

RIO BRAVO

CLIMATE ACTION PROJECT

MONITORING REPORT

Document Prepared By The Nature Conservancy, Program for Belize, and Ecosystem Services Unit of Winrock International

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1 PROJECT DETAILS

1.1 Summary Description of Project

This is an Avoided Planned Deforestation project. The project began in January 1996 and is located in the Orange Walk District of north-western Belize and contains 6,296 hectares (ha). The area within the Project Boundary was purchased creating a clear land title held by the Program for Belize. The act of purchase removed the imminent threat of purchase by industrial scale agricultural farmers who would have proceeded to deforest the area. The land titles purchased covered areas included within the Project Boundary and also areas outside the Project Boundary. The areas outside the Project Boundary contain Pine Savanna, an ecosystem type that was not under the threat of deforestation by agriculturalists. These areas are labelled as 'not eligible' in all maps.

1.2 Sectoral Scope and Project Type

This project is within sectoral scope 14 "Agriculture Forestry and Other Land Use" of the VCS. It is an Avoided Planned Deforestation project. It is not a grouped project.

1.3 Project Proponent

Name	Role	Contact / Address
Programme for Belize	Project site manager; land owner.	Edilberto Romero PO BOX 749 # 1 Eyre Street Belize City Belize Tel: (501) 227-5616

1.4 Other Entities Involved in the Project

Entity	Role	Contact / Address
The Nature Conservancy	Project development; Financial Manager; Validation/Verification lead	Alex Martinez 14A Garden City Plaza Belmopan, Cayo Belize Tel: (501) 822-0274
Winrock International	Validation & Verification technical advisor	Sarah Walker Felipe Casarim Sean Grimland 2121 Crystal Drive, Suite 500 Arlington, VA 22202 Tel: (703) 302-6556

