
	Neotis denhami
	Neotis ludwigii
	Orycteropus afer
	Polemaetus bellicosus

A 12.2 Baviaanskloof Nature Reserve (proposed grouped project area: not currently included)

History

The Baviaanskloof Nature Reserve is managed by the Eastern Cape Parks Board, and is the centre of the Baviaanskloof Mega-Reserve, a cluster of conservation sites and nature reserves, as well as private land engaged in minimum-impact agricultural and pastoral activities. The Baviaanskloof Nature Reserve was declared a World Heritage Site in 2004 because of its significant ecological processes and biodiversity. Much of the mountain land in the Baviaanskloof Nature Reserve has never been privately-owned. In 1923 the Baviaanskloof Forest Reserve was created to maintain the mountain catchment area, and in 1970 the mandate of the area was extended to include nature conservation and public recreation. In 1977 the Kouga Dam was built, and the state purchased parcels of private land along the Kouga River and close to the dam, transferring ownership to the Department of Forestry.

The Baviaanskloof Nature Reserve was formally created in 1987 when ownership was transferred from the Department of Forestry to the Eastern Cape Provincial government, and in 2004 the Eastern Cape Parks Board took over the management of the reserve for the Eastern Cape Provincial Government. Since 1987, nearly 16,000 ha of land has been purchased by or donated to the State, and an additional 15,332 ha has been purchased with the aid of private funds to expand the size of the reserve. Much of the purchased land was subjected to poor land management practices prior to incorporation into the nature reserve. In total, 12% of the thicket vegetation in the Baviaanskloof Mega-Reserve has been severely degraded by goat farming.The project area will not include the whole of the Mega-Reserve, just the area falling within the provincial Nature Reserve.

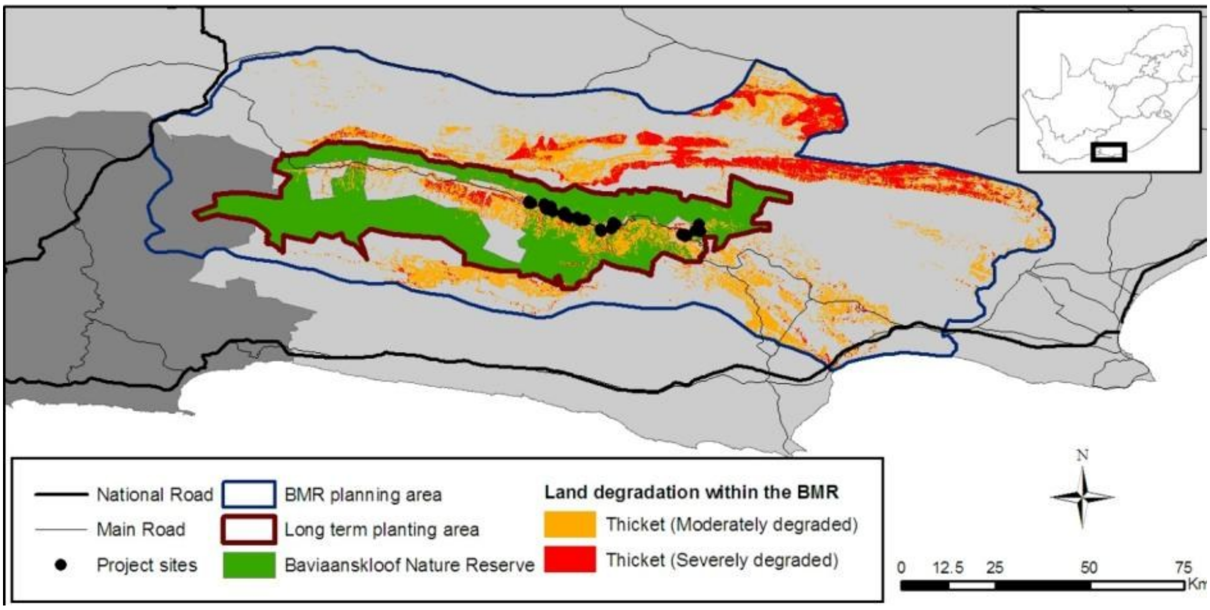


Figure A.12.7: Extent of land degradation within the Baviaanskloof Mega-Reserve. 19% of thicket vegetation in the Baviaanskloof Nature Reserve and 12% in the Baviaanskloof Mega-Reserve are severely degraded.

Climate

The climate of the proposed ARR project area is semi-arid. Mean annual temperatures for the eastern and western extremes of the study area, modelled from rainfall station data and altitude, are 18 ^{o}C and 17 ^{o}C, respectively (Schulze, et al., 2008).

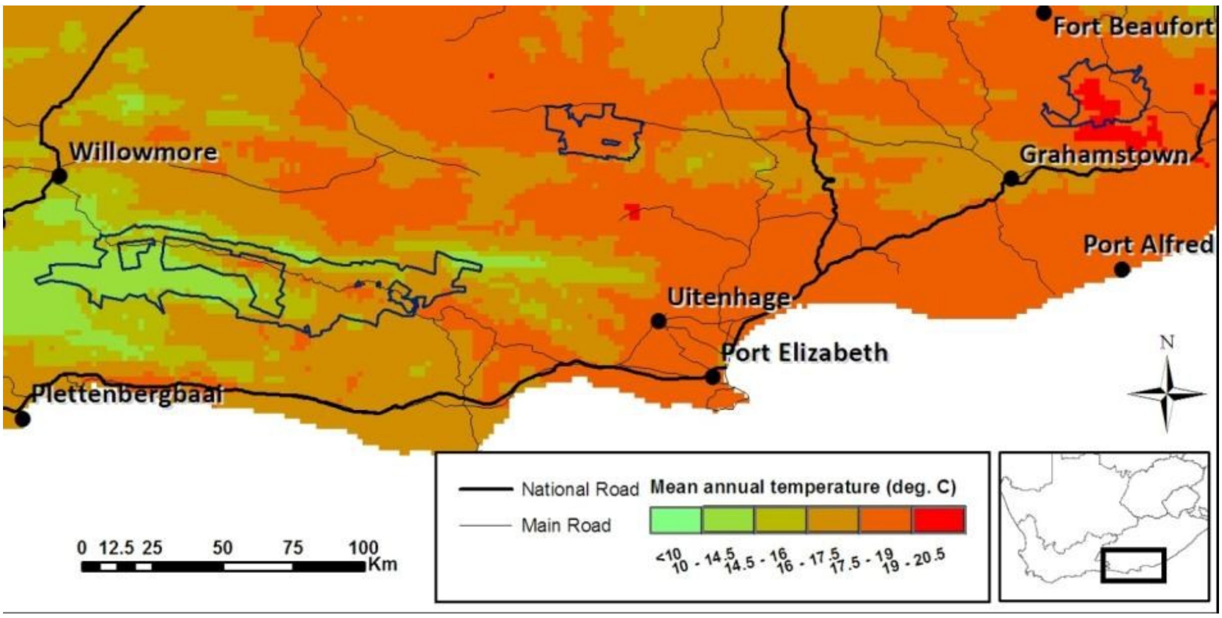


Figure A.12.8: Mean annual temperature in the STEP region of the Eastern Cape. Long term planting areas in the Baviaanskloof Nature Reserve, the Addo Elephant National Park and the GFRNR are outlined from west to east.

The mean annual precipitation and coefficient of variation (in brackets) (also modelled), are 418 mm (32%) (eastern side) and 349 mm (34%) (western side). Rainfall is cyclonic and orographic, has bimodal peaks (spring and autumn) and is relatively unreliable – rainfall events often occur as thunder storms; prolonged droughts are not uncommon.

Proportionately, more summer rainfall occurs in the east, and more winter rainfall occurs in the west. Frost occurs occasionally in winter in bottomland locations and snow is relatively common on the high peaks during winter. Restoration activities in this project will occur on mid to low slopes and thus will not be affected by frost and snow.

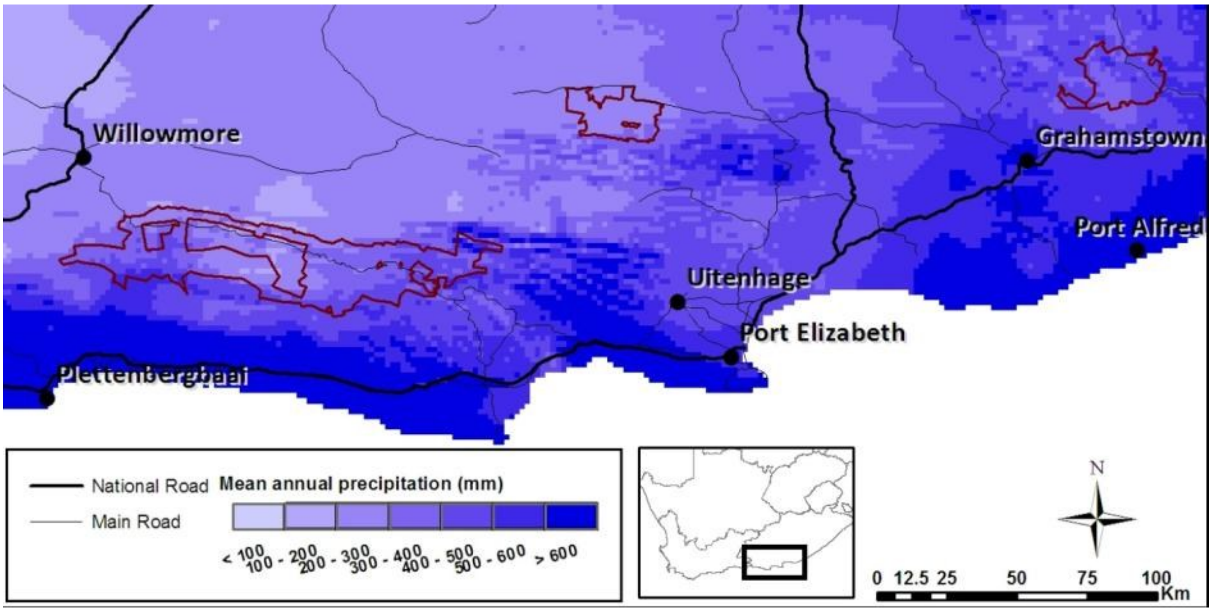


Figure A.12.9: Mean annual rainfall in the STEP region of the Eastern Cape. Long term planting areas in the Baviaanskloof Nature Reserve, the Addo Elephant National Park and the GFRNR are outlined from west to east.

Hydrology

The major river systems are the Baviaans, Gamtoos, Kouga, and Groot Rivers. Although flooding does occur in the landscape, it is uncommon. There are extensive agricultural irrigation systems in the Gamtoos Valley, obtained from the Kouga Dam, a major impoundment within the catchment, which also supplies the water needs of a large proportion of the Nelson Mandela Bay Metropol (Port Elizabeth and surrounding areas).

Geology and soils

The geology across the study area is highly varied (Figure A.12.10) but is predominantly of sedimentary origin, including conglomerates, sandstones, mudstones, siltstones and shales (Council for GeoScience, 1997). In the valley, there is an assortment of sedimentary rocks including Bokkeveld group shale and sandstone (Ceres subgroup), Table Mountain group quartzitic sandstone, shale and tillite (Nardouw subgroup), Gamtoos group limestone, phyllite, granulestone and quartzite, Uitenhage group conglomerate and sandstone (Enon formation) and alluvial deposits of sand, mud and gravel (Council for GeoScience, 1997). Soils across the Baviaanskloof are also varied as a result of a varied geology and a highly dissected terrain, and include *inter alia* Xerosols, Yermosols, Cambisols, Calcisols, Aridisols, Luvisols and Regosols[41]). Furthermore, soils in the region tend to be free-draining, rich in organic matter (under intact thicket only) (4-8 % soil carbon), nutrient-rich (including the macronutrients N, P, K, S, Ca, Mg, as well as micronutrients Mn, Fe, Zn, Cu and B (Council for GeoScience, 1997)) and have intermediate pH values (approximately 6.5-7.5). Many of the soils in the drier southern part of the project area have calcareous B horizons

[41] FAO. 1998. World reference base for soil resources. Food and Agricultural Organisation of the United Nations, Rome.

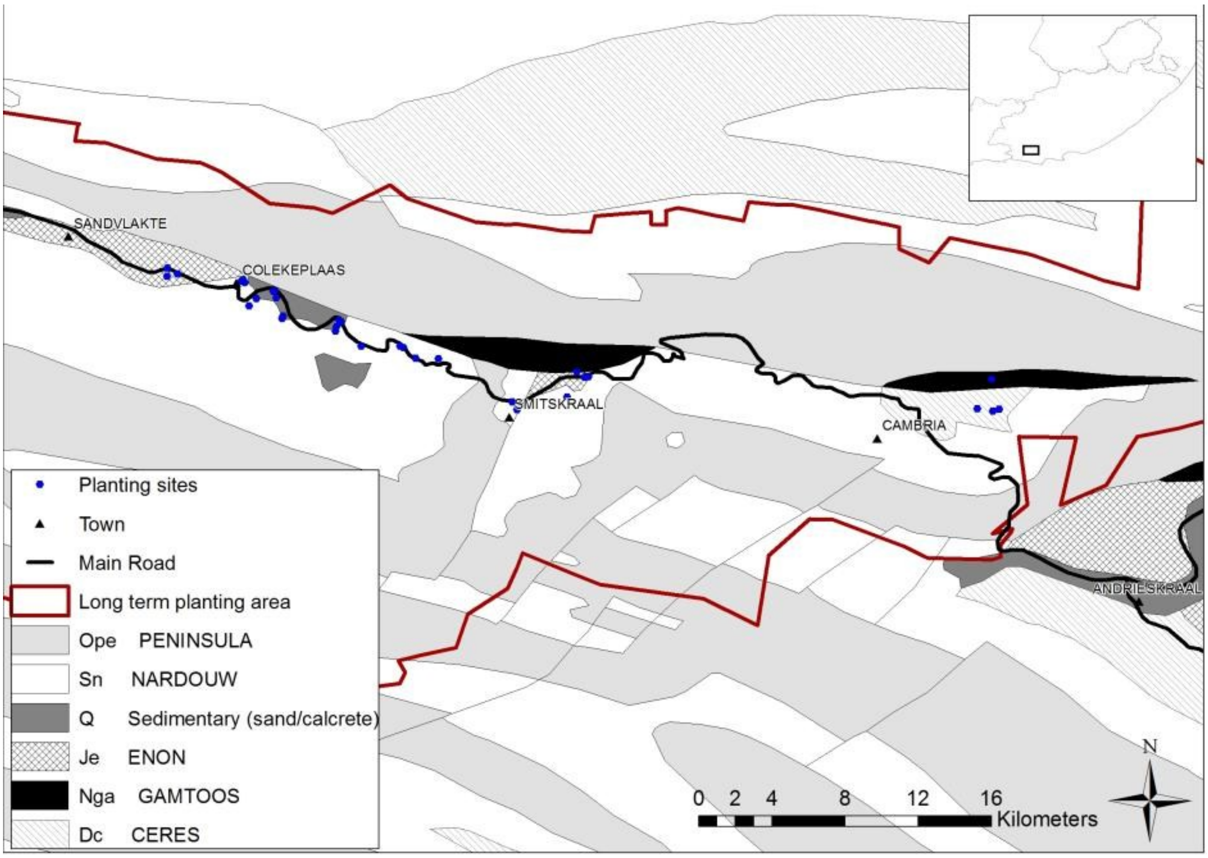


Figure A.12.10: Geology of the Baviaanskloof planting sites.

Vegetation

The vegetation in the Baviaanskloof Nature Reserve is predominantly fynbos and associated shrublands, such as renosterveld. Subtropical thicket is restricted to bottomlands and lower, colluvial slopes. Numerous benefits are offered by the thicket, namely i) in its intact state, it can support an exceptionally high natural diversity and abundance of large browsing mammals, such as black rhinoceros, African elephant (although there are no elephants present in the BNR) and antelope species (including kudu and bushbuck); ii) it is often harvested by local people for wood, fruit, and medicines; iii) it can sustain appropriately managed goat pastoralism; iv) it is the centre of a growing tourism industry; and v) it stores an unusually large quantity of ecosystem carbon for a semi-arid region (Mills A. J., et al., 2005a). It should be noted, however, that neither harvesting nor pastoralism are undertaken within the nature reserve boundary.

Subtropical thicket is composed of succulent (e.g. *P. afra*) and spinescent trees/shrubs less than 5 m tall (e.g. *Azima tetracantha*, *Gymnosporia polyacantha*, *Putterlickia pyracantha*, *Rhus longispina*, *Pappea capensis*, *Euclea undulata*, and *Schotia afra*). The main thicket vegetation types within the Baviaanskloof Nature Reserve include: Baviaanskloof Spekboom Thicket, Baviaanskloof Thicket Savanna, Gamtoos Valley Thicket, Gamtoos Bontveld, Baviaanskloof Renoster Sandolienveld and Baviaanskloof Sandolienveld (Vlok, Euston-Brown, & Cowling, 2003). The vegetation types within the project area include two solid (or pure) valley thicket types (Vlok, Euston-Brown, & Cowling, 2003), namely Baviaans Spekboom Thicket and Gamtoos Valley Thicket, which are the focal vegetation types for the Baviaanskloof area. The latter occurs under higher rainfall conditions than the former and has a lower cover of *P. afra,* which is the dominant species in Baviaans Spekboom Thicket. Indicator species within Baviaans Spekboom Thicket are *Aloe speciosa, Pappea capensis,* *Putterlickia pyracantha* and *Schotia latifolia*. Gamtoos Valley Thicket indicator species are *Cussonia gamtoosensis*, *Euphorbia grandidens*, *Aloe speciosa, Sideroxylon inerme* and *Ptaeroxylon obliquum.* Additional vegetation types found in the project area include two mosaic types (where thicket elements are blended with elements from other biomes), namely Gamtoos Bontveld (a mosaic of Gamtoos Valley Thicket and succulent Karoo) and Baviaans Thicket Savanna (a mosaic of thicket and savanna associated with alluvial soils of the valley bottoms) (Figure A.12.11). Indicator species for thicket clumps in Gamtoos Bontveld are *Pappea capenis*, *Euclea undulata*, *Schotia latifolia*, *Carissa haematocarpa*, and *Aloe africana*, and *Pteronia incana*. Indicator species in the thicket savanna are *Acacia karoo, Celtis africana, Rhus tomentosa, Plumbago auriculata* and *Lycium spp*..

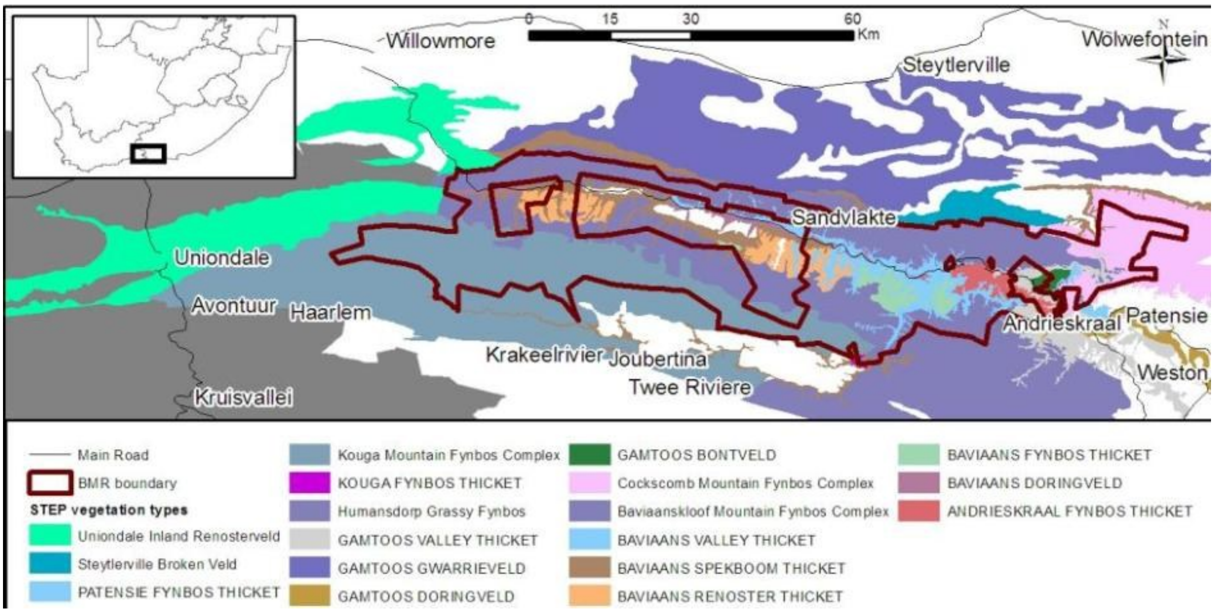


Figure A.12.11: Subtropical Thicket vegetation types of the Baviaanskloof Megareserve.