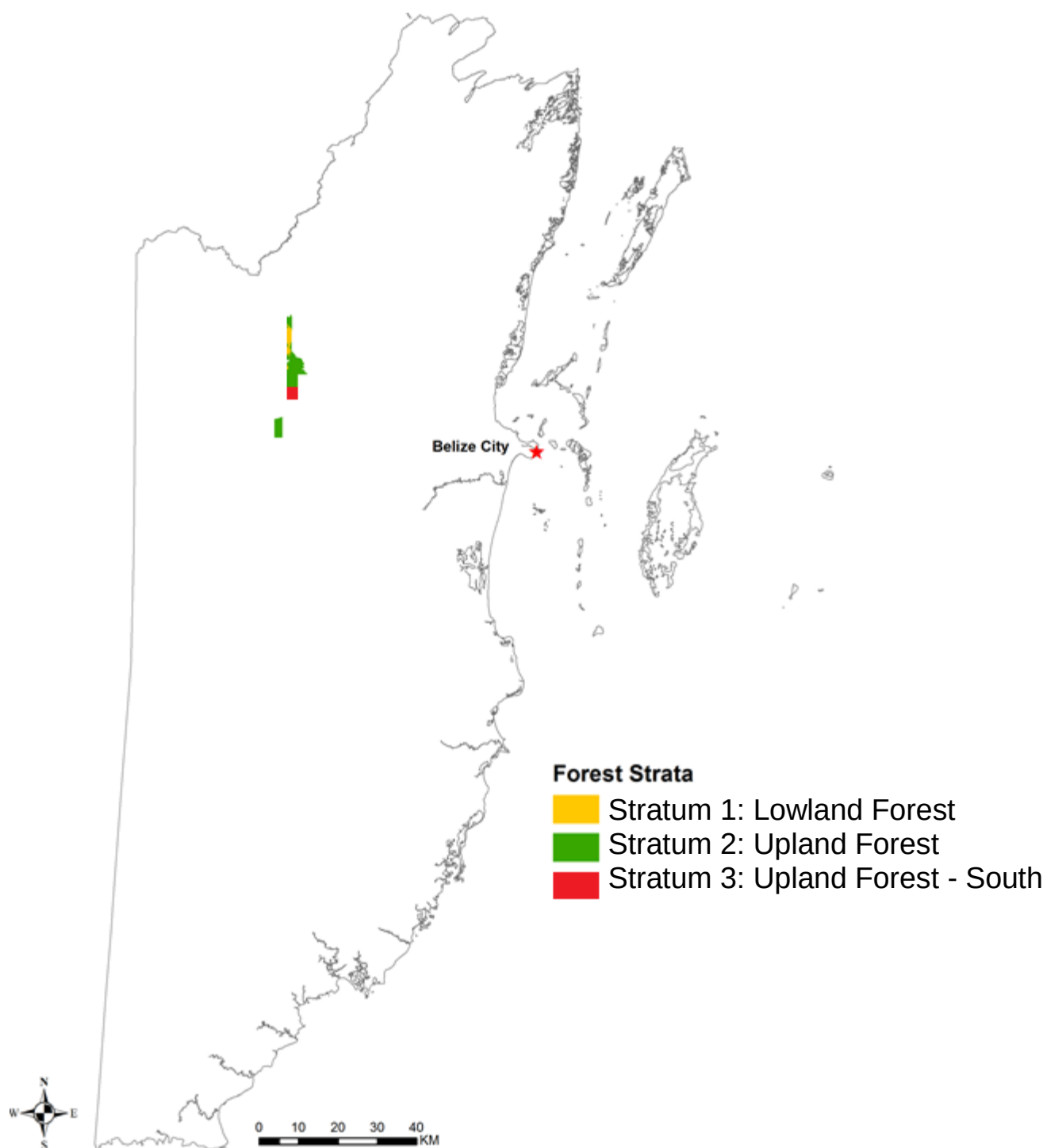
1.5 Project Start Date

Project Start Date 01 January 1996

1.6 Project Crediting Period

Crediting Period 1 January 2002 – 31 December 2021

1.7 Project Location



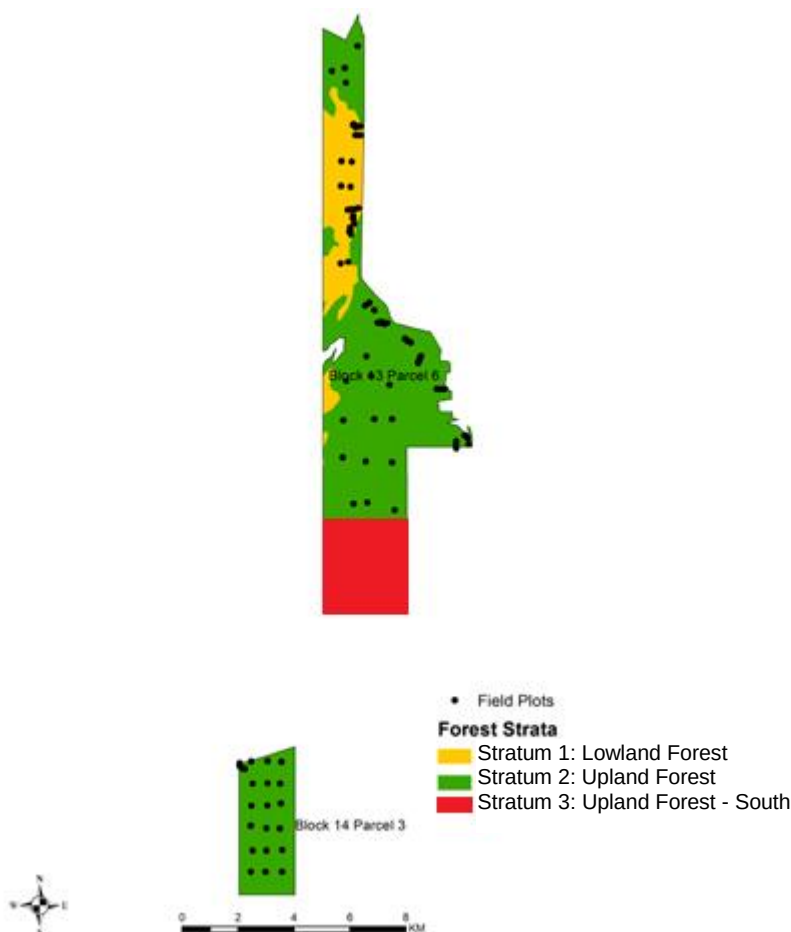


Figure 1 Rio Bravo Climate Action Project Area

1.8 Title and Reference of Methodology

Approved VCS Methodology VM0007 Version 1.2.1 REDD Methodology Modules

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The main project activity is the acquisition and protection of forest lands threatened by agricultural conversion. This has been fully accomplished through the purchase of land that would have been sold to industrial scale agricultural farmers. The Program for Belize has successfully continued to protect the land from deforestation and the threat of conversion to agriculture no longer exists.

The forest carbon stocks have been protected from, illegal logging, deforestation, and fires through ground surveys and ongoing communications with surrounding communities.

Smartwood Certified selective logging has taken place within some areas of the project boundary. Detailed surveys and logging plans have been created to minimize the impact of selective logging. No additional roads had been created. The selective logging areas have and will continue to be actively monitored and certified by Smartwood.

The Rio Bravo Climate Action Project is within the larger boundary of the Rio Bravo Conservation Management Area (RBCMA) and benefits from the added protection that such an organization size and structure is able to maintain. Therefore, the following protection activities take place both within the project boundary and the wider RBCMA. The protection work on the RBCMA is carried out by the team of rangers, based at Hill Bank station and responsible for manning the gates and mounting regular patrols. This work is backed by regular over-flights to detect problems (use of trails, illicit agriculture) from the air. The ranger operations operate using a static and dynamic approach, with some operations constant and other patrols and actions taking place in response to information of illicit activity (such as illegal logging) as and when required.

The basic protection programme is well-established with reliable funding from the national 'Debt-for-Nature' scheme, timber programme and carbon funds. The following protection activities are implemented at all times:

- The gates are permanently manned, establishing a visible presence at the main entry points;
- The team is able to react to emergencies (including fire) at any time;
- One overnight patrol is mounted per month and two surveillance over-flights are organized per year.
- Infractions are pursued through the legal system as and when necessary.
- Regular training is undertaken, organized in conjunction with Police force and conferring Special Constable status.

Patrols per se then become supplementary, covering the areas where management programmes are not providing regular ground presence. The policy of mutual reinforcement between field programmes still operates, however. The target of one patrol per month, additional to involvement in forestry and savannah management work is maintained for the wet season and raised to two per month for the dry season. Particular attention is drawn to mounting the extra dry season patrol to the two savannahs in order to detect and discourage or otherwise address:

- Setting of fires;
- Parrot theft (and monitoring of nest-boxes and known yellow-headed parrot nesting holes);
- Local infestations of cogon grass and pine bark beetle.

The second patrol continue to cover areas deemed at risk – attention is given to ensuring that at least two patrols per year check the frontier area (including its approach through Aguas Turbias), Cacao, the northern Duck Ridge and lower Booth's River area, lower Irish Creek (where the ecotourism programme also plays an important role in maintaining presence) and the south-eastern part of the boundary. Throughout, the general aim is to integrate protection and resource management more closely to make better use of available staff, equipment and transport. Annual and monthly planning is therefore a joint activity, with strong input from the Forester as the most senior staff member with direct responsibility for field operations.

As part of the monitoring, standard reports are produced that include date, time, personnel, route and specific objectives for the patrol. In forested areas, evidence of the following is recorded:

- Entry (e.g. vehicle and horse tracks, foot-prints, cut trails);
- Hunting (e.g. camps, torch batteries, cartridge cases);
- Logging (e.g. stumps, logs, extraction trails);
- NTFP extraction (e.g. cut sabal or palmetto, chicle slash-marks);
- Land clearance within the RBCMA boundaries.

The sustainable extraction of timber on the Rio Bravo is guided by a 5-year Sustainable Forest Management Plan legalized by a Long Term Private Forest Permit approved by the Belize Forest

Department. Operations are based on the annual plan of operation approved by the Forest Department for the specific area within the project area chosen for the year.

In preparation for harvesting, each compartment's boundary is demarcated and transect lines are cut every 100 meters to guide the process of stock survey. After all transects are cut, the forestry crew goes into the compartment and systematically measures and record every timber species from 20 cm DBH. Trees at and above minimum cutting diameter (MCD) are selected from the list. Some trees at and above MCD are retained as seed trees. The remaining trees are identified on a paper map, along with planned roads, skid trails, buffers and other features of High Conservation Value. The PFB forester and logging contractor are provided with the map so that selected trees can be cut and skid trails and logging decks (referred to as a barquadier) are created. The cut trees are tagged at the stump with a unique number after which the log is skidded to the logging deck. After scaling, the logs are loaded onto trucks and transported to a the mill. A signed waybill is created for each load. This document is the basis for payment to the logger and for billing the buyers.

2.2 Deviations from the Monitoring Plan

Deviation request 1:

VMD0001 "Estimation of carbon stocks in the above and belowground biomass in live tree and non-tree pools".

'II Procedures, Frequency of measurement for baseline above and belowground biomass stocks'

"Measurements of initial stocks employed in the baseline must take place within ± 5 years of the project start date, for simplicity referred to here as stocks at $t=0$ "

"Above- and belowground biomass stock estimates are valid in the baseline (i.e. treated as constant) for 10 years, after which they must be re-estimated from new field measurements."