Rare or endangered species

The Baviaanskloof Nature Reserve contains several rare and vulnerable species. Included in these are 31 rare plant species, 8 vulnerable plant species, 2 rare animal species, 4 vulnerable animal species and 7 vulnerable bird species. Full lists of the rare and vulnerable species are given in Table A.12.1 and Table A.12.2[42]. These rare and vulnerable species will benefit from the project activities The restoration of thicket will improve habitat conditions for these species.

Table A.12.1: Baviaanskloof Nature Reserve Red Data List species: flora

Status	Species
Rare	*Acrolophia barbata*
	Agathosma affinis
	Agathosma unicarpellata
	Aloe microcantha
	Aloe pictifolia
	Atalaya capensis

[42]The South African Plant Red Data List is currently being updated, the most current version can be found at: http://www.sanbi.org/biodiversity/reddata.htm

	Crassula socialis
	Cussonia gamtoosensis
	Cyrtanthus clavatus
	Cyrtanthus flamosus
	Diascia patens
	Diosma passerinoides
	Encephalartos lehmannii
	Encephalartos longifolius
	Euryops integrifolius
	Gasteria ellaphieae
	Gasteria glomerata
	Gasteria rawlinsonii
	Geissorhiza elsiea
	Gladiolus geardii
	Ischyrolepis karooica
	Leucadendron loeriense
	Leucadendron nobile
	Leucadendron rourkei
	Otholobium macradenium
	Otholobium pictum
	Paranomus esterhuyseniea
	Psoralea trullata
	Spiloxene maximiliana
	Stapelia baylissii
	Sterculia alexandrii
Vulnerable	*Agathosma spinosa*
	Aloe longistyla
	Cyrtanthus spiralis
	Dioscorea elephantipes
	Herschelianthus lugens var. lugens
	Leucadendron sorocephalodes
	Paranomus reflexus
	Widdringtonia schwarzii

Table A.12.2: Baviaanskloof Nature Reserve Red Data List species: fauna.

Status	Species
Rare	*Panthera pardus*
	Proteles cristata
Vulnerable	*Anthropoides paradiseus*
	Ardeotis kori
	Circus ranivorus
	Diceros bicornis bicornis
	Equus zebra

	Falco naumanni
	Mellivora capensis
	Neotis denhami
	Neotis ludwigii
	Orycteropus afer
	Polemaetus bellicosus

A 12.3 Great Fish River Nature Reserve (proposed grouped project area: not currently included)

History

The GFRNR is a well-established conservation area that has been operational since 1994. It comprises three historical nature reserves that have been combined into a single reserve (Sam Knott Nature Reserve, Andries Vosloo Nature Reserve and Double Drift Nature Reserve).

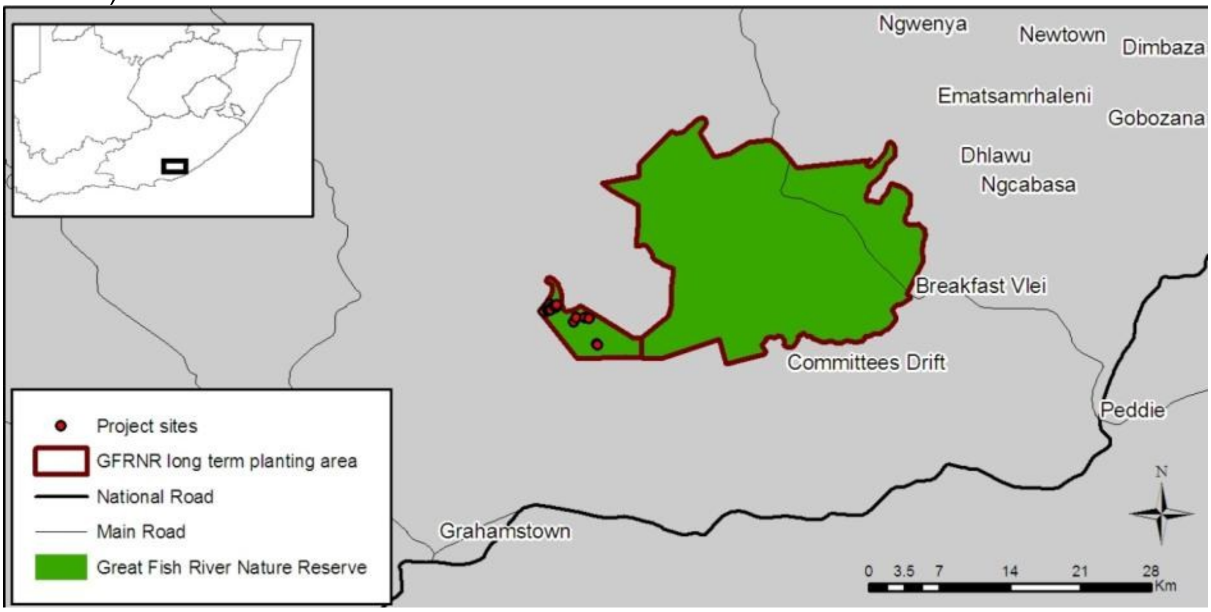


Figure A.12.12: Location of the Great Fish River Nature Reserve and the planned long term planting area in the Eastern Cape of South Africa.

The Andries Vosloo Kudu Reserve, named after a former Administrator of the Eastern Cape, was established in 1973 after the purchase, by the state, of the Kentucky, Double Drift Outspan and Grasslands farms from Mr Basil Kent. Lowestof Farm was later purchased from Mr W Smith in 1976, bringing the total area of the reserve to 6,500 ha.

Sam Knott 'Nature Reserve' was created in 1987, when the late Sam Knott bequeathed several farms to the Southern African Nature Foundation (now WWF-SA) under an agreement that the Cape Provincial Administration (now the Provincial Administration of the Eastern Cape) would manage the area.

On the eastern side of the Great Fish River, formerly the Ciskei, the L.L. Sebe Game Reserve was established when ten farms were purchased by the South African Development Trust in 1982. In 1985 the area was handed over to the Ciskei government to be managed by the Ciskei Wildlife and Resources section of Ulimocor. In 1990 the name changed to Double Drift Game Reserve.

In 1993 a joint management committee was established to manage the three reserves as a single unit, and in 1994 management of the reserve was assigned to the Eastern Cape Tourism Board and subsequently to the Eastern Cape Parks Board. The first joint management plan was implemented in 1995.

Prior to conservation, the principle land use was grazing and scattered agriculture on a number of farms, which is responsible for the degradation still present within the nature reserve. The extent of degradation is not as extreme as in Addo Elephant National Park, but much of the reserve is still moderately degraded (see Figure A.12.13). Despite long-term conservation efforts and low stocking rates of indigenous herbivores, the thicket vegetation has not recovered, and consequently restoration presents a clear opportunity to increase the biological diversity of the Nature Reserve.

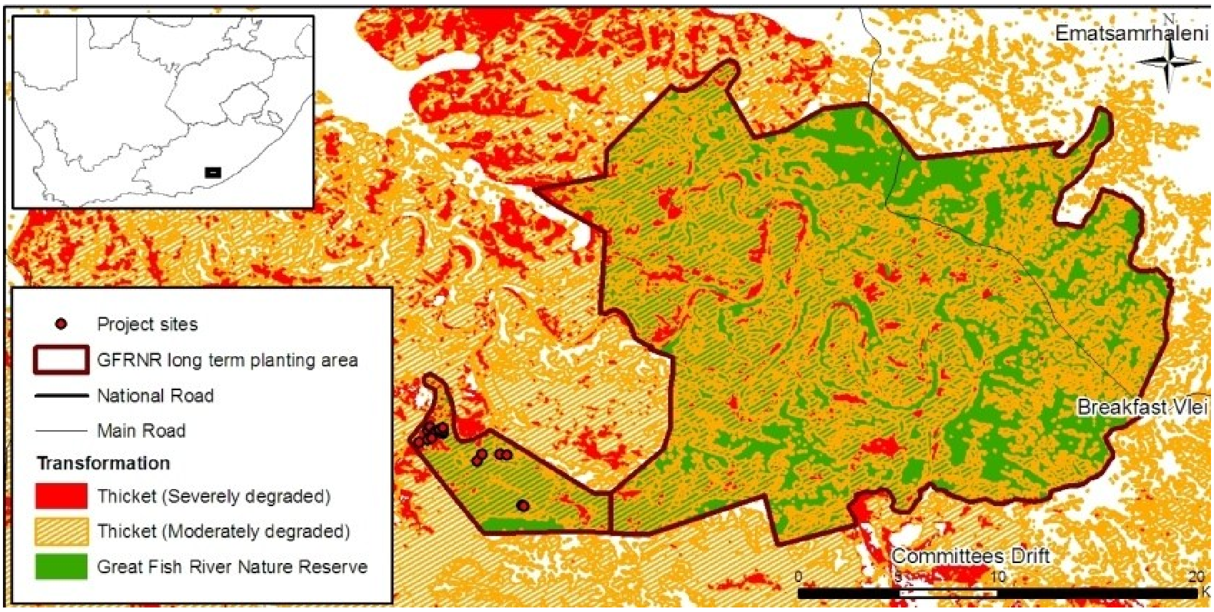


Figure A.12.13: Extent of land degradation within the Fish River Nature Reserve.

Climate

The climate in the GFRNR is semi-arid, with some variability in temperature and rainfall throughout the year and across the reserve. Variation in altitude throughout the reserve accounts for much of the variation in climatic conditions. As is typical for the region, rainfall is generally low. The mean annual precipitation is approximately 440 mm, varying between 340 mm and 561 mm within the nature reserve (Figure A.12.9). Precipitation is cyclonic and orographic, and generally unreliable, tending to fall in short, intense storms. Rainfall is also typically bimodal, peaking in October and March, with cool, dry winters.

Mean annual temperatures (Figure A.12.8) modelled from rainfall station data and altitude, are between 18°C and 20°C (Schulze, et al., 2008) Frost occurs occasionally in winter in bottomland locations during winter.

Geology and soils

The geology of the GFRNR is not highly variable. The southern part of the nature reserve is dominated by the Fort Brown shale formation of the Ecca Group, whilst the northern part is exclusively Beaufort Group mudstones and arenites of the Karoo supergroup. Both formations produce largely clay-dominated soils of moderate fertility. Soils in the southwest of the GFRNR tend towards a more loamy texture. Current planting in the GFRNR is limited to the southern part of the reserve, but future planting will occur in different soil types. Overall fertility of the soils is moderate, and all planting areas within the reserve have been assigned a fertility rating of 4 according to the methodology defined by Fey (1993).

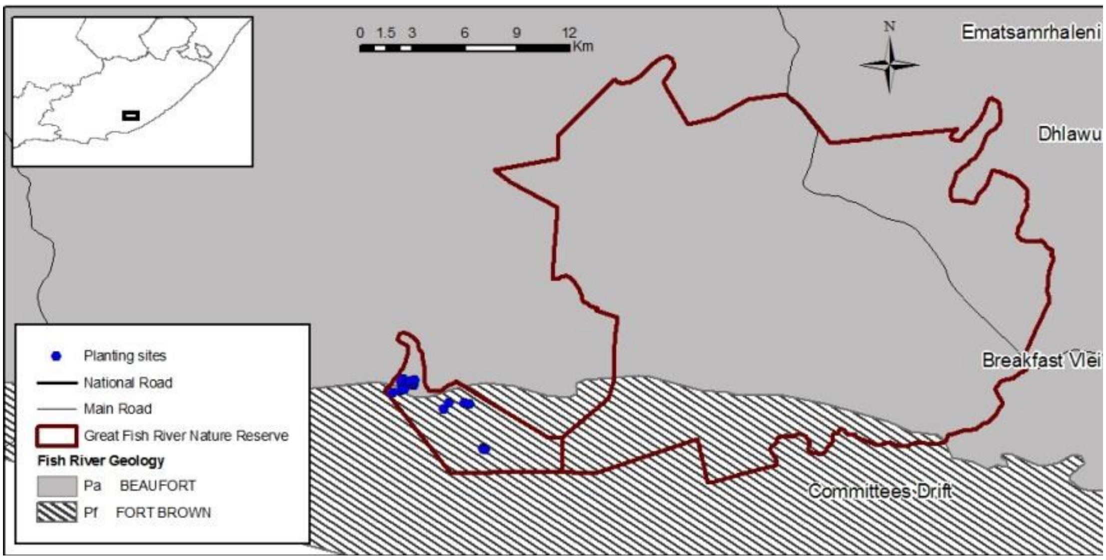


Figure A.12.14: Geology of the Great Fish River Nature Reserve.

Vegetation (Vlok & Euston-Brown, 2002)

The vegetation of the GFRNR is somewhat varied, but it is dominated by thicket vegetation. The principle vegetation type is Fish Spekboom Thicket, with a strong component of Doubledrift Karroid Thicket. Fish Spekboom Thicket is dominated by *P. afra*, with some woody tree species typical of the Fish Thicket (see below). Palatable perennial grasses, such as *Digitaria argyrograpta, Panicum deustum, Panicum maximum, Setaria neglecta* and *Themeda triandra* often grow in this thicket, but there is little pristine vegetation left. In degraded thicket, *P. afra* is rarely found, and only the woody tree component remains. *Aloe striata* is common in these areas. Fish Spekboom Thicket has a number of rare and localised endemics that are found in this vegetation type, including species typically found in the thicket component such as *Crassula intermedia, Crassula socialis, Faucaria felina ssp. Britteniae, Bergeranthus albomarginatus, Crassula decidua* and *Tetradenia barberae*. Other rare species found in open patches amongst the thicket vegetation include *Brachystelma huttoniae, Cyrtanthus smithiae, Euryops gracilipes, Monsonia vanderietiae, Ornithogalum acharophylla, Thesium junceum* and *Zaluzianskya vallispiscis*.

Fish Thicket is also found in the GFRNR. The principle difference between this vegetation type and the Fish Spekboom Thicket is the prevalence of a larger woody tree component (primarily *Scutia myrtina* and *Olea europaea*) in place of the shrubby vegetation. It has abundant *Euphorbia triangularis* and *Cussonia spicata*, with occasional occurrence of *Calodendron capense* and *Harpephyllum caffrum* in moist conditions along drainage lines. More open sites host smaller woody species such as *Brachylaena ilicifloia* and *Caddia rudis*.

Doubledrift Karroid Thicket is typified by relatively small thickets clumps dominated by *Euphorbia curviram* and *Euphorbia tetragona*. Other prominent elements include *Bulbine frutescens* and *Aloe tenuior*, with many small succulents (*Bulbine narcissifolia, Euphorbia pugniformis* and *Haworthia cooperi*) and geophytes. High fire frequency or grazing pressure can reduce the size of thicket clumps and increase the incidence of karroid shrubby species, but the occurrence of such pressures is low within the nature reserve.

The Karroid Thicket gives way to Crossroads Grassland Thicket adjacent to the Fish Spekboom Thicket. This vegetation type is typified by small clumps of thicket vegetation, without *Acacia karoo*, but dominated by *Cussonia spicata*, *Scutia myrtina*, *Ptaeroxylon obliquum* and occasionally *Euphorbia triangularis*. The southwestern corner of the Reserve has a patch of Fish Noorsveld, which is readily identified by the abundance of a local endemic, *Euphorbia bothae*. It is particularly abundant on the valley floors, but this abundance may be due to removal of *P. afra*, which is more abundant on the hill slopes. Thicket clumps include abundant *Boscia oleoides*, *Euclea undulata*, *Gymnosporia polyacantha*, *Pappea capensis, Rhus longispina* and *Schotia afra*, although these species rarely form a closed canopy. Succulent species include *Aloe africana, Cotyledon orbiculata, Crassula ovata, Euphorbia pentagona* and *Sarcostemma viminale*, and there is a well-developed grassy component between thicket clumps (*Digitaria argyrograpta, Panicum coloratum* and *Sporobolus fimbriata*).

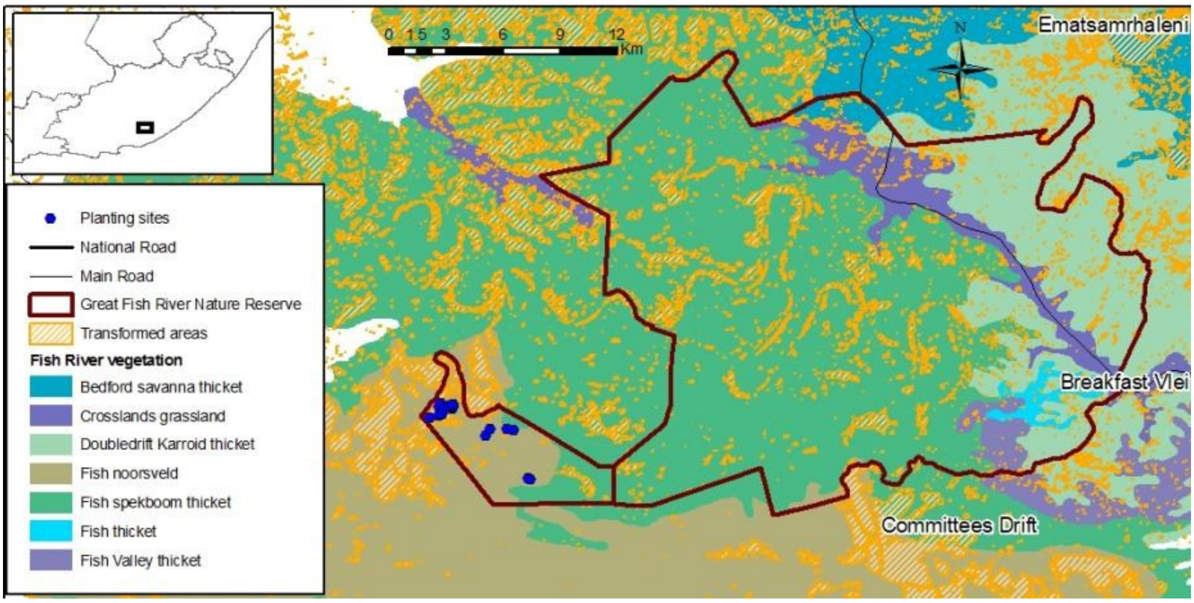


Figure A.12.15: Vegetation types of the Great Fish River Nature Reserve.

A small patch of Bedford Savanna Thicket is found in the north of the GFRNR. This thicket type strongly resembles small patches of Fish River Thicket scattered amongst a grassland matrix. The thicket is typified by *Rhus longispina*, *Schotia afra*, *Scutia myrtina* and *Azima tetracantha*, whilst the grassland often has abundant *Acacia karoo*.

Small areas of Fish Valley Thicket also occur in the southeastern corner of the GFRNR. Fish River Valley Thicket is typified by dense, tall stands of *Euphorbia curvirama* and *Euphorbia tetragona* that tend to tower over the woody component. However, this vegetation type tends to be very diverse, with an abundant series of spinescent shrubs and climbers, as well as a rich variety of grasses, herbs and succulents, forming dense cover. Woody species include the dominant *Rhus longispina*, *Pappea capensis, Schotia afra* and *Euclea undulata* trees as well as abundant *Boscia oleoides*, *Cussonia spicata* and *Ptaeroxylon obliquum*.

Rare or Endangered species

The GFRNP contains several rare and vulnerable species. Included in these is 1 critically endangered plant species, 2 endangered plant species, 11 vulnerable plant species, 1 endangered bird species and 11 vulnerable bird species. Full lists of the rare and vulnerable species are given in Table A.12.3 and Table A.12.4. These rare and vulnerable species will benefit from the project activities The restoration of spekboom thicket will improve habitat conditions for these species.

Table A.12.3: Great Fish River Nature Reserve Red Data List species: flora.

Status	Species
Critically Endangered	*Corpuscularia lehmannii*
Endangered	*Agathosma bicornuta*
	Haworthia attenuata var. attenuata
Vulnerable	*Apodolirion macowanii*
	Aspalathus arenaria
	Aspalathus steudeliana
	Brachystelma luteum
	Ceropegia fimbriata subsp. fimbriata
	Encephalartos trispinosus
	Eriospermum bracteatum
	Euryops gracilipes
	Haworthia herbacea var. herbacea
	Nerine huttoniae
	Prunus africana

Table A.12.4: Great Fish River Nature Reserve Red Data List species: fauna.

Status	Species
Endangered	*Poicephalus robustus*
Vulnerable	*Anthropoides paradiseus*
	Ardeotis kori
	Balearica regulorum
	Circus ranivorus
	Eupodotis senegalensis
	Falco naumanni
	Gyps coprotheres
	Neotis denhami
	Neotis ludwigii
	Podica senegalensis
	Polemaetus bellicosus

Annex 13 Literature review

A large amount of research has been conducted in the subtropical thicket of the Eastern Cape, and into the impacts of restoration by means of planting *P. afra* in particular. Much of this is referenced in this document, and the abstracts for several of the seminal works are included in this section for review.

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Patterns and implications of transformation in semi-arid succulent thicket, South Africa

R.G. Lechmere-Oertel[a,*], G.I.H. Kerley[a], R.M. Cowling[b]

[a]*Terrestrial Ecology Research Unit, Department of Zoology, University of Port Elizabeth, P.O. Box 1600, Port Elizabeth 6000, South Africa*

[b]*Terrestrial Ecology Research Unit, Department of Botany, University of Port Elizabeth, P.O. Box 1600, Port Elizabeth 6000, South Africa*

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Abstract

Transformation of South African succulent thicket in response to grazing is widespread and characterized by the extensive replacement of dense closed-canopy thicket with a 'pseudo-savanna' of remnant trees with an ephemeral field layer. In this study, we examined the patterns of transformation in a semi-arid succulent thicket ecosystem using replicated fence line contrasts. We quantified the changes in plant species and functional diversity, physiognomy and biomass. We tested whether the remnant tree guild of the transformed thicket is in a stable state, using aerial photographs and ground-truthing to track the survivorship of canopy trees over 60 years in transformed landscapes. We investigated the impacts of transformation on recruitment into the canopy tree guild by measuring seedling establishment across the fence line contrasts. Transformation results in a significant loss of plant and functional diversity. There is a significant reduction in the biomass and structural complexity of the vegetation, both vertically and horizontally. The canopy tree guild in transformed thicket is not stable owing to ongoing adult mortality and little successful recruitment. These results are interpreted in a framework of ecosystem functioning and long-term stability. We suggest that the pseudo-savanna typical of transformed succulent thicket is

*Corresponding author. Current address: Maloti-Drakensberg Transfrontier Project, P.O. Box 1362, Howick 3290, South Africa. Tel.: +27 33 239 1883; fax: +27 33 239 1895.

E-mail addresses: richard@maloti.org (R.G. Lechmere-Oertel), graham.kerley@upe.ac.za (G.I.H. Kerley), rmc@kingsley.co.za (R.M. Cowling).

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Figure A.13.1: Lechmere-Oertel *et al.*, 2005. Patterns and implications of transformation in semi-arid succulent thicket, South Africa. Journal of Arid Environments 62:459-474.

Austral Ecology (2005) **30**, 615–624

Landscape dysfunction and reduced spatial heterogeneity in soil resources and fertility in semi-arid succulent thicket, South Africa

RICHARD G. LECHMERE-OERTEL,[1]* RICHARD M. COWLING[2] AND GRAHAM I. H. KERLEY[1]
Terrestrial Ecology Research Unit, Departments of [1]Zoology and [2]Botany, University of Port Elizabeth, Port Elizabeth, 6000, South Africa

Abstract Succulent thicket in the Eastern Cape of South Africa is one of many rangeland ecosystems in the world that displays evidence of unsustainable grazing pressure. Widespread transformation of succulent thicket has resulted in the replacement of the typical two-phase perennial vegetation patches with a structurally simple field layer of ephemeral and weakly perennial grasses and forbs. We hypothesized that (i) transformation of succulent thicket leads to a switch from a spatially heterogeneous landscape to a homogenous and relatively infertile state; and (ii) that this loss of fertility is associated with a breakdown in the processes that conserve resources and promote water use efficiency. We tested these hypotheses at five fenceline contrast sites in Sundays River Thicket, an arid form of succulent thicket. We compared soil fertility (organic carbon, available nitrogen and phosphorus), texture, matric potential, and surface microtopography in the two main microhabitats on either side of the fencelines using a nested anova. Our results show that intact Sundays River thicket has a distinct spatial pattern of soil fertility where nutrients and organic carbon are concentrated under the patches of perennial shrubs, compared with under canopy trees. Transformation results in a significant homogenization of this pattern and an overall reduction in the fertility of the landscape. The proportion of the landscape surface that promotes infiltration due to a distinct litter layer decreases from 60% to 0.6%. Soil moisture retention (matric potential) also decreases with transformation. We interpret these patterns within the framework of semi-arid landscape functionality.

Key words: desertification, landscape function, matric potential, microtopography, soil nutrient.

INTRODUCTION

There has been considerable interest in the long term impact of livestock on semi-arid rangelands across the world. This arises from the perception that large areas of these rangelands have become transformed through unsustainable livestock production. In the semi-arid and arid rangelands of the world, such transformation is termed desertification (Arnalds & Archer 2000), and is primarily recognized through physical changes in the environment, such as loss of vegetation cover, loss of soil and organic matter and reduced water use efficiency (Whitford 2002). Such physical changes are often accompanied by a significant reduction in plant and animal production, upon which much human livelihood in those areas relies. As up to 75% of landscapes that can be desertified have become so to some degree (Karrar & Stiles 1984), there is an urgent need to understand the dynamics of transformation in semi-arid rangelands. This is particularly so in the succulent thicket in South Africa (described below) where up to 80% has been transformed by reduced cover of perennial shrubs (Lloyd *et al.* 2002) due to unsustainable stocking of domestic goats.

The landscape functionality framework developed in Australia (Ludwig *et al.* 1997; Ludwig & Tongway 2000), which builds on earlier work by Noy-Meir (1973) and Westoby *et al.* (1989), provides powerful insight into the dynamics of semi-arid rangelands and how to recognize transformation of these systems. Importantly, the framework provides testable predictions that allow comparisons of the extent of landscape dysfunction under different management treatments. The framework suggests that healthy landscapes conserve resources and have processes that enrich fertile patches in an infertile matrix. A prediction from the framework is that functional landscapes have a high degree of spatial organization at a patch scale (Ludwig & Tongway 1995a; Holm *et al.* 2002a), with resource-rich soils associated with perennial vegetation patches, surrounded by infertile bare patches, that is, a two-phase mosaic.

*Corresponding author. Present address: Maloti-Drakensberg Transfrontier Programme, Howick, 3295, South Africa (Email: richard@maloti.org).
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Figure A.13.2: Lechmere-Oertel *et al.*, 2005b. Landscape dysfunction and reduced spatial heterogeneity in soil resources and fertility in semi-arid succulent thicket, South Africa. *Austral Ecology* 30: 615-624.

Rate of Carbon Sequestration at Two Thicket Restoration Sites in the Eastern Cape, South Africa

Anthony J. Mills[1,2,3] and Richard M. Cowling[4]

Abstract

Ecosystem carbon storage in intact thicket in the Eastern Cape, South Africa exceeds 20 kg/m², which is an unusually large amount for a semiarid ecosystem. Heavy browsing by goats transforms the thicket into an open savanna and can result in carbon losses greater than 8.5 kg/m². Restoration of thicket using cuttings of the dominant succulent shrub *Portulacaria afra* could return biodiversity to the transformed landscape, earn carbon credits on international markets, reduce soil erosion, increase wildlife carrying capacity, improve water infiltration and retention, and provide employment to rural communities. Carbon storage in two thicket restoration sites was investigated to determine potential rates of carbon sequestration. At the farm Krompoort, near Kirkwood, 11 kg C/m² was sequestered over 27 years (average rate of 0.42 ± 0.08 kg C m^{-2} yr^{-1}). In the Andries Vosloo Kudu Nature Reserve, near Grahamstown, approximately 2.5 kg C/m² was sequestered over 20 years (0.12 ± 0.03 kg C m^{-2} yr^{-1}). Slower sequestration in the Kudu Reserve was ascribed to browsing by black rhinoceros and other herbivores, a shallower soil and greater stone volumes. Planting density and *P. afra* genotype appeared to affect sequestration at Krompoort. Closely-packed *P. afra* planting may create a positive feedback through increased infiltration of rainwater. The rate of sequestration at Krompoort is comparable to many temperate and tropical forests. Potential earnings through carbon credits are likely to rival forest-planting schemes, but costs are likely to be less due to the ease of planting cuttings, as opposed to propagating forest saplings.

Key words: biomass, carbon sequestration, *Portulacaria afra*, restoration, semiarid landscapes, soil carbon, thicket.

Introduction

Ecosystem carbon storage in the arid form of South African succulent thicket (Vlok et al. 2003), found in areas receiving 250–350 mm mean annual rainfall, exceeds 20 kg/m² (Mills, O'Connor, et al. 2003, 2005). This is an exceptional amount of carbon for a warm, semiarid region and is more akin to mesic forest ecosystems (Mills, Cowling, et al. 2005). In its untransformed state, xeric thicket has an almost complete cover of dense, relatively tall (3–4 m) evergreen vegetation and has a much higher biomass than would be expected under semiarid conditions (Lechmere-Oertel 2004; Mills, Cowling, et al. 2005; Lechmere-Oertel et al. 2005*b*). Much of the biomass comprises the succulent shrub *Portulacaria afra*, known locally as spekboom (Acocks 1953; Vlok et al. 2003). The vegetation has been used for farming goats since the early 1900s. Heavy browsing by goats has resulted in the loss of *P. afra*, which is highly palatable to livestock, and the transformation of thicket to an open "savanna." The transformed savanna comprises ephemerals and short-lived grasses (known locally as "opslag"), whose abundance tracks rainfall events, and scattered remnant trees (Hoffman & Cowling 1990; Lechmere-Oertel et al. 2005*b*). Approximately 45% of *P. afra*–dominated thicket in South Africa (5,519 km² out of a total of 12,624 km²) has been altered in this manner (Lloyd et al. 2002).

Carbon lost as a result of degradation in the arid succulent thicket near Kirkwood, Eastern Cape was estimated to be approximately 4.0 kg/m² in soils to a depth of 500 mm and 4.5 kg/m² in biomass (above- and belowground) (Mills 2003; Mills, O'Connor, et al. 2005). Effective restoration of transformed thicket could be achieved by planting *P. afra* cuttings because this species propagates vegetatively in nature and takes root from cuttings rapidly (Swart & Hobson 1994). Restoration could potentially return greater than 8.5 kg C/m² to transformed sites, but the potential rate of return is unknown. Two lines of evidence suggest that return of carbon may occur faster than in other transformed semiarid systems. Lechmere-Oertel et al. (2005*a*) found that the leaf litter productivity of *P. afra* (0.45 kg m^{-2} yr^{-1}, dry matter [DM]) was similar to mesic forest systems, and Aucamp and Howe (1979) found that the net primary production of thicket was approximately 1.1 kg m^{-2} yr^{-1} wet aboveground biomass (0.45 kg DM m^{-2} yr^{-1} assuming a dry:wet ratio of 0.4). Benefits associated with restoration would include restoration of ecosystem services such as carbon sequestration, herbivore browse and flood control, the restoration of biodiversity, control of soil erosion, and the provision of jobs in

[1] Department of Soil Science, Stellenbosch University, Private Bag X01, Matieland 7602, South Africa.
[2] South African National Biodiversity Institute, Private Bag X7, Claremont 7735, South Africa.
[3] Address correspondence to A. J. Mills, email mills@sanbi.org
[4] Terrestrial Ecology Research Unit, Department of Botany, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth 6031, South Africa.

Figure A.13.3: Mills & Cowling, 2006. Rates of Carbon Sequestration at Two Thicket Restoration Sites in the Eastern Cape, South Africa. *Restoration Ecology* 14(1):38-49.

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Soil carbon and nitrogen in five contrasting biomes of South Africa exposed to different land uses

A.J. Mills[1, 2*], M.V. Fey[1]

[1]Department of Soil Science, University of Stellenbosch, Private Bag X01, Stellenbosch, 7602, South Africa
[2]National Botanical Institute, Private Bag X7, Claremont, 7735, South Africa

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Stocks of soil C to a depth of 50 cm in untransformed, indigenous veld ranged from 21 t ha^{-1} in karoo to 168 t ha^{-1} in thicket and stocks of N ranged from 3.4 t ha^{-1} in karoo to 12.8 t ha^{-1} in grassland. Mean soil C in thicket (5.6%, 0-10 cm) was approximately five times greater than expected for a semi-arid region. Removal of vegetation due to cultivation, grazing or burning reduced soil C and N at all sites. Soil C under intact thicket was greater than at sites degraded by goats (71 vs 40 t ha^{-1}, 0-10 cm). Restoration of thicket could potentially sequester ~40 t C ha^{-1}. The sale of this sequestered carbon to the international market may make restoration of thousands of hectares of degraded thicket financially feasible. Soil C under plant cover was greater than in exposed soil in renosterveld (28 vs 15 t ha^{-1}) and in karoo (7 vs 5 t ha^{-1}). Parent material was also related to soil C content. In grassland, soil C was greater in dolerite-derived than sandstone-derived soils (54 vs 27 t ha^{-1}); and in bushveld it was greater in basalt-derived than granite-derived soils (28 vs 14 t ha^{-1} in unburnt plots). Annual burning in bushveld reduced soil C, particularly at the surface. Soil C in the 0-1 cm layer of unburnt plots was 2 to 3 times greater than in burnt plots.

Keywords: land use, sequestration, soil carbon, soil nitrogen, South African biomes

*To whom correspondence should be addressed (E-mail: mills@nbi.ac.za)

Introduction

The increase in atmospheric CO_2 and associated concerns of global warming have turned the world's attention towards the global C cycle (Lal, 2001). Sequestering C into biomass or soil could buy time to address the problem but the production of biomass in a mostly semi-arid country such as South Africa is limited by available water. Consequently stocks of soil C per unit area in South Africa are typically lower than in temperate, mesic regions (Du Preez & Snyman, 1993; Du Toit & Du Preez, 1995; Schulze, 2000). Soil with a cover of vegetation tends to have more C than exposed soil because plants recycle C and they may suppress mineralisation by releasing antibacterial exudates (Theron, 1951; 1963), and reduce mineralisation catalysed by wetting and drying of the soil (Birch, 1958) by shading and cooling and by intercepting rainfall. Removal of vegetation by ploughing, grazing, browsing or burning reduces soil organic matter. Declines in C due to cultivation have been recorded in grasslands of the highveld (Du Toit *et al.*, 1994; Nel *et al.*, 1996) but the extent to which land use affects soil C in other South African regions is largely unknown. In this paper, soil C is examined in five contrasting biomes and stocks of soil C under vegetation, in open, bare soils and in soils exposed to a variety of land use practices (including cultivation, livestock husbandry, pastures, forestry and veld burning) are compared.

Materials and methods

Study areas

The study sites (Figure 1) were named after the characteristic natural vegetation types for each area as defined by Low & Rebelo (1996) and included: West Coast Renosterveld (renosterveld), Central Nama Karoo (karoo); Xeric Succulent Thicket (thicket); Moist Upland Grassland (grassland); and Mixed Lowveld Bushveld (bushveld). A summary of geographic features including climate, vegetation, geology, soils, and land uses is presented in Tables 1 and 2.

Figure 1 The location of the five study sites.

Sampling

Composite samples, comprising 15-20 subsamples, were taken at least 10 m apart with an auger to a depth of 10 cm as described below:

(a) **Renosterveld** - Dwyka sediment-derived soils were sampled from (i) open renosterveld i.e., on bare ground outside of bush clumps; (ii) below renosterbos bushes (*Elytropappus rhinocerotis* [L.f.] Less.); and (iii) old wheatlands planted to medic (*Medicago* spp.); and (iv) cultivated wheat fields. Dolerite-derived soils were sampled from (i) virgin veld and (ii) cultivated wheat fields. All sites were at least 500 m apart.

Figure A.13.4: Mills & Fey, 2004a. Soil carbon and nitrogen in five contrasting biomes of South Africa exposed to different land uses. *South African Journal of Plant and Soil* 21(2):94-103.

Plant and Soil **265:** 153–163, 2004.

Transformation of thicket to savanna reduces soil quality in the Eastern Cape, South Africa

Anthony Mills[1,2,3] & Martin Fey[1]
[1]*Department of Soil Science, University of Stellenbosch, Private Bag X1, Matieland, 7602, South Africa.* [2]*National Botanical Institute, Private Bag X7, Claremont, 7735, South Africa.* [3]*Corresponding author**

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Key words: soil crusting, soil organic matter, soil quality, succession, thicket

Abstract

Xeric succulent thicket in the Eastern Cape, South Africa has been used for farming goats since the early 1900s. This habitat is characterised by a dense cover of the succulent bush *Portulacaria afra* and by a warm, semi-arid climate with evenly distributed annual rainfall of 250–400 mm. Heavy browsing by goats results in the loss of *P. afra* and transforms the thicket to an open savanna dominated by annual grasses. Eight fence-line comparisons between thicket and savanna were used to investigate differences in soil quality associated with the vegetation change. Composite soil samples were taken to a depth of 10 cm from 1 ha plots on either side of the fence-line. Associated with the change from thicket to savanna, a significant decrease (paired t-test, $P < 0.05$) was found in total C (respective means of 5.6 vs. 3.0%), total N (0.33 vs. 0.24%), labile C (2.8 vs. 1.5%), CO_2 flux (1.9 vs. 0.5 μmol m^{-2} s^{-1}), soil respiration in the laboratory (144 vs. 79 ng C kg^{-1} s^{-1}), (NH_4)OAc-extractable Mg (55 vs. 28 mmol$_c$ kg^{-1}), and laboratory infiltration rate (51 vs. 19 mm h^{-1}). In the same direction there was a similarly significant increase in modulus of rupture (16 vs. 34 kPa), water-soluble Ca (2.3 vs. 3.4 mmol$_c$ kg^{-1}) and pH (6.7 vs. 7.7). The soil C content of 5.6% in thicket is surprisingly high in this warm, semi-arid climate and suggests that the dense *P. afra* bush strongly regulates soil organic matter through microclimate, erosion control, litter quantity and perhaps chemistry. Savanna soils had a greater tendency to crust (as evident in a lower rate of laboratory infiltration and greater modulus of rupture) than thicket soils. This was attributed to their lower organic matter content, which probably reduced aggregate stability. Savannas are likely to be more prone to runoff and erosion not only because of sparser vegetation but also because of a decline in soil quality.

Introduction

Patches of vegetation in semi-arid regions are usually hotspots of soil organic matter and nutrients (Schlesinger et al., 1990). This is because vegetation shades the surface, protects the soil from raindrop impact, replenishes soil organic matter through litter and root sloughing, traps atmospheric dust and provides cover for birds and mammals (Kellman, 1979; Belsky et al., 1989; Frost and Edinger, 1991; Vetaas, 1992; Roos and Allsopp, 1997; Scholes and Archer, 1997; Allsopp, 1999). Belsky et al. (1989), for example, found in a Kenyan savanna that N, P, K, total C and soil water content were greater under the canopy of *Acacia tortilis* than outside it. Livestock farming has lead to bush encroachment and a reduction in carrying capacity in many semi-arid grasslands and savannas (Archer et al., 1988; Asner et al., 2003). Despite a decline in carrying capacity, soil quality is often improved because soil organic matter tends to increase with increasing bush cover (Hibbard et al., 2001; Hudak et al., 2003). The direction of change is not, however, predictable and the ecological processes involved are controversial (Hibbard et al., 2001). High livestock stocking rates can also result in a loss of vegetation cover and an associated decrease in soil nutrient status, organic matter, water content and infiltrability (Seitlheko et al., 1993; Mworia et al., 1997; Allsopp, 1999). Robin-

*FAX No: +27 21 8084791. E-mail: mills@nbi.ac.za

Figure A.13.5: Mills & Fey, 2004b. Transformation of thicket to savanna reduces soil quality in the Eastern Cape, South Africa. *Plant and Soil* 265:153-163.