It is requested that years since the project start date be allowed to be increased to ± 6 years. The project start is date: 15 Sept 1994, and although field measurements were taken in 1995, the measurement methods in 2000 are more consistent with other field measurement methods used elsewhere. In addition, additional field measurements were taken in the area surrounding the project area, providing a better estimate of carbon stocks.

Deviation request 2:

VMD0001 "Estimation of carbon stocks in the above and belowground biomass in live tree and non-tree pools".

'II Procedures, Frequency of measurement for baseline above and belowground biomass stocks'

"Above- and belowground biomass stock estimates are valid in the baseline (i.e. treated as constant) for 10 years, after which they must be re-estimated from new field measurements. For each stratum, where the re-measured estimate is within the 90% confidence interval of the $t=0$ estimate, the $t=0$ stock takes precedence and is re-employed, and where the re-measured estimate is outside the 90% confidence interval of the $t=0$ estimate, the new stock estimate takes precedence and is used for the subsequent period."

The start date of the project is 15 Sept 1994. Field measurements were taken in 2000. No field measurements were at the 'baseline renewal period' in 2004 since this project took place prior to that rules existence. Therefore it is requested that the field measurement data taken in 2000 be allowed to be used for the second baseline period.

Deviation request 3:

VMD0015 V2 “Methods for Monitoring of GHG Emissions and Removals”

Section 5.2.2.1 Degradation through extraction of trees for illegal timber or fuelwood and charcoal

“ $A_{Deg,i}$ shall be sampled by surveying several transects of known length and width across the access-buffer area (equal in area to at least 1% of $A_{Deg,i}$) to check whether new tree stumps are evident or not. If there is little to no evidence that trees are being harvested (see next paragraph on how to estimate emissions and use tool T-SIG to determine if significant or not) then degradation can be assumed to be zero and no monitoring is needed. This limited sampling must be repeated each time the PRA indicates a potential for degradation.

If the limited sampling does provide evidence that trees are being removed in the buffer area, then a more systematic sampling must be implemented. The sampling plan must be designed using plots systematically placed over the buffer zone so that they sample at least 3% of the area of the buffer zone ($A_{Deg,i}$). The diameter of all tree stumps will be measured and conservatively assumed to be the same as the DBH. If the stump is a large buttress, identify several individuals of the same species nearby and determine a ratio of the diameter at DBH to the diameter of buttress at the same height above ground as the measured stumps. This ratio will be applied to the measured stumps to estimate the likely DBH of the cut tree. The above and below ground carbon stock of each harvested tree must be estimated using the same allometric regression equation and root to shoot ratio used in the module for estimating the carbon pool in trees (CP-AB) in the baseline scenario¹. The mean above and below ground carbon stock of the harvested trees is conservatively estimated to be the total emissions and to all enter the atmosphere. This sampling procedure shall be repeated every 5 years and the results annualized by dividing the total emissions by five.”

Since incomplete sampling of illegal logging existing from the start of the project, it is requested that a more conservative approach be implemented. Under this approach, using the forest inventory data, the average biomass of mahogany and cedar is estimated. It is then assumed that the biomass of all the mahogany and cedar trees within $A_{Deg,i}$ are harvested and emitted in the first year of the project. This is clearly a strongly conservative approach as in reality, only a small portion of mahogany and cedar trees have been harvested through illegal logging. For example, within the current FSC selective logging taking place, over 50% of the volume removed is from mahogany trees.

Deviation Request 4:

VMD0001 “Estimation of carbon stocks in the above and belowground biomass in live tree and non-tree pools”.

*II Procedures**Part 1: Aboveground tree biomass: Estimation of carbon stocks in aboveground tree biomass ($C_{AB_tree,i}$)*

The mean carbon stock in aboveground tree biomass per unit area is estimated based on field measurements in sample fixed area plots or sample points using prisms employing representative random or systematic sampling.

¹ If species-specific equations are used in the baseline and species cannot be identified from stumps then it shall be assumed that the harvested species is the species most commonly harvested for the specific degradation purpose (e.g. fuelwood, charcoal or timber). A PRA shall be used to determine the most commonly harvested species

It is requested that it be allowable to employ random sampling of clustered plots along transects. Analysis of the mean and uncertainty will then be estimated using clusters of plots. In addition, it is requested that it be allowable to conservatively estimate the biomass of areas within the project boundary where no biomass plots exist by assuming the mean biomass of such areas equates to 80% of the mean biomass found within the stratum where biomass plots have been placed. Additional documentation has been provided elaborating on the methods employed².

2.3 Grouped Project

This is not a grouped project.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Data / Parameter: (as in monitoring report):	A_i , Area of stratum i
Years when monitored:	1994, 2000, 2004, 2010
Type of monitoring equipment used:	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	CF , Carbon fraction of dry matter
Years when monitored:	NA
Type of monitoring equipment used:	NA
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Default value 0.47 t C t-1 d.m.used
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	CF_j , Carbon fraction of biomass for tree species j
Years when monitored:	NA
Type of monitoring equipment used:	NA
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Default value 0.47 t C t-1 d.m.used
Any QA/QC processes used to ensure the reported data/parameter:	

² Supplementary Documents\Annex Q Carbon Stock Data\Rio Bravo - Baseline Carbon Pool Stocks Report

Data / Parameter: (as in monitoring report):	D_j Basic wood density in t d.m. m ⁻³ for species j
Years when monitored:	NA
Type of monitoring equipment used:	NA
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Default value used
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	D_{mn} , Mean wood density of commercially harvested species
Years when monitored:	NA
Type of monitoring equipment used:	NA
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Default value used
Any QA/QC processes used to ensure the reported data/parameter:	

3.2 Data and Parameters Monitored

Data / Parameter: (as in monitoring report):	Project Forest Cover Monitoring Map
Years when monitored:	1994, 2000, 2004, 2010
Type of monitoring equipment used:	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	Degradation PRA Results
Years when monitored:	2011
Type of monitoring equipment used:	PRA of forest guards
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	RioBravo_IllegalLoggingSurvey-RangerResponses.pdf
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$A_{DefPA,i,u,t}$ Area of recorded deforestation in the project area in stratum i converted to land use u at time t
Years when monitored:	1994, 2000, 2004, 2010
Type of monitoring equipment used:	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010

References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$A_{Deg,i}$, Area potentially impacted by degradation processes in stratum i
Years when monitored:	2011
Type of monitoring equipment used:	GIS delineation and ground truthing
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	GIS datasets
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$A_{DECKS,i,t}$, Area of logging decks in stratum i at time t
Years when monitored:	1999, 2004, 2005, 2008, 2009, 2010 (years when logging took place in project area)
Type of monitoring equipment used:	Post Harvest Assessments (based on field measurements)
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Supplementary Documents\Annex O Monitoring\Selective Logging Data\Post-Harvest_Assessments, Supplementary Documents\Annex O Monitoring\Selective Logging Data\EmissionsLoggingInfrastructure.xlsx
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$A_{DistPA,q,i,t}$, Area impacted by natural disturbance in the project stratum i converted to natural disturbance stratum q at time t; ha
Years when monitored:	1999, 2004, 2005, 2008, 2009, 2010 (years when logging took place in project area)
Type of monitoring equipment used:	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	cherrington, emil a. et. al [2010] - forest cover & deforestation in belize 1980 - 2010
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$A_{ROAD,i,t}$, Area of roads in stratum i at time t
Years when monitored:	1999, 2004, 2005, 2008, 2009, 2010 (years when logging took place in project area)
Type of monitoring equipment used:	GIS dataset of roads based on field measurements and post-harvest assessment reports