Austral Ecology (2005) **30**, 797–804

Effects of goat pastoralism on ecosystem carbon storage in semiarid thicket, Eastern Cape, South Africa

A. J. MILLS,[1,2]* R. M. COWLING,[3] M. V. FEY,[1] G. I. H. KERLEY,[3] J. S. DONALDSON,[2] R. G. LECHMERE-OERTEL,[3] A. M. SIGWELA[3], A. L. SKOWNO[2] AND P. RUNDEL[4]
[1]Department of Soil Science, University of Stellenbosch, Private Bag X01, Matieland, 7602, [2]South African National Biodiversity Institute, Private Bag X7, Claremont, 7735, South Africa (Email: mills@sanbi.org), [3]Terrestrial Ecology Research Unit, Departments of Botany and Zoology, University of Port Elizabeth, Port Elizabeth, South Africa, and [4]Department of Ecology and Evolutionary Biology, University of California, Los Angeles, California, USA

Abstract Intensive pastoralism with goats transforms semiarid thicket in the Eastern Cape, South Africa from a dense vegetation of tall shrubs to an open landscape dominated by ephemeral grasses and forbs. Approx. 800 000 ha of thicket (which prior to the introduction of goats had a closed canopy and a *Portulacaria afra* Jacq. component) have been transformed in this manner. Ecosystem C storage in intact thicket and loss of C due to transformation were quantified. Carbon storage in intact thicket was surprisingly high for a semiarid region, with an average of 76 t C ha^{-1} in living biomass and surface litter and 133 t C ha^{-1} in soils to a depth of 30 cm. Exceptional C accumulation in thicket may be a result of *P. afra* dominance. This succulent shrub switches between C_3 and CAM photosynthesis, produces large quantities of leaf litter (approx. 450 g m^{-2} $year^{-1}$) and shades the soil densely. Transformed thicket had approx. 35% less soil C to a depth of 10 cm and approx. 75% less biomass C than intact thicket. Restoration of transformed thicket landscapes could consequently recoup more than 80 t C ha^{-1}.

Key words: biomass, carbon stocks, goats, pastoralism, soil carbon, thicket.

INTRODUCTION

Semiarid solid thicket (characterized by a dense canopy of tall shrubs and a *Portulacaria afra* Jacq. component) occupies approx. 1.7 million hectares in the Eastern Cape, South Africa (Lloyd *et al.* 2002). Despite a long association with a diverse assemblage of large and medium-sized indigenous herbivores (Midgley 1991; Kerley *et al.* 1995), thicket is surprisingly sensitive to injudicious pastoralism (Stuart-Hill & Danckwerts 1988; Stuart-Hill 1992). Heavy browsing by goats can transform thicket from a dense closed-canopy shrubland into an open savanna-like system with a cover of ephemeral grasses and forbs within a few decades, and possibly even within a decade (Hoffman & Cowling 1990; Kerley *et al.* 1995; Lechmere-Oertel *et al.* 2005a). Approximately 800 000 ha of semiarid thicket has been transformed in this manner, and the process of transformation is evident in another 600 000 ha (Lloyd *et al.* 2002). We hypothesized that transformation reduces total ecosystem C storage, as loss of above-ground biomass is highly visible (Fig. 1), and soil C is likely to be reduced where canopy cover is removed (Allsopp 1999; Mills & Fey 2003, 2004a). We asked the question: how much C is lost when thicket is transformed?

Warm, semiarid landscapes are not where one would intuitively expect to find large stocks of ecosystem C. Ecologists are accustomed to a pattern of increasing biomass along a rainfall gradient from deserts to forests (Woodward 1987). The common perception is that low water availability in warm, semiarid landscapes limits accumulation of biomass because water demand tends to increase with an increase in biomass. While this is true, multiple exceptions to such a pattern occur in semiarid and arid lands where water is not the primary limiting factor. Decoupling from water as a limiting factor occurs, for example, in desert areas dominated by phreatophytic species of *Prosopis* which tap groundwater pools. Moreover, with this example, nitrogen fixation by root nodules reduces limitations due to nitrogen as well. Physiological decoupling from water limitation can also occur where crassulacean acid metabolism (CAM) metabolic systems can allow highly efficient use of water and thus relatively high productivity and biomass in areas with very low rainfall. Accumulation of soil C also tends to be limited in these landscapes (Post *et al.* 1982) because soils are exposed to sunlight (as a result of limited plant cover), which enhances rates of mineralization of soil organic matter (via temperature effects) (Jenkinson 1981) and photo-

*Corresponding author.
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Figure A.13.6: Mills *et al.*, 2005a. Effects of goat pastoralism on ecosystem carbon storage in semiarid thicket, Eastern Cape, South Africa. *Austral Ecology* 30:797-804.

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Ecosystem carbon storage under different land uses in three semi-arid shrublands and a mesic grassland in South Africa

A.J. Mills[1,2]*, T.G. O'Connor[3], J.S. Donaldson[2], M.V. Fey[1], A.L. Skowno[2], A.M. Sigwela[4], R.G. Lechmere-Oertel[4] & J.D. Bosenberg[2]

[1]Department of Soil Science, Stellenbosch University, Private Bag X1, Matieland, 7602, South Africa
[2]South African National Biodiversity Institute, Private Bag X7, Claremont, 7735, South Africa
[3]Centre for African Ecology, School of A.P.E.S., University of the Witwatersrand, Johannesburg, Private Bag X03, PO Wits, 2050, South Africa
[4]Terrestrial Ecology Research Unit, Departments of Botany & Zoology, University of Port Elizabeth, Port Elizabeth, 6031, South Africa

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Carbon (C) storage in biomass and soils is a function of climate, vegetation type, soil type and land management. Carbon storage was examined in intact indigenous vegetation and under different land uses in thicket (250-400 mm mean annual precipitation), xeric shrubland (350 mm), karoo (250 mm), and grassland (900-1200 mm). Carbon storage was as follows: (i) mean soil C (0-50 cm): thicket (T) = grassland (G) > xeric shrubland on Dwyka sediments (XS) > xeric shrubland on dolerite (XSD) > karoo (K) (168, 164, 65, 34 & 26 t ha^{-1}, respectively); (ii) mean root C: T > G > XS = XSD (25.4, 11.4, 7.2 & 7.1 t ha^{-1}); (iii) mean above-ground C including leaf litter: T > XS > G > K > XSD (51.6, 12.9, 2.0, 1.7 & 1.5 t ha^{-1}). Carbon stocks in intact indigenous vegetation were related more to woodiness of vegetation and frequency of fire than to climate. Biomass C was greatest in woody thicket and soil C stocks were greatest in thicket and grassland. Total C storage of 245 t ha^{-1} in thicket is exceptionally high for a semi-arid region and is comparable with mesic forests. Soil C dominated ecosystem C storage in grassland and was influenced more by soil parent material than land use. The semi-arid sites (xeric shrubland and thicket) were more sensitive to effects of land use on C storage than the grassland site. Effects of land use on C stocks were site- and land use-specific and defied prediction in many instances. The results suggest that modelling of national C stocks would benefit from further research on the interactions between C storage, land use, and soil properties.

Keywords: carbon stocks; cultivation; pastoralism; pastures; plantations

*To whom correspondence should be addressed (E-mail: mills@sanbi.org)

Introduction

Sequestering C in vegetation or soils could mitigate the problem of a rising atmospheric CO_2 concentration (Lal, 2001). Change in land use can potentially release or sequester soil and biomass C (Mendham, O'Connell & Grove, 2003). The distribution of C within a landscape, the influence of land use on C and the relationship between climate and C need to be considered when developing plans for C sequestration at a national level (Post & Kwon, 2000; Post *et al.*, 2001). Such information will assist decision makers in deciding where carbon sequestration efforts are best expended. In an earlier paper, Mills and Fey (2004) examined soil C and N at five study sites in South Africa. The following paper examines the influence of climate and land use on ecosystem C storage (i.e. in soils and biomass) at four of these sites and ascertains whether the effect of land use on C storage is predictable.

Six factors affecting the accumulation of C within an ecosystem were identified *a priori*. Firstly, C storage is positively related to water availability, which is a function of mean annual precipitation and temperature. Soil C tends to increase with an increase in mean annual precipitation (Dalal & Mayer, 1987; Hontoria, Rodriguez-Murillo & Saa, 1999) probably because primary productivity tends to be a function of rainfall (Knapp & Smith, 2001), and organic matter inputs into the soil will tend to be greater in mesic than arid regions. Secondly, C storage will increase with an increase in woody biomass. Thirdly, frequent fire will lead to a decrease in C storage in both biomass (Tilman *et al.*, 2000) and soils (Birch, 1958; Knapp, Conrad & Blair, 1998; Bird *et al.*, 2000). Fourthly, tillage will reduce C storage in biomass and soils (Tiessen, Salcedo & Sampaio, 1992; Gregorich *et al.*, 1994; Aslam, Choudhary & Saggar, 2000; Francis, Tabley & White, 2001). Fifth, the establishment or maintenance of a permanent cover of vegetation (e.g. pasture, thicket) will maintain or increase soil C (Dalal & Chan, 2001; Dominy & Haynes, 2002). The effect of pasture establishment on biomass C depends on the natural vegetation structure. Pastures may accumulate more biomass C than natural grassland if a dense grass sward is established, but will have less biomass C than woody systems. Sixth, any of the above effects will be dependent on inherent chemical and physical properties of the soil as well as changes to such properties (Oades, 1993; Zech *et al.*, 1997; Percival, Parfitt & Scott, 2000). The establishment of plantations in grassland, for example, may be expected to reduce soil water content, improve soil aeration and therefore reduce soil C storage (Birch, 1958; Jaiyeoba, 1998).

Based on these expectations, it was predicted that the effects of land use on C storage in grassland, xeric shrubland and thicket vegetation types in the study sites would be as follows: (i) goat pastoralism in thicket, which results in a loss of the dense matrix of shrubs (Lechmere-Oertel, 2004; Lechmere-Oertel, Kerley & Cowling, 2004a; Lechmere-Oertel, Kerley & Cowling, 2004b), would reduce soil and biomass C; (ii) cultivation of wheat in xeric shrubland would reduce soil C; (iii) establishment of annual leguminous pastures on old

Figure A.13.7: Mills *et al.*, 2005b. Ecosystem carbon storage under different land uses in three semi-arid shrublands and a mesic grassland in South Africa. *South African Journal of Plant and Soil* 22(3):183-190.

Annex 14 Calculation of carbon sequestration

Calculations for carbon sequestration were carried out in Excel 2007. The spreadsheet is attached as a separate document.

Annex 15 Aerial imagery of planting sites in the project areas

A 15.1 Analysis of 1973 and 2009 aerial imagery

To determine if the thicket cover has increased (regenerated) over time, 1973 aerial images corresponding to the 2009 images were analysed in the GIS programme ArcMap 9.3.

Five 1 ha plots were selected within the Great Fish River Nature Reserve in areas classified as moderately and severely degraded thicket (Vlok & Euston-Brown, 2002; Lloyd et al, 2002) using a randomization algorithm in the GIS programme ArcView 3.2. Thicket within the 1 ha areas was outlined on the 2009 images. As it was not possible to determine the height of the trees and shrubs on the images, all thicket was outlined, including trees and shrubs below the 2 m threshold. The cover therefore represents an over-estimate (conservative in the context of the analysis).

The 1973 aerial imagery is not orthorectified, so the images were individually geo-referenced to the 2009 images. The delineated 2009 cover is overlaid on the 1973 images for comparison. Due to the poor resolution of the older images, it was not possible to outline the thicket. Rather, a visual inspection of change in thicket cover relative to the corresponding 2009 thicket clumps was undertaken.

The results of the analysis of the 2009 thicket cover are presented in Table A.15.1. The average cover of the two severely degraded and three moderately degraded 1 ha areas is 26 %. The images analysed are presented as Figure A.15.1 – Figure A.15.10. The 2009 thicket cover is outlined in blue. Thicket (darker areas on the 1973 images) covered all of the areas outlined in blue on the 1973 images, and in some cases it is clear that the cover was greater in 1973, indicating that there has been continued deterioration of the degraded areas over this period.

Table A.15.1: Results of the 2009 one hectare area thicket cover analysis.

ID number	Level of degradation	Percentage thicket cover in 2009
1	Severe	13.9
2	Severe	36.8
3	Moderate	29.9
4	Moderate	24.2
5	Moderate	25.4
Average		**26.0**

The conclusions of the analysis are two-fold:

i. The average thicket cover in 2009 of the five 1 ha areas analysed was less than 30 %. As these areas were randomly selected from the moderately and severely degraded portions of the Great Fish River Nature Reserve, it can be shown that on average in the project area, degraded land will have less than 30 % thicket cover. Those sites that are determined to have higher cover after site inspection will be excluded from the project.

ii. There has been no increase in thicket cover from 1973 to 2009 in the 1 ha areas analysed. Using the same rationale as point 1 above, it can be concluded that there has been no natural regeneration of thicket cover in the moderately and severely degraded landscapes to be planted in the project area.

All areas to be planted in the Baviaanskloof Nature Reserve and Addo Elephant National Park project areas are classified as moderately and severely degraded thicket (Vlok & Euston-Brown, 2002; Lloyd et al, 2002). The results of the above analysis are therefore applicable to these project areas as well.

Figure A.15.1: Area 1, 13.9 % thicket cover in the 1 ha area (2009 imagery).

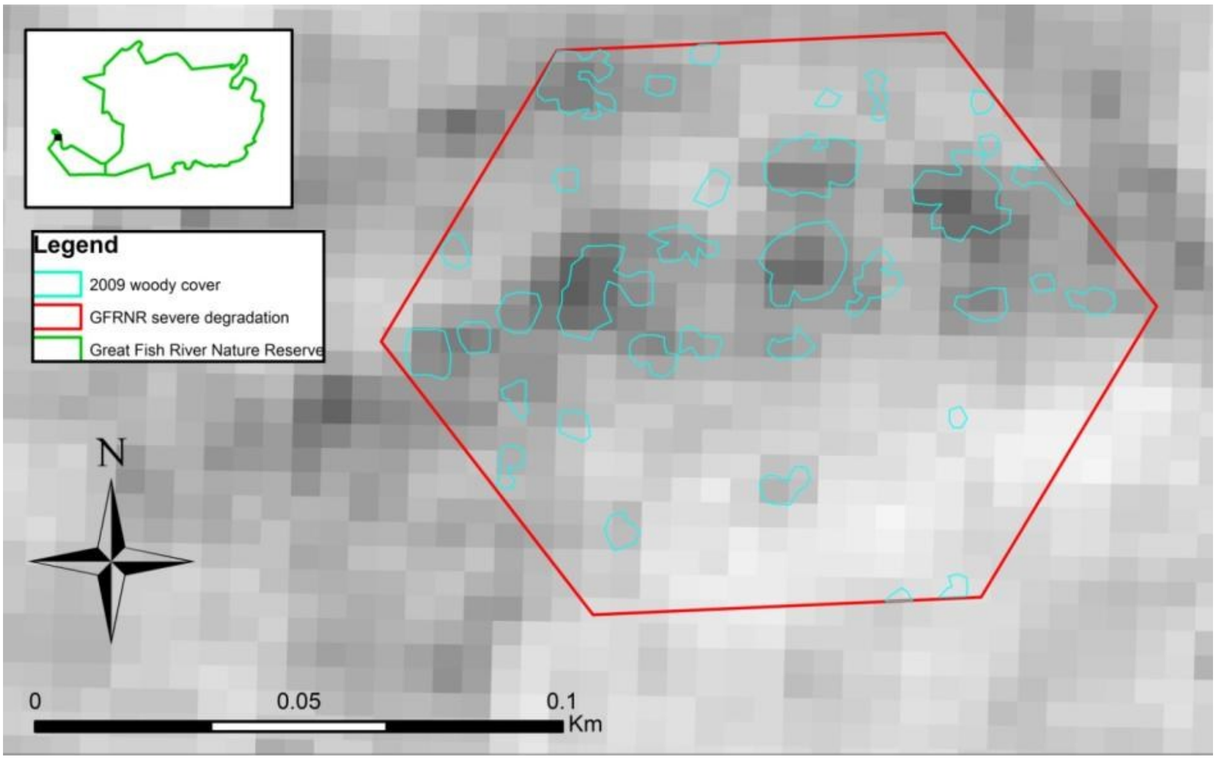

Figure A.15.2: Area 1 (1973 imagery).

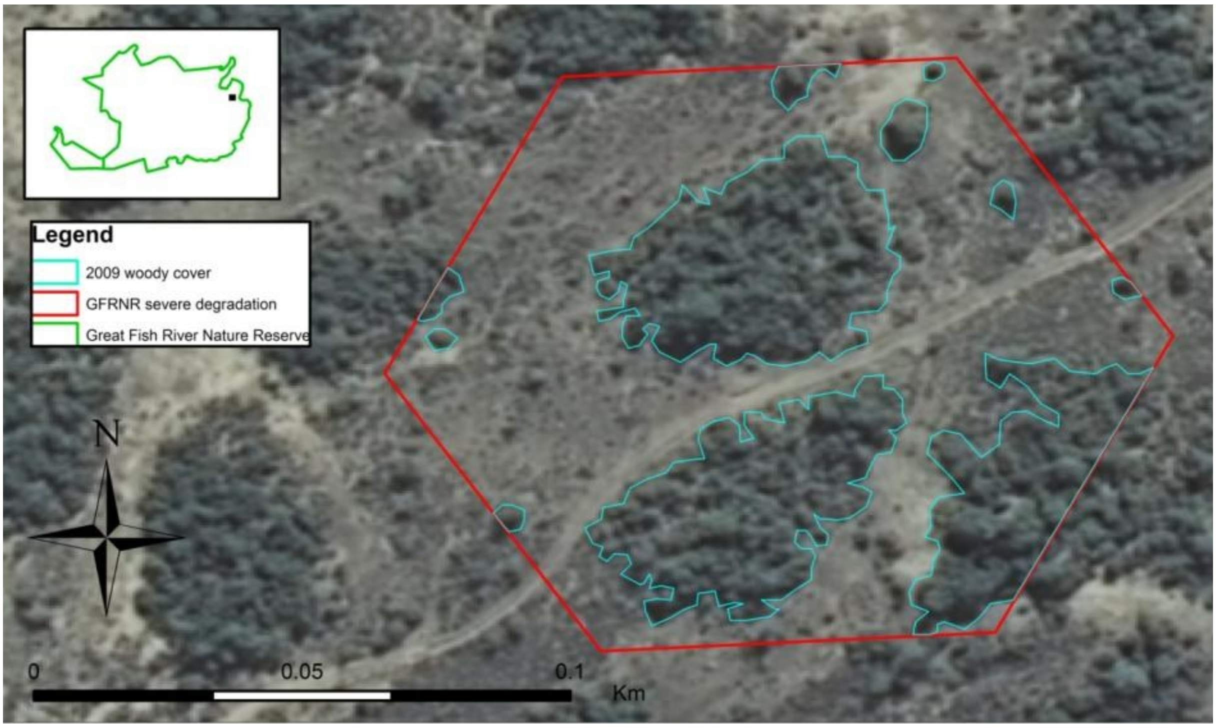

Figure A.15.3: Area , 36.8 % thicket cover in the 1 ha area (2009 imagery).

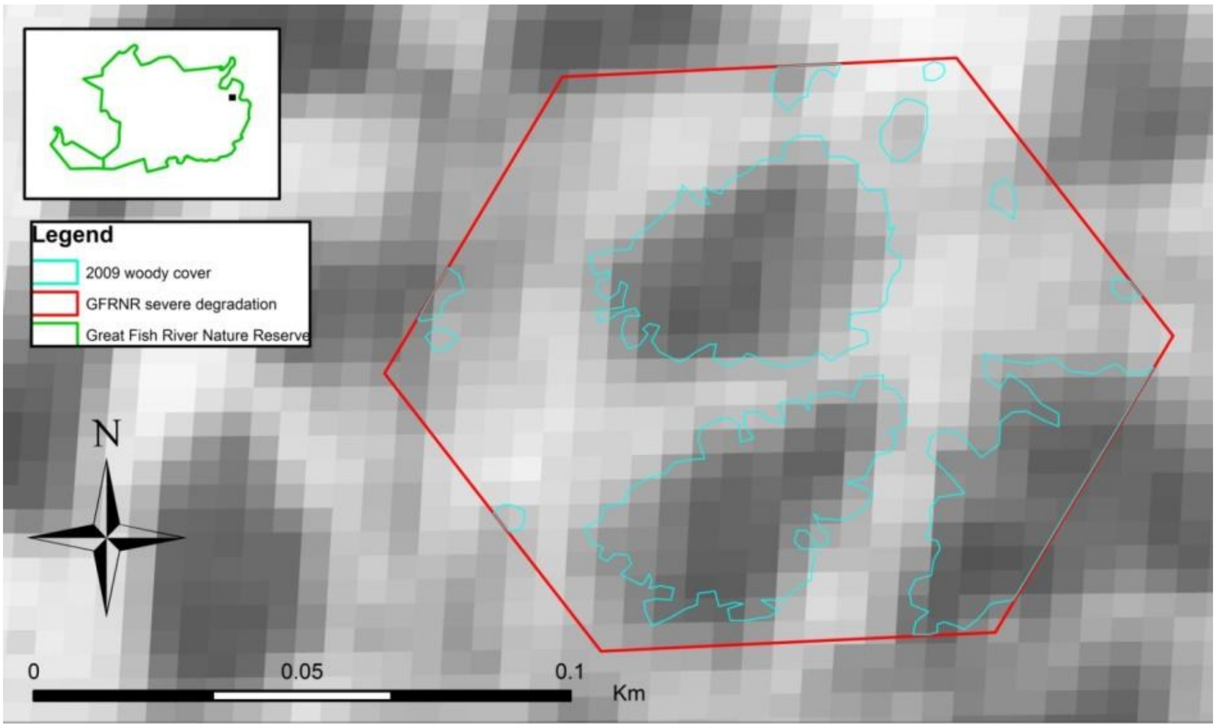

Figure A.15.4: Area 2 (1973 imagery).

Figure A.15.5: Area 3, 29.9 % thicket cover in the 1 ha area (2009 imagery).

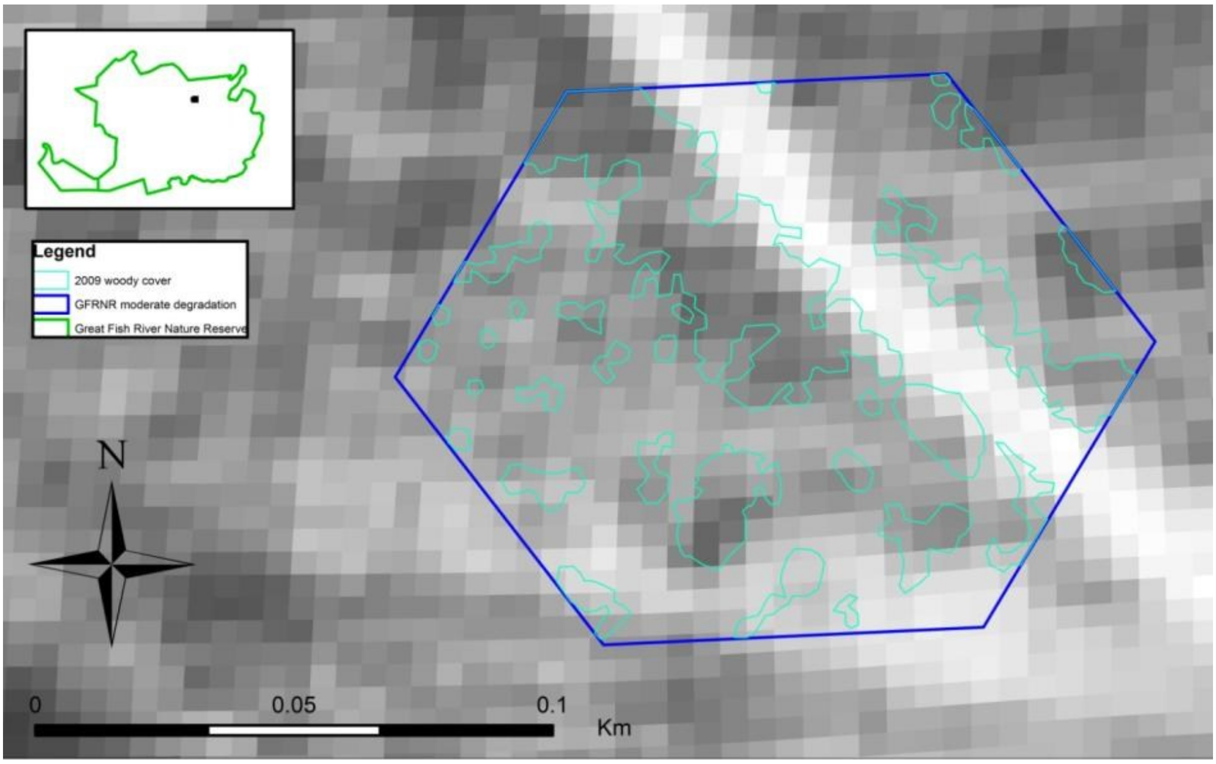

Figure A.15.6: Area 3 (1973 imagery).

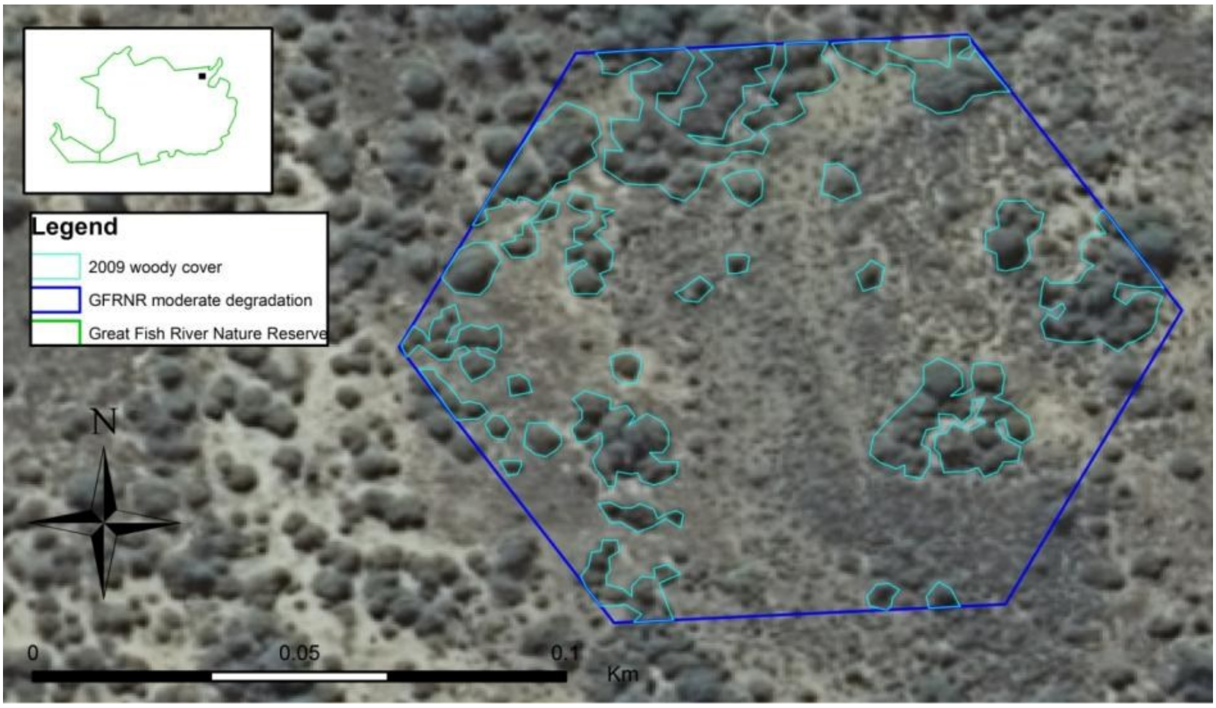

Figure A.15.7: Area 4, 24.2 % thicket cover in the 1 ha area (2009 imagery).

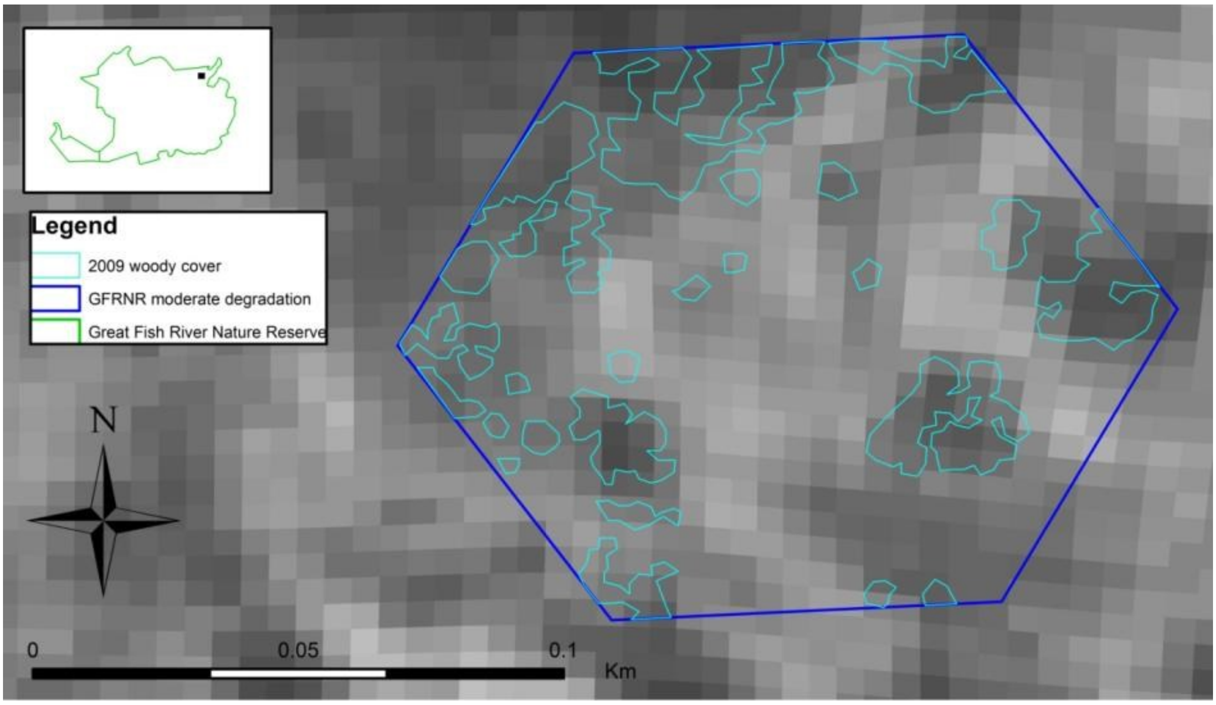

Figure A.15.8: Area 4 (1973 imagery).

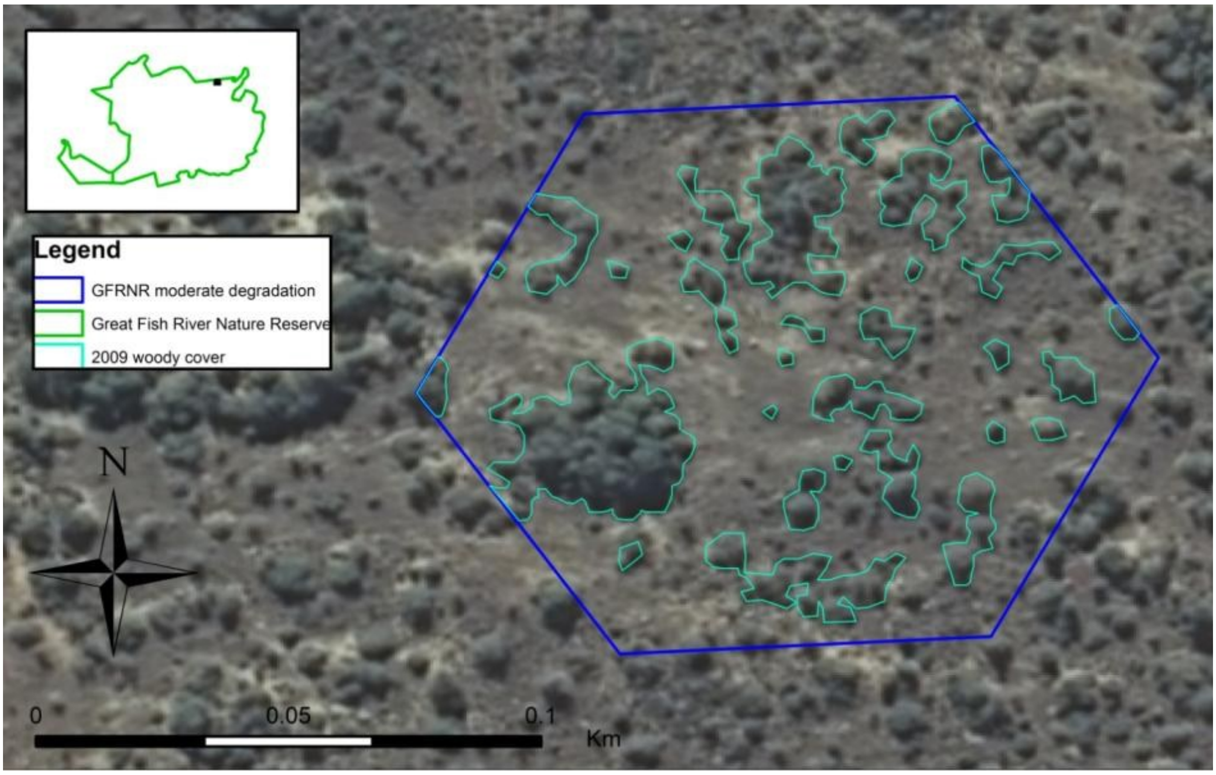

Figure A.15.9: Area 5, 25.4 % thicket cover in the 1 ha area (2009 imagery).

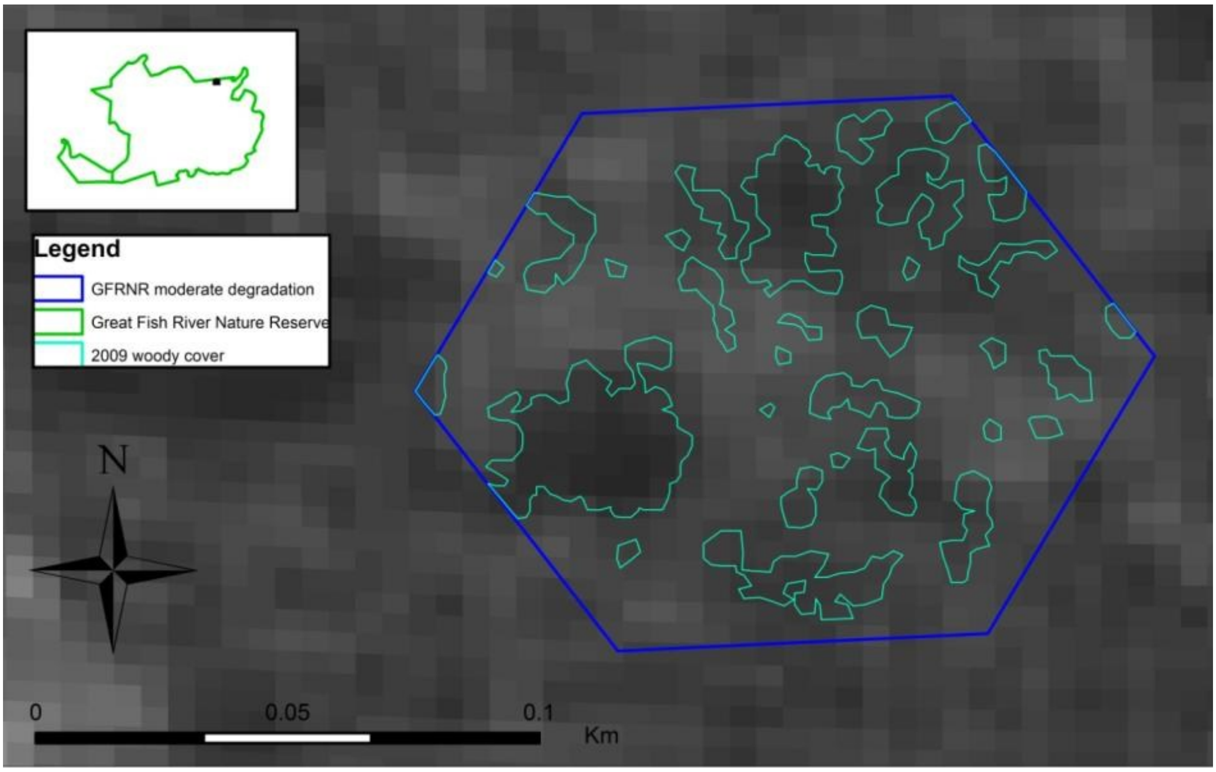

Figure A.15.10: Area 5 (1973 imagery).

A 15.2 Site Maps (survivorship, vegetation and soil information and contract details)

Figure A.15.11: Addo Site 1; Contract codes TBA; 2008 aerial photograph.

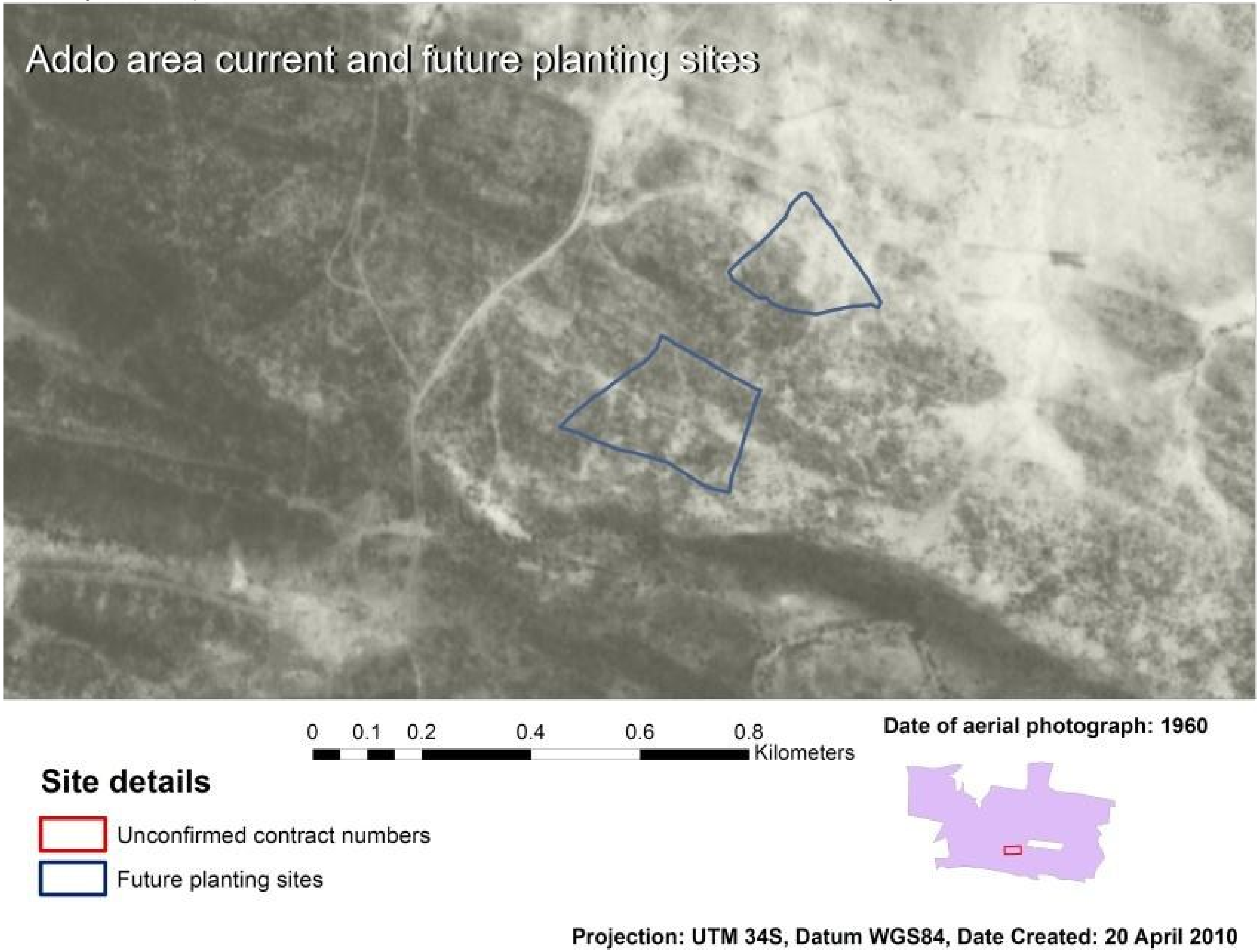

Figure A.15.12: Addo Site 1; Contract codes TBA; 1960 aerial photograph.