References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	\\Supplementary Documents\\Annex A GIS \\Roads, Supplementary Documents\\Annex O Monitoring\\Selective Logging Data\\Post-Harvest Assessments
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$C_{Deg,i,t}$, Biomass carbon of trees cut and removed through illegal logging and fuelwood and charcoal extraction degradation process from plots measured in stratum i at time t
Years when monitored:	NA
Type of monitoring equipment used:	Forest Inventory Data
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	RioBravo_ForestInventory1999_2010.xlsx
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$C_{AB_tree_dest, i}$, Carbon stock in aboveground tree biomass assumed to be killed per unit area resulting from the creation of the skid trail in stratum i
Years when monitored:	2000, 2011
Type of monitoring equipment used:	Field measurements and survey of logging operator
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	SurveyofLoggingActivities.JPG, rio_bravo_baseline_carbon_data.xlsx, tab: TREE_00 less 30 dbh
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$C_{BB_tree_dest, i}$, Carbon stock in belowground tree biomass assumed to be killed per unit area resulting from the creation of the d trail in stratum i
Years when monitored:	2000
Type of monitoring equipment used:	Field measurements, root-to-shoot ratio
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	SurveyofLoggingActivities.JPG, rio_bravo_baseline_carbon_data.xlsx, tab: TREE_00 less 30 dbh
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	F_{LU} , Land use factor before or after conversion
Years when monitored:	NA
Type of monitoring equipment used:	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4

References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	F_{MG} , Management factor before or after conversion
Years when monitored:	NA
Type of monitoring equipment used:	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	F_i , Input factor before or after conversion
Years when monitored:	NA
Type of monitoring equipment used:	Stock Change Factors are provided in Tables 5.5, 5.10, and 6.2 of the IPCC 2006GL Volume 4
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	L_{sk} , Length of skid trail sk
Years when monitored:	1999, 2004, 2005, 2008, 2009, 2010 (years when logging took place in project area)
Type of monitoring equipment used:	Post-harvest assessment reports and maps of skid trails
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Supplementary Documents\Annex O Monitoring\Selective Logging Data\Post-Harvest_Assessments, Supplementary Documents\Annex O Monitoring\Selective Logging Data\SkidTrails, Supplementary Documents\Annex O Monitoring\Selective Logging Data\EmissionsLoggingInfrastructure.xlsx
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$V_{EXT,z,i,t}$, Volume extracted from logging stratum z in stratum i at time t
Years when monitored:	1999, 2004, 2005, 2008, 2009, 2010 (years when logging took place in project area)
Type of monitoring equipment used:	Field Measurements

References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	\\Supplementary Documents\\Annex O Monitoring\\Selective Logging Data\\Harvest_data: TimberHarvest_Invoices, Forest Management Plan 2006-2010(completetext), RioBravo_Harvest_Summary.xlsx, 1999 Harvest Yield.XLS, WB6.xls, volumes per comp2005.xls, Sorted Waybills 2008.xls, RawWayBillDeliveryData2009.xls, 2010 Delivery 24Mar-8Oct10.xls
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	$V_{EXT,j,z,i,t}$, The volume of timber extracted of species j for logging stratum z, in stratum i at time t;
Years when monitored:	1999, 2004, 2005, 2008, 2009, 2010 (years when logging took place in project area)
Type of monitoring equipment used:	Field Measurements
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	\\Supplementary Documents\\Annex O Monitoring\\Selective Logging Data\\Harvest_data: TimberHarvest_Invoices, Forest Management Plan 2006-2010(completetext), RioBravo_Harvest_Summary.xlsx, 1999 Harvest Yield.XLS, WB6.xls, volumes per comp2005.xls, Sorted Waybills 2008.xls, RawWayBillDeliveryData2009.xls, 2010 Delivery 24Mar-8Oct10.xls
Any QA/QC processes used to ensure the reported data/parameter:	

Data / Parameter: (as in monitoring report):	W_{SKID} , Mean width of skid trails
Years when monitored:	2011
Type of monitoring equipment used:	Direct measurement of skidder
References to evidence which supports that the data/parameter was monitored and was monitored per the correct frequency.	Supplementary Documents\\Annex O Monitoring\\Selective Logging Data\\Harvest_data\\SurveyofLoggingActivities.JPG
Any QA/QC processes used to ensure the reported data/parameter:	

3.3 Description of the Monitoring Plan

3.3.1 Monitoring Organizational Structure

Program for Belize (PFB) owns and manages the project area. They are responsible for monitoring of the project. Monitoring work is carried out by a team of rangers, based at Hill Bank who are responsible for manning the gates and mounting regular patrols. This work is backed by regular aerial flights to detect problems (use of trails, illicit logging) from the air. The team cooperates with the Belize Defense Force and Forest Department when appropriate. Patrols are organized on a monthly basis to areas deemed to require oversight and the team responds to information of illicit activity as and when required.

PfB is governed by a board of directors whom decide policy directions, approve the yearly budgets, and support fund raising activities. The immediate link between the staff and the board is the executive director. The executive director oversees the organization to ensure that the board policies are being followed.

The executive director is assisted by the financial controller, administrator and the technical coordinator. The financial controller manages the budget and ensures that services take place and employees' benefits and salaries are paid. The administrator oversees the supply of goods and services to the main office and the field stations. Two permanent field stations exist with permanent station managers and support staff: La Milpa and Hillbank. These field stations are located outside the carbon project boundary but within the wider Rio Bravo conservation management area. The field-station managers report to the administrator.

The technical coordinator manages all forest related work including managing sustainable timber harvest, carbon sequestration activities and some research. The forestry crew, including the forester, field ecologist and assistant forester, all report to the technical coordinator. Any activity related to sustainable timber harvest, carbon data collection, fire management, verification of areas and volume of illegal harvest is carried out by the three forestry staff and temporary assistants, the number of which changes depending on the need.

Two field-station managers, based at La Milpa and Hillbank field stations, report to the administrator and manage the field personnel including the rangers and support staff. The Hillbank station managers is directly responsible for the ranger patrols and reporting any findings to the administrator who will then liaise with the BDF, Police or Forest Department to set up more intense patrols as necessary. The administrator also plans over flights and other land management issues.