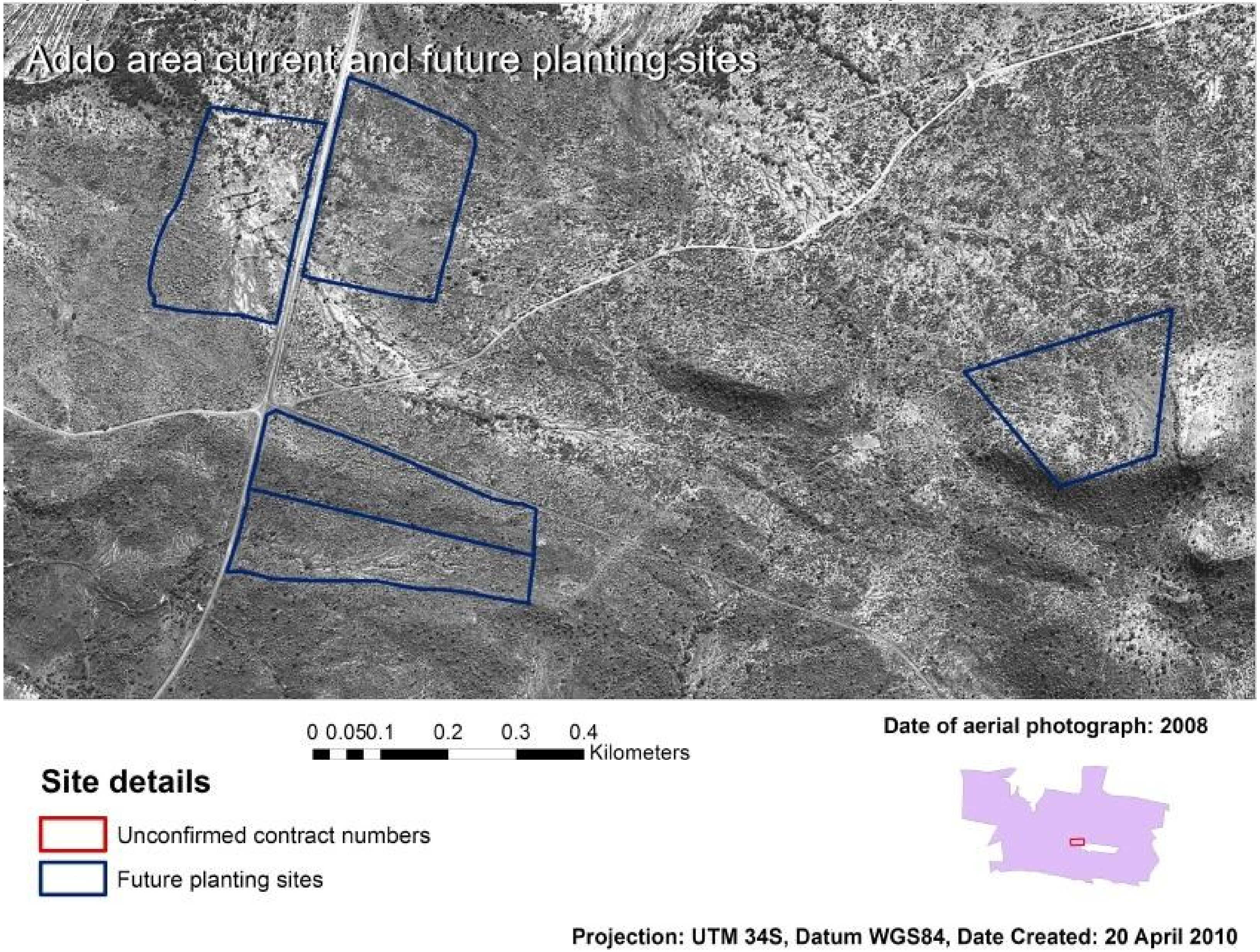

Figure A.15.13: Addo Site 2; Contract codes TBA; 2008 aerial photograph.

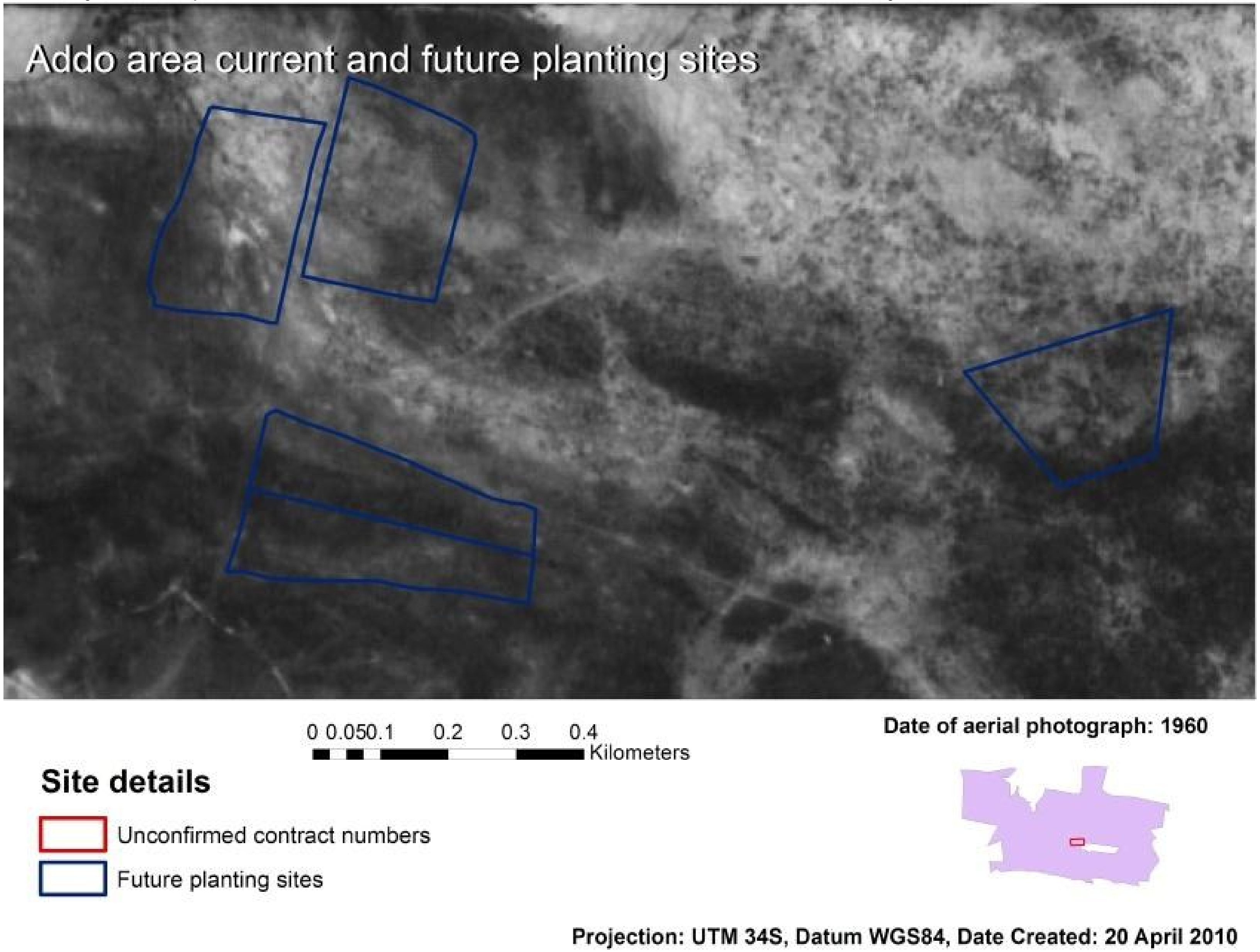

Figure A.15.14: Addo Site 2; Contract codes TBA; 1960 aerial photograph.

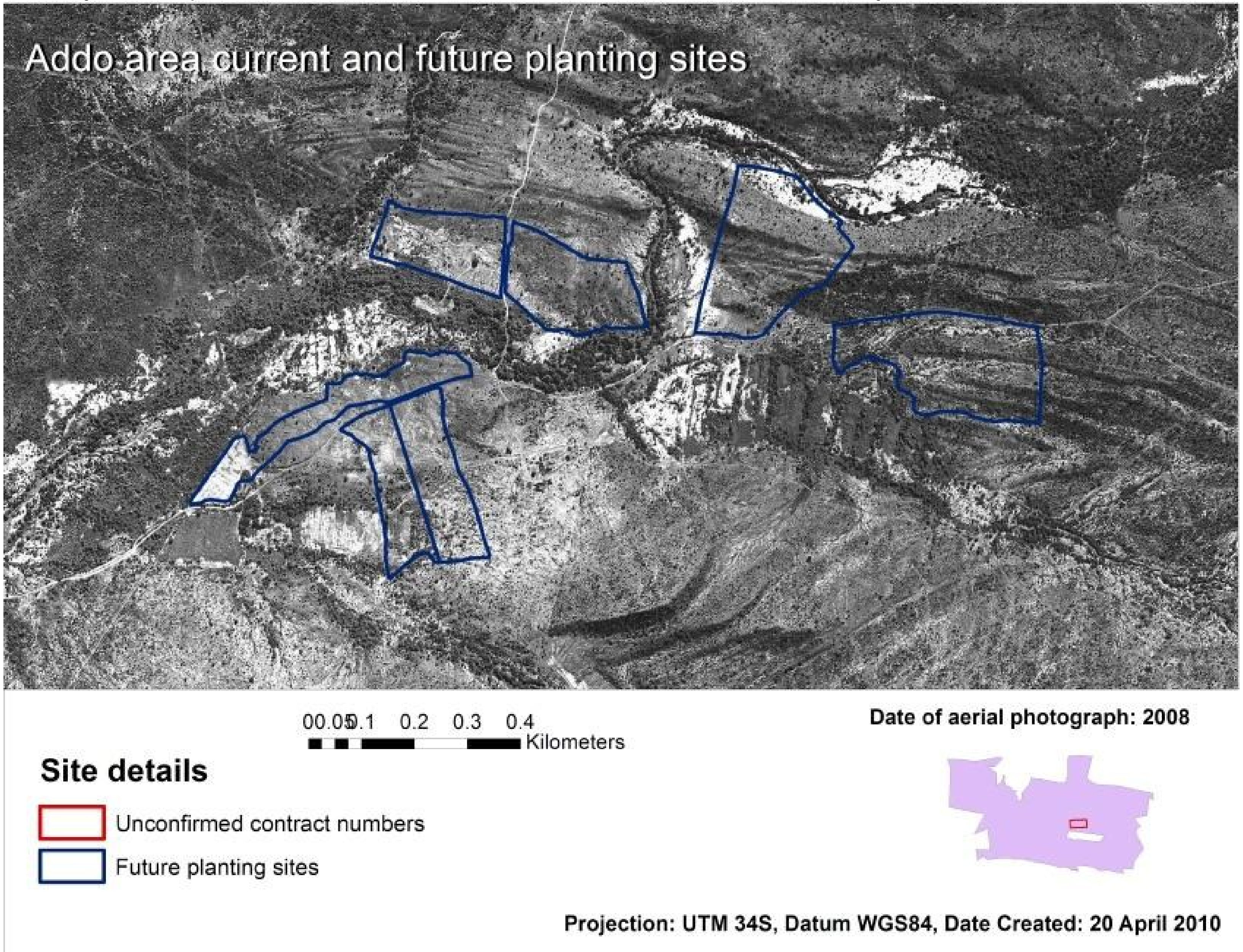

Figure A.15.15: 1: Addo Site 3; Contract codes TBA; 2008 aerial photograph.

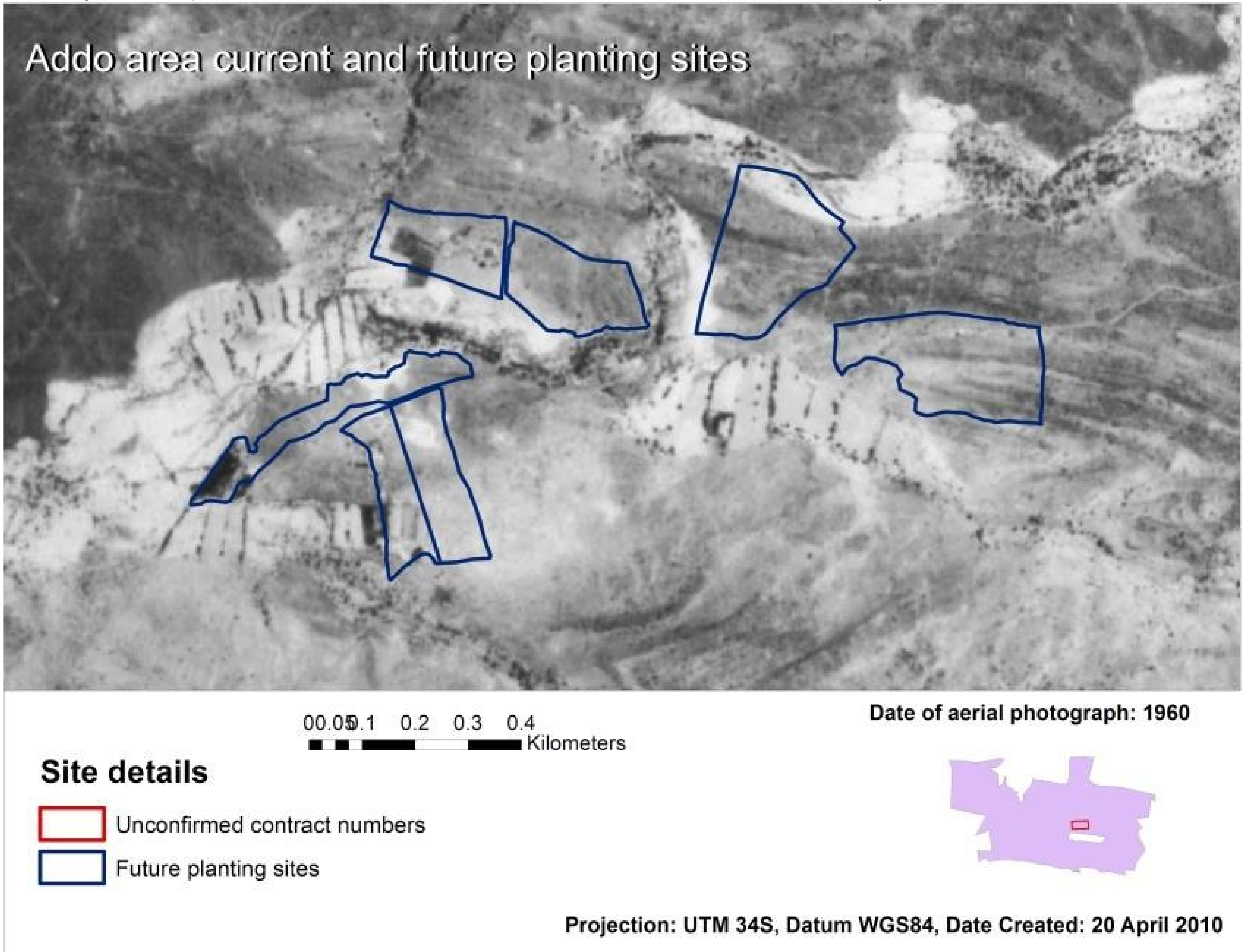

Figure A.15.16: Addo Site 3; Contract codes TBA; 1960 aerial photograph.

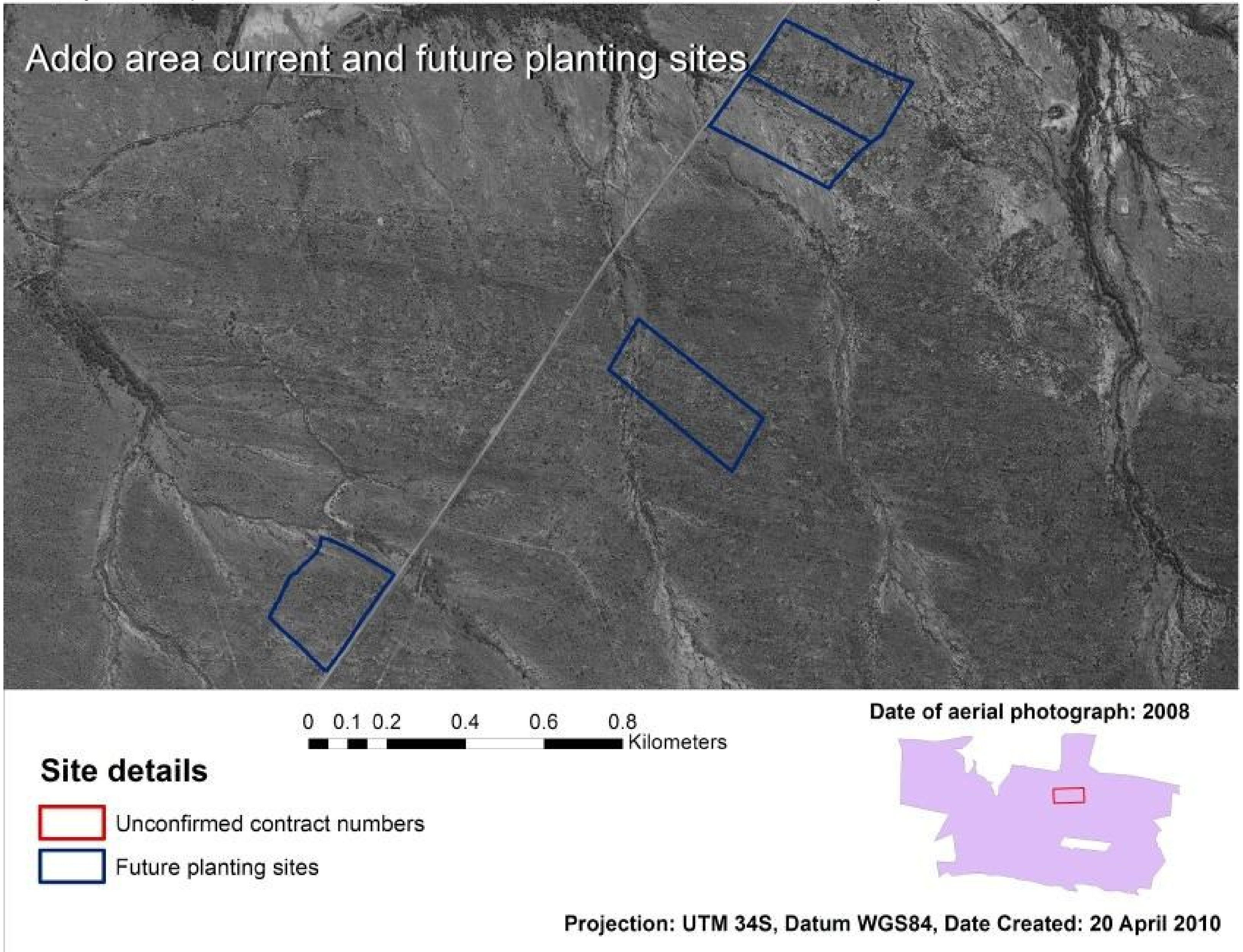

Figure A.15.17: Addo Site 4; Contract codes TBA; 2008 aerial photograph.

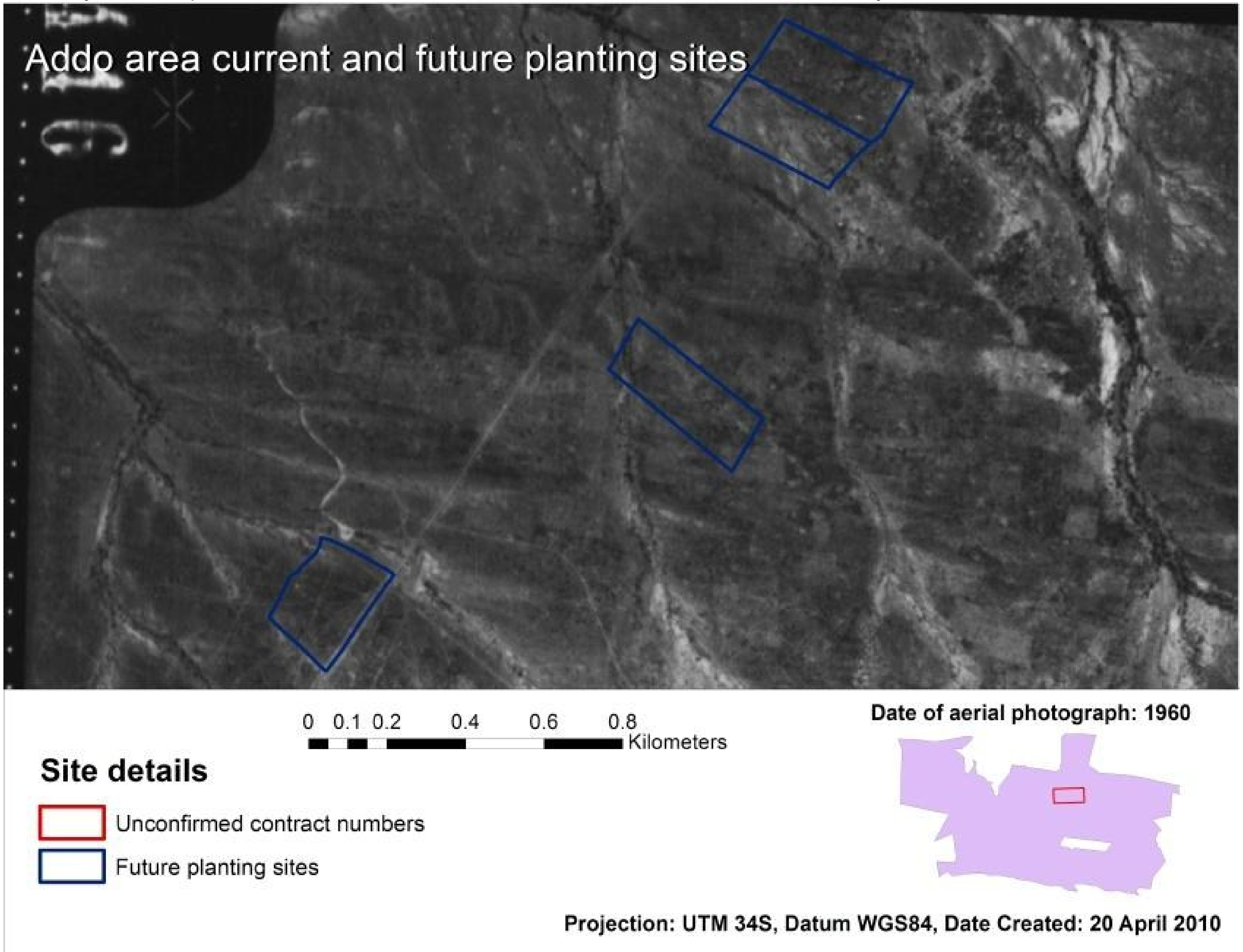

Figure A.15.18: Addo Site 4; Contract codes TBA; 1960 aerial photograph.

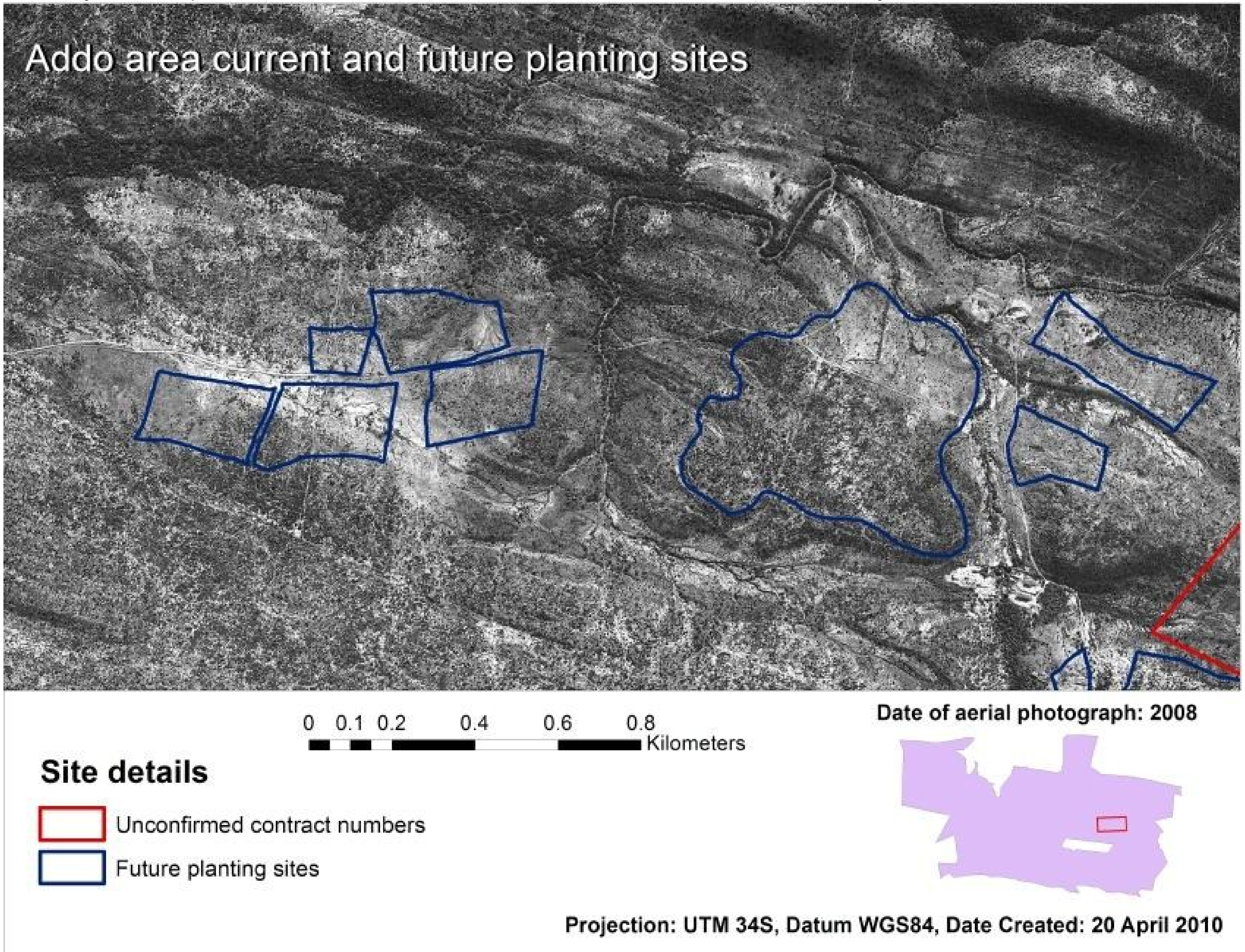

Figure A.15.19: Addo Site 5; Contract codes TBA; 2008 aerial photograph.

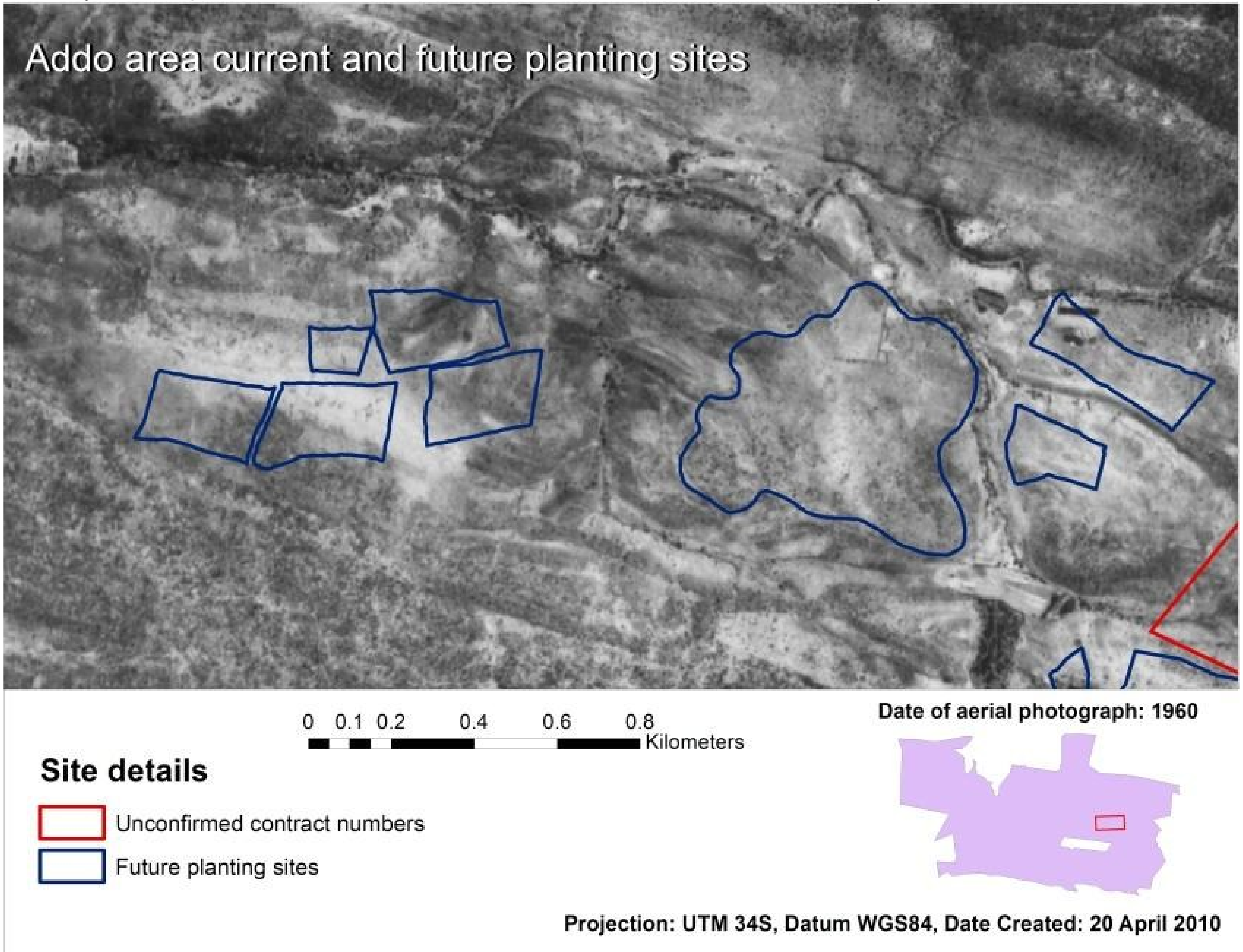

Figure A.15.20: Addo Site 5; Contract codes TBA; 1960 aerial photograph.

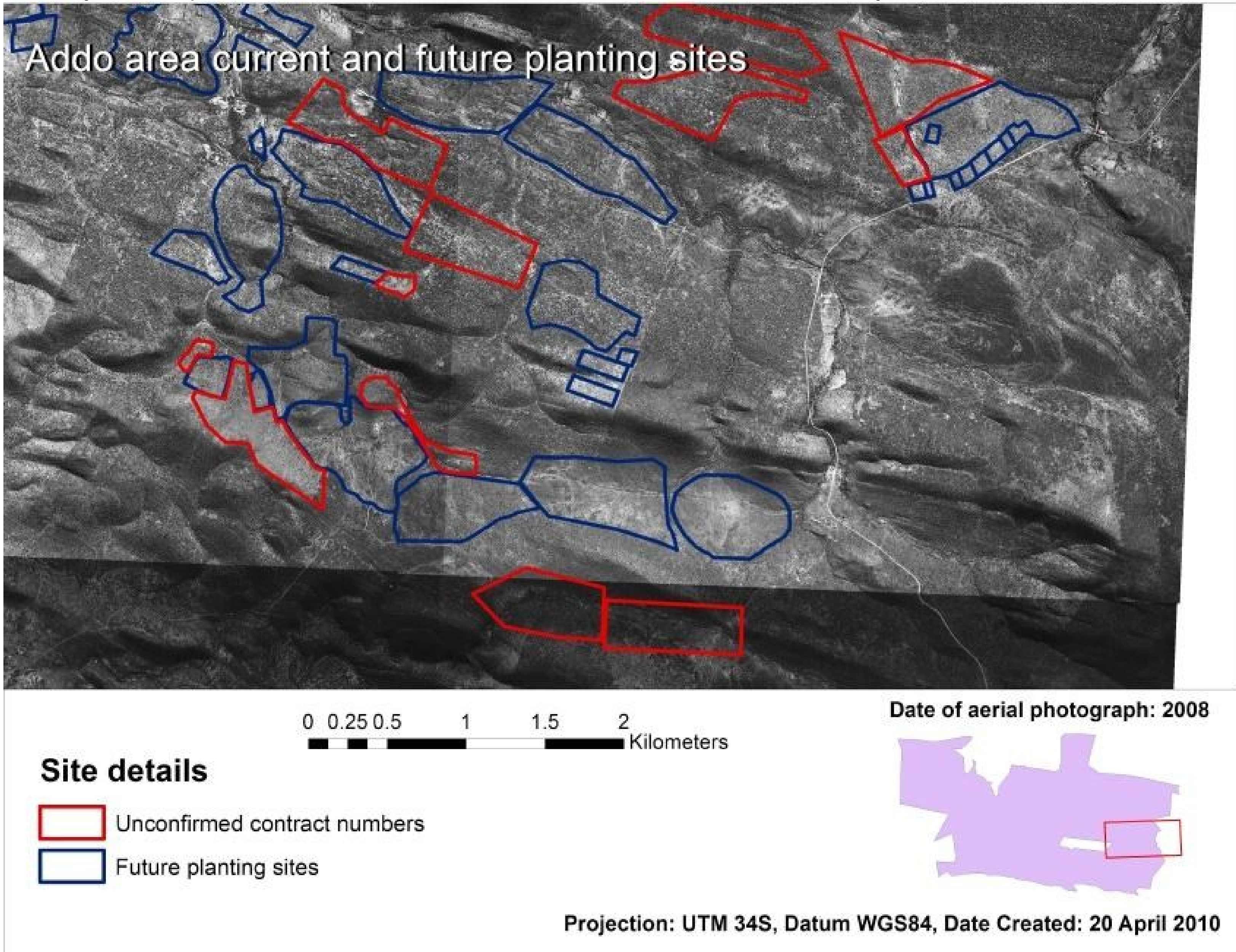

Figure A.15.21: Addo Site 6; Contract codes TBA; 2008 aerial photograph.

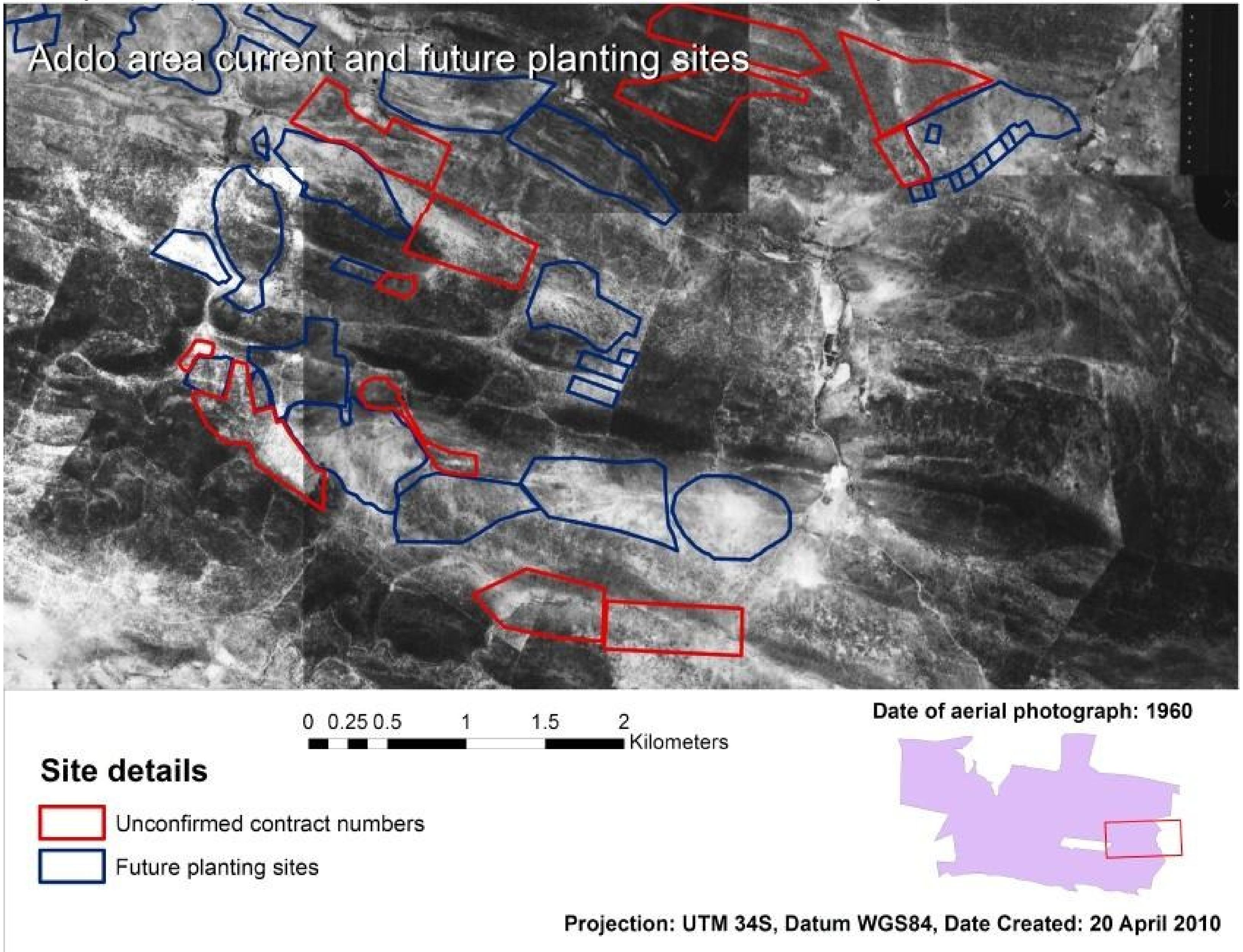

Figure A.15.22: Addo Site 6; Contract codes TBA; 1960 aerial photograph.

Annex 16 Methodological deviations from AR-AMS0002 (V3)

Several deviations from the selected methodology have been pinpointed and undertaken for the purposes of improved accuracy. It is believed that none of these deviations results in changes to the baseline scenario of the additionality of the project. Furthermore, they do not impact negatively on the conservativeness of the the methodology's criteria or change the project GHG sources, sinks and reservoirs. In most cases, the deviations have been undertaken in order to accommodate local values or equations which will improve the accuracy of estimations. Some deviations were also undertaken due to errors in the calculations as published in the methodology. All deviations are specified below.