3.3.2 Monitoring Data generation, recording and storage

Program for Belize follows a set of standard procedures for the monitoring of the project area. Protective ground patrols are conducted once a month except during the extra dry season when they are conducted twice a month.

Data collected is kept on file for the duration of the project. This includes inventory data on carbon stocks, monitoring plans, permanent plot names and locations (if any are used), and GIS data. Reports from protective patrols and aerial flights are entered into a computer and kept on file for review. The data is kept in commonly used formats such as Microsoft Office formats for reports and tables, and for GIS data, shapefile or .tif format. Metadata, especially for GIS data, is maintained and updated as needed.

PfB maintains monitoring records in both hard copies and digital formats. The main activities monitored include fires and illegal activities. The ranger crew (10 persons) is deployed by the Hillbank station manager to area of high risk. The rangers will report on a daily basis to the Hillbank station manager in hard copy format. The station manager will summarize these reports on a monthly basis and submit these to the administrator in digital format. These monthly reports are further summarized quarterly and presented to the PfB board of directors. These reports are discussed at board level and recommendations for further actions are documented in the minutes of the meeting. The executive director then passes the updated strategy to the PfB staff for action. All board papers are in hard copy and digital formats. All digital copies are housed in PfB offices in Belize City.

3.3.3 Procedures for handling internal auditing and non-conformities

PfB's management plan is based on "Adaptive Management" principles. This means that activities within the approved management plans can be deleted or new activities added based on the prevailing conditions. However, given PfB's experience in managing the Rio Bravo, most potential threats or opportunities are identified in the plan, at least from a global perspective. Any major change in management actions will be presented by the executive director to the PfB board of directors for approval. This is necessary as the deviation from the approved plan can result in significant financial demands from

the organization. The board will authorize the executive director to incur the expenses and will support the fund raising efforts needed to do what needs to be done. PfB's staff, including the administrator, field station manager or the technical coordinator will lead the new activities that became necessary.

Existing activities that simply require the redirection of temporal or special parameters are decided by PfB's staff, including the administrator, field station manager or the technical coordinator.

From the Rio Bravo Climate Action Project perspective, project oversight is provided by a board of directors comprised of a representative from each financial participant, TNC and PfB. The board approves annual plans, including the annual budget. TNC acts as the funds manager with PfB implementing the activities on the ground. Quarterly reports are presented to TNC by PfB who monitor fund use and activities being implemented. Any deviation from the annual plan is presented by PfB to TNC for approval by the project board through the two financial representatives.

3.3.4 Monitoring of Baseline

The Baseline has been reassessed every ten years, based on the methods written in the Methodology Module VMD0006. The parameters that must be reassessed include the projected annual proportion of land that is deforested in the stratum per year during that baseline period ($D\%_{\text{planned},i,t}$), the pre-deforestation carbon stocks, the post-deforestation carbon stocks, and the GHG emissions resulting from deforestation activities.

Although the VMD0006 specifies the collection of forest carbon stock levels within the project boundary every ten years, because this project took place prior to the VMD0006 being created, a Methodology Deviation is requested to allow the carbon stock data from 2000 to be used.

The annual proportion of land that is deforested was calculated for the second baseline period using the methods delineated in VMD0006.

3.3.5 Application of Monitoring Module

3.3.5.1 *Applicability: The strata defined in the baseline module are fixed and have not been changed*

As delineated in VMD0015 V2, to monitor this project the sources of land-use and land-cover change data are chosen. This data is then processed, interpreted, and analyzed.

3.3.5.2 *Step 1. Selection of sources of land-use and land cover change data*

As dictated by the methodology modules used, this monitoring only takes place within the project boundary.

The landcover data describing the forest strata come from Meerman, 2005³. This data is in an update to the Meerman & Sabido 2001 map, which was essentially an update of the 1995 Vegetation map of Belize by Iremonger and Browkaw. This Iremonger and Browkaw map was sourced heavily from the 1959 Natural Vegetation Map of Belize by Wright et al. The Meerman 2005 data describes two forest types located inside the project area, which are here referred to as: Lowland Forest and Upland Forest. Field data was collected within each forest type and the results show that the carbon stocks are significantly different (> 20%) that it is justified to keep the forest types separated in two strata. However, due to differences in carbon measurement data, the Upland Forest stratum is separated into two strata: Upland Forest and Upland Forest – South.

³ Meerman, J. 2005. Belize Ecosystem Map: 2004. Programme for Belize, Belize City. 2 volumes 50 + 88 pp.

Landcover change data comes from Cherrington et al 2010⁴. This data describes the deforestation across Belize from 1980 – 2010 at a medium scale resolution, 30 meters. It was created using the Landsat archive available through the Regional Visualization and Monitoring System (SERVIR).

3.3.5.3 Step 2. Interpretation and analyses

3.3.5.3.1 Monitoring Deforestation

This step estimates that emissions resulting from deforestation within the project area.

The Cherrington⁵ deforestation data set was created using a multi-temporal maximum likelihood classification schema that was applied to Landsat imagery from 1980 through 2010. It applies a simple forest, non-forest classification scheme to the lands of Belize. Secondary forest regrowth is not included as ‘forest’ in this data.

The area found to have been deforested per year is multiplied by the change in carbon stocks resulting from such deforestation.

$$\Delta C_{P,DefPA,i,t} = \sum_{u=1}^U A_{DefPA,u,i,t} * \Delta C_{pools,P,Def,u,i,t} \quad (1)$$

$$\Delta C_{P,DefLB,i,t} = \sum_{u=1}^U A_{DefLB,u,i,t} * \Delta C_{pools,P,Def,u,i,t} \quad (2)$$

Where:

$\Delta C_{P,DefPA,i,t}$	Net carbon stock change as a result of deforestation in the project case in the project area in stratum i at time t ; t CO ₂ -e
$\Delta C_{P,DefLB,i,t}$	Net carbon stock change as a result of deforestation in the project case in the leakage belt in stratum i at time t ; t CO ₂ -e
$A_{DefPA,u,i,t}$	Area of recorded deforestation in the project area stratum i converted to land use u at time t ; ha
$A_{DefLB,u,i,t}$	Area of recorded deforestation in the leakage belt stratum i converted to land use u at time t ; ha
$\Delta C_{pools,Def,u,i,t}$	Net carbon stock changes in all pools in the project case in land use u in stratum i at time t ; t CO ₂ -e ha ⁻¹
u	1,2,3,... U post-deforestation land uses
i	1, 2, 3 ... M strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD project activity

The emission per unit area is equal to the difference between the stocks before and after deforestation minus any wood products created from timber extraction in the process of deforestation:

$$\Delta C_{pools,Def,i,t} = C_{BSL,i} - C_{P,post,i} - C_{wp,i} \quad (3)$$

Where:

⁴ Cherrington, E., E. Ek, P. Cho, B.F. Howell, B.E. Hernandez, E.R.Anderson, A.I.Flores, B.C. Garcia, E. Sempris, D.E. Erwin. 2010. Forest Cover and Deforestation in Belize: 1980-2010. SERVIR, Cathalac. 42 pp.

⁵ Cherrington, E., E. Ek, P. Cho, B.F. Howell, B.E. Hernandez, E.R.Anderson, A.I.Flores, B.C. Garcia, E. Sempris, D.E. Erwin. 2010. Forest Cover and Deforestation in Belize: 1980-2010. SERVIR, Cathalac. 42 pp.

$\Delta C_{pools,Def,u,i,t}$	Net carbon stock changes in all pools as a result of deforestation in the project case in land use u in stratum i at time t ; t CO ₂ -e ha ⁻¹
$C_{BSL,i}$	Carbon stock in all pools in the baseline case in stratum i ; t CO ₂ -e ha ⁻¹
$C_{P,post,u,i}$	Carbon stock in all pools in post-deforestation land use u in stratum i ; t CO ₂ -e ha ⁻¹
$C_{WP,i}$	Carbon stock sequestered in wood products from harvests in stratum i ; t CO ₂ -e ha ⁻¹
u	1,2,3,... U post-deforestation land uses
i	1, 2, 3 ... M strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD project activity

3.3.5.3.2 Monitoring degradation

For the project area, the net greenhouse gas emissions resulting from degradation is equal to the sum of stock changes due to degradation through extraction of trees for illegal timber or fuelwood and charcoal, and extraction of trees for selective logging from forest management areas possessing a FSC certificate:

$$\Delta C_{P,Deg,i,t} = \Delta C_{P,DegW,i,t} + \Delta C_{P,SelLog,i,t} \quad (4)$$

Where:

$\Delta C_{P,Deg,i,t}$	Net carbon stock change as a result of degradation in the project area in the project case in stratum i at time t ; t CO ₂ -e
$\Delta C_{P,DegW,i,t}$	Net carbon stock change as a result of degradation through extraction of trees for illegal timber or fuelwood and in the project area in the project case in stratum i at time t ; t CO ₂ -e
$\Delta C_{P,SelLog,i,t}$	Net carbon stock change as a result of degradation through selective logging of FSC certified forest management areas in the project area in the project case in stratum i at time t ; t CO ₂ -e
i	1, 2, 3 ... M strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD project activity

3.3.5.3.2.1 Monitoring degradation through wood extraction

The Program for Belize has monitored the occurrence of illegal wood extraction over time. This monitoring also include the location potentially impacted by this type of activity, as PFB monitors illegal harvesting within Rio Bravo Climate Action Project, and the species targeted in illegal wood extraction.

However, due to the early start date of this project, the methods provided in the Monitoring Module VMD0015 V2 to monitor and measure directly the trees that have been cut through sampling has not taken place consistently since the project start date. Therefore, an alternative and conservative approach to estimate the biomass lost due to illegal logging has been used.

A survey was conducted of the forest rangers to determine whether there is potential for illegal logging and the distance of degradation penetration from access points⁶. Based on the results of the survey the

⁶Supplementary Documents\Annex O Monitoring\Degradation Illegal Wood Extraction\RioBravo_IllegalLoggingSurvey.docx

area subject to degradation (A_{deg}) has been conservatively delineated with a 500m buffer surrounding all roads, old logging roads, and along the 'RSM seismic line'⁷.

The only tree species that are removed by illegal loggers are mahogany and cedar. As part of project's selective activities, the PfB has conducted timber surveys within the project boundary. Using this survey, the average biomass of mahogany and cedar were estimated. It was then conservatively assumed that the entire biomass of these two trees would be illegally extracted within A_{deg} and therefore emitted as illegal wood extraction.

$$\Delta C_{P,DegIL-F,i,t} = A_{Deg,i} * \frac{C_{Deg,i,t}}{AP_i} \quad (5)$$

Where:

$\Delta C_{P,DegIL-F,i,t}$	Net carbon stock changes as a result of degradation through illegal logging and fuelwood extraction in stratum i in the project area at time t ; t CO ₂ -e
$A_{Deg,i}$	Area potentially impacted by degradation processes in stratum i ; ha
$C_{DegIL-F,i,t}$	Biomass carbon of trees cut and removed through illegal logging and fuelwood extraction degradation process from plots measured in stratum i at time t ; t CO ₂ -e
AP_i	Total area of degradation sample plots in stratum i ; ha
i	1, 2, 3 ... M strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD project activity

3.3.5.3.3 Monitoring degradation due to selective logging of forest management areas possessing a FSC certificate

Selective logging is taking place within the project boundary during the project.

The area of selective logging is monitored using a GIS. GIS file of the timber management areas controlled by Program for Belize shows a grid of planned logging areas and included logging dates from 1997 to 2010 and planned locations for 2011. The data show that within the project area 1137 hectares have been logged between 1999 to 2011. Based on the current logging plans, 1,130 hectares will be logged between 2012-2015. The remaining 2177 hectares available for logging may be logged in the future, however, the date of such logging is unknown as specific logging plans have not yet been finalized past 2015.

The emissions from certified selective logging are monitored through the monitoring of volume of wood extracted overtime, and monitoring of the length of skid-trails, logging decks, and logging roads constructed to allowing for logging. The monitoring of such variables are requirements of the SmartWood verification system.

Through the application of VMD0015 V2 Methods for Monitoring GHG Emissions and Removals, emissions arising in the logging gap and emissions from logging infrastructure were estimated annually. Annual timber volumes reported by PfB, as well as data reporting lengths and widths of skid trail and roads and areas of decks collected under the SmartWood verification were used to estimate yearly emissions from degradation. The principle of conservativeness was taken into consideration when estimating emissions during monitoring. For instance, data concerning construction of roads collected for SmartWood verification were not clear in terms of length of newly constructed roads; nevertheless, the total length of road used for each given year was assumed to be newly constructed and therefore emitted in the monitoring.

⁷Supplementary Documents\Annex O Monitoring\Degradation Illegal Wood Extraction\RioBravo_IllegalLoggingSurvey-RangerResponses.pdf

$$\Delta C_{P, SelLog, i, t} = \sum_{t=1}^t (C_{LG, i, t} + C_{LR, i, t} - C_{WP, i, t}) \quad (6)$$

Where

$\Delta C_{P, SelLog, i, t}$	Net carbon stock change as a result of degradation through selective logging of FSC certified forest management areas in the project area in the project case in stratum i at time t ; t CO ₂ -e
$C_{LG, i, t}$	Actual net project emissions arising in the logging gap in stratum i at time t ; t CO ₂ -e
$C_{LR, i, t}$	Actual net project emissions arising from logging infrastructure in stratum i at time t ; t CO ₂ -e
$C_{WP, i, t}$	Carbon stock in wood products pool from stratum i , at time t ; t CO ₂ -e
t	1, 2, 3 ... t years elapsed since the start of the project activity

Emissions arising in the logging gap

By following the steps outlined in the methodology: "VMD0015 V2 Methods for Monitoring of GHG Emissions and Removals" the emissions arising in the logging gap and in the logging infrastructure were estimated.