A 16.1 Deviation 1: Baseline and *ex post* calculation of biomass of a plant (allometric equation method – Equation B.21)

$$C_{AB\_Tree,ijk,t} = A_{ijk} \cdot nTR_{ik} \cdot f_k(DBH,H) \cdot CF_k \cdot \left(\frac{1}{1000}\right) \quad \text{(B.21,B.15)}$$

where:

$f_k(DBH,H)$	Allometric equation quantifying the relationship between above ground biomass of tree species k; kg tree^{-1} to the diameter at breast height (DBH) and tree height (H) for species k; dimensionless. Mean DBH and H values can be estimated for stratum i sub-stratum j species k
A_{ijk}	Area of stratum i sub-stratum j species k; ha
nTR_{ik}	Number of trees in stratum i species k; trees ha^{-1}
CF_k	Carbon fraction for species k; t C (t.d.m.)$^{-1}$

The local allometric equation for the plant species (*P. afra*) is as follows:

$$\mathrm{Log_{10}C_{mass}} = (1.1043 \cdot \mathrm{Log_{10}CBSA}) + 2.4464 \quad \textbf{(AL.1)} \text{ (Powell M. J., 2009)}$$

where:

$\mathrm{C_{mass}}$	Mass of carbon per tree in stratum i sub-stratum j species k; kg C
$CBSA$	Combined basal stem area of the tree; m^2

DEVIATION:

Since the local allometric equation (AL.1) provides a measure of the mass of carbon per plant rather than the biomass, it is equivalent to the result of two terms from B.21:

$$f_k(DBH,H) \cdot CF_k$$

Consequently, these two terms are replaced in B.21 with the single term for the allometric equation:

$$f_k(DBH,H)$$

Furthermore, since the allometric equation uses an alternative measure of plant growth from the specified diameter at breast height, it is better represented as $f_k(CBSA)$. This change is in line with the guidance provided by VCS with respect to allometric equations for carbon estimation[43]. The revised version of the equation is therefore as shown below:

$$C_{AB_{Tree},ijk,t} = A_{ijk} \cdot nTR_{ik} \cdot f_k(CBSA) \cdot \left(\frac{1}{1000}\right) \quad \text{(B.21.dev, B.15 dev)}$$

This is a direct substitution of like terms, and consequently does not affect the conservativeness of the equation. The replacement of an allometric equation with a local one

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[43] VCS (2011) VCS AFOLU Guidance: Additional guidance for VCS Afforestation, Reforestation and Revegetation projects using CDM Afforestation/Reforestation Methodologies. Guidance document. Available from: http:// http://www.v-c-s.org/docs/VCS%20Guidance%20-%20Developing%20VCS%20ARR%20projects.pdf [Accessed 12/05/2011].

measuring different characteristics is explicitly permitted by the VCS, as detailed in the VCS Guidance for Afforestation, Reforestation and Revegetation projects (VCS, 2011).

A 16.2 Deviation 2: *Ex ante* changes in carbon stock of below-ground biomass

The equation provided by the selected methodology for calculating the below-ground biomass of the tree component is appropriate only if yield tables are available for the species.

$$\Delta C_{BB_{Tree},ijk} = I_{Tree,ijk} \cdot D_k \cdot BEF_k \cdot R_{T,k} \cdot CF_k \quad \textbf{(B.31)}$$

where:

$\Delta C_{BB_{Tree},ijk}$ Average annual change in carbon stock in below-ground biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

$I_{Tree,ijk}$ Average annual increment of merchantable timber volume for stratum i sub-stratum j species k in year t; m^3 ha^{-1} yr^{-1}

D_k Basic wood density for species k; t.d.m. m^{-3}

BEF_k Biomass expansion factor for species k to convert merchantable volume into above-ground biomass; dimensionless

$R_{T,k}$ Root-shoot ratio of tree species k; dimensionless

CF_k Carbon fraction for tree species; t C $(t.d.m.)^{-1}$

Yield tables are not available for *P. afra*. Furthermore, there are two errors in this equation:

i) In order to convert the volume of wood to a mass, either one of the biomass expansion factor or the wood density should be used, not both as specified in equation B.31.

ii) There is no area term in the equation, which means that the equation returns carbon stock change per hectare, not for the overall project.

However, the methodology does explicitly allow calculation of the above-ground biomass using allometric equations. Furthermore, the methodology specifies *“The below-ground biomass is represented as a proportion of the above-ground biomass*”. Equation B.32 represents this calculation for non-tree biomass, using the above-ground biomass and the root:shoot ratio to calculate the below-ground biomass:

$$\Delta C_{BB\_NTree\_Shrub,ijk} = \Delta C_{AB\_NTree\_Shrub,ijk} \cdot R_{S,k} \quad \textbf{(B.32)}$$

where:

$\Delta C_{BB\_NTree\_Shrub,ijk}$ Average annual change in the below-ground non-tree shrub biomass in stratum i sub-stratum j species k a t; t C ha^{-1}

$\Delta C_{AB\_NTree\_Shrub,ijk}$ Average annual change in the above-ground non-tree shrub biomass in stratum i sub-stratum j species k at time t; t C ha^{-1}

$R_{S,k}$ Root-shoot ratio for shrub species k; dimensionless

This equation calculates the below-ground biomass by multiplying the above-ground biomass by the conversion factor, which is the purpose of the value R. Consequently, a modified version of this equation is used to calculate the below-ground component of the tree biomass, as outlined below:

$$\Delta C_{BB\_Tree,ijk,t} = \Delta C_{AB\_Tree,ijk,t} \cdot R_{T,k} \quad \textbf{(I.1)}$$

where:

$\Delta C_{BB\_Tree,ijk,t}$ Average annual change in carbon stock in below-ground biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

$\Delta C_{AB\_Tree,ijk,t}$ Average annual change in carbon stock in above-ground biomass for stratum i sub-stratum j species k in year t; t C yr^{-1}

$R_{T,k}$ Root-shoot ratio for tree species k; dimensionless

It is considered that this deviation is conservative since it adheres to the methodological guidelines as they are written within AR-AMS0002 V3, and avoids the errors inherent in the use of equation B.31.

A 16.3 Deviation 3: *Ex post* calculation of changes in the carbon stocks of litter (Equations M.23 and M.24)

AR-AM0002 (V3) specifies that if the carbon stocks in litter are to be included in ex-ante calculations, then the following *ex post* equations from the monitoring section should be used:

$$C_{L,m,ijk} = A_{ijk} \cdot C_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \quad \textbf{(M.23)}$$

$$\Delta C_{L,m,ijk,t} = [(C_{L,m_2,ijk} - C_{L,m_1,ijk})/T_L] \cdot CF_L \quad \textbf{(M.24)}$$

where:

$C_{L,m,ijk}$ Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m; tC

$C_{L_{wet},ijk}$ Carbon in wet litter biomass for stratum i sub-stratum j species k at monitoring event m; g m^{-2}

A_{ijk} Area of stratum i sub-stratum j species k at monitoring event m; ha

MP_L Weight fraction of moisture of litter biomass (0 to 1) [(wet weight – dry weight)/wet weight]; dimensionless

a_{ijk} Area of sampling frame; m^2

$\Delta C_{L,m,ijk,t}$ Average annual change in carbon stock of litter for stratum i sub-stratum j species k at monitoring event m; t C yr^{-1}

$C_{L,m_2,ijk}$ Carbon stock of litter in stratum i sub-stratum j species k at monitoring event m_2; t C

$C_{L,m_1,ijk}$ Carbon stock of litter in stratum i sub-stratum j species k at monitoring event m_1; t C

T_L Time interval between m_2 and m_1; yr

CF_L Carbon fraction of litter; dimensionless (IPCC default: 0.370)

There is an error in equation M.23: both the terms $C_{L,m,ijk}$ and $C_{L_{wet},ijk}$ are specified as being measures of the carbon in the litter biomass. However, according to the monitoring methodology, $C_{L_{wet},ijk}$ is obtained by measuring the wet litter biomass, and consequently both these terms are measures of biomass. This error is repeated in equation M.24, where the terms $C_{L,m_2,ijk}$ and $C_{L,m_1,ijk}$ are referred to as measures of carbon stock in the litter. These terms are then multiplied by the term CF_L, the carbon fraction of dry litter. This multiplication would be necessary only if the previous terms were measures of biomass, in order to convert them to measures of carbon. It is therefore considered that the terms reflect an error in the equations as specified in AR-AMS0002 (V3), and consequently modified versions of the two equations are used in the *ex post* calculations, as specified below.

$$B_{L,m,ijk} = A_{ijk} \cdot B_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \quad \textbf{(M.23.dev)}$$

$$\Delta C_{L,m,ijk,t} = [(B_{L,m_2,ijk} - B_{L,m_1,ijk})/T_L] \cdot CF_L \quad \textbf{(M.24.dev)}$$

where:

$B_{L,m,ijk}$	Dry litter biomass for stratum *i* sub-stratum *j* species *k* at monitoring event *m*; t.d.m.
$B_{L_{wet},ijk}$	Wet litter biomass for stratum *i* sub-stratum *j* species *k* at monitoring event *m*; g m^{-2}
A_{ijk}	Area of stratum *i* sub-stratum *j* species *k* at monitoring event *m*; ha
MP_L	Weight fraction of moisture of litter biomass (0 to 1) [(wet weight – dry weight)/wet weight]; dimensionless
a_{ijk}	Area of sampling frame; m^2
$\Delta C_{L,m,ijk,t}$	Average annual change in carbon stock of litter for stratum *i* sub-stratum *j* species *k* at monitoring event *m*; t C yr^{-1}
$B_{L,m_2,ijk}$	Dry biomass of litter in stratum *i* sub-stratum *j* species *k* at monitoring event m_2; t.d.m.
$B_{L,m_1,ijk}$	Dry biomass of litter in stratum *i* sub-stratum *j* species *k* at monitoring event m_1; t.d.m.
T_L	Time interval between m_2 and m_1; yr
CF_L	Carbon fraction of litter; dimensionless (IPCC default: 0.370)

This deviation is undertaken to ensure accuracy of the measurements of carbon litter biomass, and reflects an error in the equations as specified by the methodology. It si not considered to violate the conservatveness or additionality of the methodology.

A 16.4 Deviation 4: *Ex ante* calculation of changes in the carbon stocks of litter (Equations M.23 and M.24)

AR-AMS0002 (V3) specifies that if litter is to be included as a carbon pool in the *ex ante* estimate, the equations used in the monitoring methodology should be followed (see Deviation 3 above for an explanation of the errors in these equations). However, the concentration of litter carbon obtained from the literature meta-analysis (see Annex 7). does not include values for the biomass and moisture content of the litter. It is not therefore possible to follow the equations exactly, and modified versions of the equations must be used. These modifications correspond merely to an algebraic rearrangement of the equations in order to accommodate the terms, as specified below:

$$B_{L,m,ijk} = A_{ijk} \cdot B_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \qquad \textbf{(M.23.dev)}$$

$$\Delta C_{L,m,ijk,t} = \left[\left(B_{L,m_2,ijk} - B_{L,m_1,ijk}\right)/T_L\right] \cdot CF_L \qquad \textbf{(M.24.dev)}$$

where:

$B_{L,m,ijk}$	Dry litter biomass for stratum *i* sub-stratum *j* species *k* at monitoring event *m*; t.d.m.
$B_{L_{wet},ijk}$	Wet litter biomass for stratum *i* sub-stratum *j* species *k* at monitoring event *m*; g m^{-2}
A_{ijk}	Area of stratum *i* sub-stratum *j* species *k* at monitoring event *m*; ha
MP_L	Weight fraction of moisture of litter biomass (0 to 1) [(wet weight – dry weight)/wet weight]; dimensionless
a_{ijk}	Area of sampling frame; m^2
$\Delta C_{L,m,ijk,t}$	Average annual change in carbon stock of litter for stratum *i* sub-stratum *j* species *k* at monitoring event *m*; t C yr^{-1}

$B_{L,m_2,ijk}$ Dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_2; t.d.m.
$B_{L,m_1,ijk}$ Dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_1; t.d.m.
T_L Time interval between m_2 and m_1; yr
CF_L Carbon fraction of litter; dimensionless (IPCC default: 0.370)

Moving the carbon fraction term ($\cdot CF_L$) from Equation M.24.dev to equation M.23.dev will provide the following equations:

$$C_{L,m,ijk} = A_{ijk} \cdot B_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \cdot CF_L \quad \textbf{(M.23.2)}$$

$$\Delta C_{L,m,ijk,t} = \left[\left(C_{L,m_2,ijk} - C_{L,m_1,ijk}\right)/T_L\right] \quad \textbf{(M.24.2)}$$

where:
$C_{L,m,ijk}$ Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m; t C
$C_{L,m_2,ijk}$ Carbon in dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_2; t C
$C_{L,m_1,ijk}$ Carbon in dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_1; t C

These equations together provide an arithmetically equivalent value for the change in carbon stocks of litter ($\Delta C_{L,m,ijk,t}$), and therefore do not deviate in a fundamental way from the equations laid out in the methodology. Furthermore, the terms in M.23.2 ($B_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \cdot CF_L$) provide a value for litter carbon stock per hectare when multiplied together. The values obtained from the literature meta-analysis provide a similar measure, and consequently this value can be substituted for those terms:

$$\left(B_{L_{wet},ijk} \cdot (1 - MP_L) \cdot (\frac{1}{a_{ijk}}) \cdot \frac{1}{100} \cdot CF_L\right) = C_{meta,ijk,m}$$

where:
$C_{meta,ijk,m}$ Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m calculated from meta-analysis; tC ha^{-1}

Consequently, the modified equations used to calculate the *ex ante* change in litter carbon stock are as follows:

$$C_{L,m,ijk} = A_{ijk} \cdot C_{meta,ijk,m} \quad \textbf{(M.23.ex.ante)}$$

$$\Delta C_{L,ijk,t} = \left[\left(C_{L,ijk,t_2} - C_{L,ijk,t_1}\right)/T_L\right] \quad \textbf{(M.24.ex.ante)}$$

where:
$C_{L,m,ijk}$ Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m; t C
MP_L Weight fraction of moisture of litter biomass (0 to 1) [(wet weight – dry weight)/wet weight]; dimensionless
A_{ijk} Area of stratum i sub-stratum j species k at monitoring event m; ha
a_{ijk} Area of sampling frame; m^2
$\Delta C_{L,m,ijk,t}$ Average annual change in carbon stock of litter for stratum i sub-stratum j species k at monitoring event m; t C yr^{-1}
$C_{L,m_2,ijk}$ Carbon in dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_2; t C

$C_{L,m_1,ijk}$	Carbon in dry biomass of litter in stratum i sub-stratum j species k at monitoring event m_1; t
T_L	Time interval between m_2 and m_1; yr
CF_L	Carbon fraction of litter; dimensionless (IPCC default: 0.370)
$C_{meta,ijk,m}$	Carbon in dry litter biomass for stratum i sub-stratum j species k at monitoring event m calculated from meta-analysis; tC ha^{-1}

This deviation is not considered to violate the conservativeness or additionality of the methodology, since it merely replaces a set of terms with a corresponding empirical measurement obtained from a number of field observations.

A 16.5 Deviation 5: *Ex ante* estimation of emissions from biomass burn (inserted equation I.2)

As laid out in AR-AM0002 (v3) this section is moderately incomplete. Several deviations from the methodology have been introduced in order to improve the accuracy and conservativeness of the methodology.
Firstly, although it is implied in the methodology, the equation detailing the calculation of the total emissions from fire is not included. Hence, the following equation was introduced:

$$E_{BiomassBurn} = E_{BiomassBurn,CO_2} + E_{Non-CO_2\_BiomassBurn} \quad \text{(inserted I.2)}$$

where:

$E_{BiomassBurn}$	Increase in GHG emissions from biomass burning within the project boundary; t CO_2e yr^{-1}
$E_{BiomassBurn,CO_2}$	CO_2 emissions from biomass burning in the project area; t CO_2e yr^{-1}
$E_{Non-CO_2\_BiomassBurn}$	Non-CO_2 emissions from biomass burning in the project area; t CO_2e yr^{-1}

A 16.6 Deviation 6: *Ex ante* estimation of emissions from biomass burn (Equation B.40)

Equation B.40 is incorrect as printed in AR-AM0002 (v3).

$$E_{BiomassBurn,CO_2} = A_{BiomassBurn,i} \cdot B_{AB\_Ntree,i} \cdot CE \cdot CF_{NTree} \cdot 44/12 \quad \text{(B.40)}$$

The equation in its original form would only calculate the total emissions from a single stratum, since it does not sum each stratum. The revised version of the equation is shown below

$$E_{BiomassBurn,CO_2} = \sum_i (A_{BiomassBurn,i} \cdot B_{AB\_Ntree,i} \cdot CE \cdot CF_{NTree} \cdot 44/12) \quad \text{(B.40.1)}$$

where:

$A_{BiomassBurn,i}$	Area of biomass burn; stratum i; ha yr^{-1}
$B_{AB\_NTree,i}$	Average stock in above ground biomass for stratum i prior to burn; t.d.m. ha^{-1}
CE	Combustion efficiency; dimensionless (IPCC default = 0.5)
CF_{NTree}	Carbon fraction of dry biomass; t C $(t.d.m.)^{-1}$
$44/12$	Ratio of molecular weights of CO_2 and carbon; dimensionless

This is merely a correction of the equation as printed in the methodology, and does not affect the conservativeness of the methodology.

Secondly, Equation B.40 has been modified in order to simplify the calculation.The area of burn ($A_{BiomassBurn,i}$) can be represented by the total area of stratum i (A_i) multiplied by the fraction of the biome that typically burns in a single year (F_{Burn}). The terms $B_{AB\_Ntree,i} \cdot CF_{NTree}$ correspond to the average carbon stock of stratum *i* per hectare, and multiplying this by the total area of stratum *i* gives us the total carbon in stratum *i* ($C_{AB\_Tree,ijk,t}$). Therefore:

$A_{BiomassBurn,i} \cdot B_{AB\_Ntree,i} \cdot CF_{NTree} = C_{AB\_Tree,ijk,t} \cdot F_{Burn}$

and by algebraic substitution:

$$E_{BiomassBurn,CO_2} = \sum_i C_{AB\_Tree,ijk,t} \cdot F_{Burn} \cdot CE \cdot 44/12 \qquad \text{(B.40.dev)}$$

This deviation is an algebraic equivalency used to sinmplify the *ex ante* calculations, and does not affect the conservativeness of the equation.

A 16.7 Deviation 7: Determination of total sample size. (Equation M.1)

The methodology cites the following equation for calculating the total number of sample sites in the project area:

$$\mathrm{n} = \left(\frac{\mathrm{t}\alpha/_2}{\mathrm{A}}\right)^2 \left(\sum_{\mathrm{i}=1}^{\mathrm{N_I}} \mathrm{W_i}\,\mathrm{S_i}\sqrt{\mathrm{C_i}}\right)\left(\sum_{\mathrm{i}=1}^{\mathrm{N_S}} \mathrm{W_i}\,\mathrm{S_i}\Big/\sqrt{\mathrm{C_i}}\right) \qquad \text{(M.1)}$$

where:

n	Sample size (number of sample plots required for monitoring)
$\mathrm{t}\alpha/_2$	Value of the Student t statistic, for α = 0.1 (implting a 90% confidence level)
$\mathrm{N_s}$	Total number of strata defined
$\mathrm{N_i}$	Number of potential sample units (permanent sample plots) in stratum *i*
N	Total number of potential sample units (permanent sample plots)
$\mathrm{S_i}$	Standard deviation in stratum *i*
A	Permissible error in the mean
C_i	Cost of selecting a sample plot in stratum *i*

$W_i = N_i/N_s$

It is considered that the second term of the equation $(\sum_{\mathrm{i}=1}^{\mathrm{N_I}} \mathrm{W_i}\,\mathrm{S_i}\sqrt{\mathrm{C_i}})$ should be summed for each stratum (N_S), rather than summed for the undefined term N_I as written in the methodology. This is most likely a typographical error. Consequently, the modified equation should be written as:

$$\mathrm{n} = \left(\frac{\mathrm{t}\alpha/_2}{\mathrm{A}}\right)^2 \left(\sum_{\mathrm{i}=1}^{\mathrm{N_S}} \mathrm{W_i}\,\mathrm{S_i}\sqrt{\mathrm{C_i}}\right)\left(\sum_{\mathrm{i}=1}^{\mathrm{N_S}} \mathrm{W_i}\,\mathrm{S_i}\Big/\sqrt{\mathrm{C_i}}\right) \qquad \text{(M.1.dev)}$$

Furthermore, when carrying out the calculation as written, values of several million to several hundred million sampling plots per hectare were recommended. This is clearly erroneous, and after some investigation and comparison with other methodologies for calculating the number of sample sites, it was determined that there was an error in definition for the term *Wi* as printed. The term Ns (number of strata) should be substituted with N (total number of potential sample units) in the definition. The correct definition, as used for calculation, should read:

$$W_i = N_i / N$$

Comparison of this modified equation gave realistic values for the number of sample plots required, which were in line with those estimated by the Winrock Sourcebook for LULUCF Projects (Timothy, Sarah, & Sandra, 2005) and the UNFCCC Tool for calculation of the number of sample plots (UNFCCC, 2009 [2]). It is therefore considered that this deviation improves the conservativeness of the methodology.

Annex 17 Project planting plan for the Darlington Dam section of the Addo Elephant National Park

Attached as separate document.