Volume of wood extracted through selective logging

The volume extracted with selective logging practices was monitored through the forest management certification process. The volume of timber harvested is reported by PFB and verified through audits conducted by SmartWood.

Biomass of extracted logs

Biomass of the commercial logs extracted is calculated by multiplying the reported yearly volume by the wood density and converting it into carbon and carbon dioxide equivalent. According to Reyes et al. (1992)⁸ the average wood density in the tropical Americas is 0.6 t m⁻³.

$$C_{EXT, z, i, t} = \sum_{j=1}^S (V_{EXT, j, z, i, t} * D_j * CF_j * \frac{44}{12}) \quad (7)$$

Where:

$C_{EXT, z, i, t}$	Biomass carbon stock of timber extracted within the project boundary for logging stratum z , in stratum i at time t ; t CO ₂ -e
$V_{EXT, j, z, i, t}$	The volume of timber extracted of species j for logging stratum z , in stratum i at time t ; m ³
D_j	Basic wood density of species j ; t d.m.m ⁻³
CF_j	Carbon fraction of biomass for tree species j ; t C t ⁻¹ d.m.
z	1,2,3...Z logging strata
j	1, 2, 3 ... S_{PS} tree species

⁸ Reyes, G., Brown, S., Chapman, J., and Lugo, A. 1992. Wood densities of tropical tree species. USDA Forest Service. General Technical Report SO-88. 18 pp.

t 1, 2, 3 ... t years elapsed since the start of the project activity

Estimation of emissions resulting from logging gap

The emissions resulting from the logging gap itself are then calculated by combining the estimated biomass of the wood extracted per year within the stratum plus the logging damage factor multiplied by the extracted volume.

$$C_{LG,i,t} = \sum_{z=1}^Z (C_{EXT,z,i,t} + (LDF_{z,i} * V_{EXT,z,i,t} * \frac{44}{12})) \quad (8)$$

Where

$C_{LG,i,t}$	Actual net project emissions arising in the logging gap, in stratum i at time t ; t CO ₂ -e
$C_{EXT,z,i,t}$	Biomass carbon stock of timber extracted within the project boundary for logging stratum z , in stratum i at time t ; t CO ₂ -e
$LDF_{z,i}$	Logging damage factor for logging stratum z , in stratum i ; t C m ⁻³
$V_{EXT,z,i,t}$	Volume extracted from logging stratum z , in stratum i at time t ; m ³
Z	1,2,3... Z logging strata
i	1, 2, 3 ... M strata
t	1, 2, 3 ... t years elapsed since the start of the project activity

As delineated in the methodology, a logging damage factor default value of 0.69 t C m⁻³ was used.

Emissions arising through logging infrastructure

Emissions arising from logging infrastructure were estimated using data reported in the "Post-Harvest Assessment Reports" (PHA) conducted by PfB after every logging season.

Skid trails

Skid trail emission factor

To create a skid trail emission factor ($C_{skid,i}$), two alternate methods are supplied in the methodology. Method A was used to create the skid trail emission factor.

Based on survey of logging activities from the manager of the logging operations conducting selective logging within the project boundary, the maximum size tree the skidder is able to push over is 18 cm⁹. The same type of skidder has been used throughout the year of logging operations, however, to ensure a conservative approach is used, it was conservatively assumed that the skidder cannot damage any trees over 30 cm in diameter at breast height. The biomass plots collected during the baseline were used to then estimate the average biomass of trees less than 30 cm DBH. It was then assumed all trees within the area of skid trails created were killed. The emission factor from skid trails was estimated by multiplying the aboveground carbon stocks impacted by the skidder by the area constructed with skid trails.

As delineated in the methodology, the mean width of skid trails was conservatively estimated to be the width of the tires on the largest skidder type * 140%. The width of the tires was measured directly and reported by the manager of the logging operations taking place within the project boundary.

⁹Supplementary Documents\Annex O Monitoring\Selective Logging Data\SurveyofLoggingActivities.JPG

$$SK_i = (C_{dest,i} + \Delta C_{SOC,sk,i}) * \frac{1}{10,000} * W_{SKID} \quad (9)$$

$$C_{dest,i} = C_{AB_tree_dest,i} + C_{BB_tree_dest,i} + C_{AB_non-tree,i} + C_{BB_non-tree,i} \quad (10)$$

Where:

SK_i	Skid trail emission factor (Average emissions resulting from dead wood created in the process of skid trail creation per length of skid trail) in stratum i ; t t CO ₂ -e m ⁻¹
$C_{dest,i}$	Mean live carbon stock of trees and non-tree biomass assumed to be killed per unit area in creation of skid trail in stratum i ; t CO ₂ -e ha ⁻¹
$\Delta C_{SOC,sk,i}$	Carbon stock change in organic carbon resulting from skid trail creation in stratum i ; t CO ₂ -e ha ⁻¹
W_{SKID}	Mean width of skid trails in stratum i ; m
$C_{AB_tree_dest,i}$	Carbon stock in aboveground tree biomass assumed to be killed per unit area resulting from the creation of the skid trail in stratum i ; t CO ₂ -e ha ⁻¹
$C_{BB_tree_dest,i}$	Carbon stock in belowground tree biomass assumed to be killed per unit area resulting from the creation of the skid trail in stratum i ; t CO ₂ -e ha ⁻¹
$C_{AB_non-tree,i}$	Carbon stock in aboveground non-tree biomass in stratum i ; t CO ₂ -e ha ⁻¹
$C_{BB_non-tree,i}$	Carbon stock in belowground non-tree biomass in stratum i ; t CO ₂ -e ha ⁻¹
$1/10,000$	Conversion of units from hectares to m ²
i	1, 2, 3 ... M strata

Emissions from the soil pool due to the creation of the skid trail are conservatively estimated based on the methods defined in the IPCC 2006GL¹⁰:

$$\Delta C_{SOC,sk,i} = C_{SOC,i,t=0} - C_{SOC,i,t=0} * F_{LU} * F_{MG} * F_i \quad (11)$$

Where:

$\Delta C_{SOC,sk,i}$	Carbon stock change in soil organic carbon resulting from skid trail creation in stratum i ; t CO ₂ -e ha ⁻¹
$C_{SOC,i,t=0}$	Mean carbon stock in soil organic carbon for stratum i , at time $t=0$; t CO ₂ -e ha ⁻¹
F_{LU}	land use factor before or after conversion; dimensionless
F_{MG}	management factor before or after conversion; dimensionless
F_i	input factor before or after conversion; dimensionless
i	1, 2, 3, ... M strata
t	1, 2, 3, ... t^* years elapsed since the projected start of the REDD project activity

¹⁰ http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_05_Ch5_Cropland.pdf

Estimation of emissions from skid trails

The emissions from the creation of skid trails during each year of logging is estimated by multiplying the total length of skid trails created in a given year by skid trail emission factor created for the overall project:

$$\Delta C_{SKID,i,t} = L_{SKID,i,t} * SK_i \quad (12)$$

Where

$\Delta C_{SKID,i,t}$ Change in carbon stock resulting from skid trail creation in stratum i at time t ; t CO₂-e

$L_{SKID,i,t}$ Length of skid trails in stratum i at time t ; m

SK_i Skid trail emissions factor (Average emissions resulting from dead wood created in the process of skid trail creation per length of skid trail) in stratum i ; t CO₂-e m⁻¹

t 1, 2, 3 ... t years elapsed since the start of the project activity

The length of skid trails created was estimated based on the information listed in Post Harvest Assessments¹¹.

Logging Roads

Length and widths of logging roads used during the selective logging process each year were compiled from Post Harvest Assessment reports¹². Annual area of road was then calculated by simply multiplying these two variables on a per year basis. Emissions from roads conservatively assume the complete clearing of the forest; therefore, the baseline forest carbon stock of the stratum where logging was placed was multiplied by the annual area to obtain total emissions. Logging roads lengths reported as used, but not specified as newly constructed, were conservatively assumed to be newly constructed and consequently added to annual emissions estimation.

$$\Delta C_{ROAD,i,t} = A_{ROAD,i,t} * C_{BSL,i} \quad (13)$$

Where

$\Delta C_{ROAD,i,t}$ Change in carbon stock resulting from logging road creation in stratum i at time t ; t CO₂-e

$A_{ROAD,i,t}$ Area of roads in stratum i at time t ; ha

$C_{BSL,i}$ Carbon stock in all pools in the baseline case in stratum i ; t CO₂-e ha⁻¹

i 1, 2, 3 ... M strata

t 1, 2, 3 ... t years elapsed since the start of the project activity

Logging Decks

Total areas of logging decks used each year were compiled from Post Harvest Assessment reports. Logging decks conservatively assume complete clearing of the forest, and therefore the baseline forest carbon stock of the stratum where logging deck was placed was multiplied by the annual area to obtain total emissions.

¹¹ Supplementary Documents\Annex O Monitoring\Selective Logging Data\Post-Harvest_Assessments

¹² Supplementary Documents\Annex O Monitoring\Selective Logging Data\Post-Harvest_Assessments

$$\Delta C_{DECKS,i,t} = A_{DECKS,i,t} * C_{BSL,i} \quad (14)$$

Where

$\Delta C_{DECKS,i,t}$	Change in carbon stock resulting from logging deck creation in stratum i at time t ; t CO ₂ -e
$A_{DECKS,i,t}$	Area of logging decks in stratum i at time t ; ha
$C_{BSL,i}$	Carbon stock in all pools in the baseline case in stratum i ; t CO ₂ -e ha ⁻¹
i	1, 2, 3 ... M strata
t	1, 2, 3 ... t years elapsed since the start of the project activity

Total emissions from infrastructure

The net emission in the project case is then equal to the sum of emissions resulting from skid trails, roads, and logging decks created for selective logging operations.

$$C_{LR,i,t} = \Delta C_{SKID,i,t} + \Delta C_{ROAD,i,t} + \Delta C_{DECKS,i,t} \quad (15)$$

Where

$C_{LR,i,t}$	Actual net project emissions arising from logging infrastructure in stratum i at time t ; t CO ₂ -e
$\Delta C_{SKID,i,t}$	Change in carbon stock resulting from skid trail creation in stratum i at time t ; t CO ₂ -e
$\Delta C_{ROAD,i,t}$	Change in carbon stock resulting from logging road creation in stratum i at time t ; t CO ₂ -e
$\Delta C_{DECKS,i,t}$	Change in carbon stock resulting from logging deck creation in stratum i at time t ; t CO ₂ -e
i	1, 2, 3 ... M strata
t	1, 2, 3 ... t years elapsed since the start of the project activity

3.3.5.3.4 Monitoring areas undergoing natural disturbance

In late October of 2010 the Rio Bravo Climate Action Project area underwent a major natural disturbance as hurricane Richard's path crossed portions of the project area. Only Parcel 14 Block 3 was affected by the hurricane. Field work was conducted and data collected in the affected parcel. Carbon stock estimates were measured in 15 plots. No post-stratification due to hurricane damage was required. Of the three existent strata (Lowland Forest, Upland Forest, and Upland Forest – South), only Upland Forest occurs in the damage area.

The methods estimating the carbon stocks of hurricane affected areas rigorously followed the methodology and are described in detail in a Supplementary Document¹³. An initial assessment of three plots was first completed in July 2011. These three plots were randomly placed inside the parcel using a

¹³See: Post-hurricane Carbon Stock Assessment Report (Annex Monitoring\Natural Disturbance Data\ Rio Bravo - Post-hurricane Carbon Stock Assessment Report.docx)

GIS program, ArcGIS. The plots locations were sent to PFB in both table format and GIS format. PFB would navigate to the plots using a GPS and then perform the data collection according to the SOP¹⁴. The results from these three plots indicated severe damage to the forest carbon stocks. This SOP used the following tree sizes within the nested plots:

- Small nest: 6 m radius, measure all trees > 5 cm DBH
- Medium nest: 14 m radius, measure all trees > 20 cm DBH
- Large nest: 20 m radius, measure all trees > 70 cm DBH

It was determined that more plots would need to be completed in order for the results to be robust enough to make assumptions about the entire parcel. A second set of 15 plots was randomly placed inside the parcel for follow up data collection. These plot locations were sent to PFB in the same manner as before. The second set of field data collection occurred in August 2011. A slightly modified SOP was used this time¹⁵. This SOP modified the tree sizes in the nested plots to:

- Small nest: 6 m radius, measure all trees > 5 cm DBH
- Medium nest: 14 m radius, measure all trees > 15 cm DBH
- Large nest: 20 m radius, measure all trees > 30 cm DBH

The net carbon stock change as a result of the disturbance is equal to the area disturbed multiplied by the emission per unit area.

$$\Delta C_{P,DistPA,i,t} = \sum_{q=1}^Q A_{DistPA,q,i,t} * \Delta C_{poolsP,Dist,q,i,t} \quad (16)$$

$$\Delta C_{P,DistLB,i,t} = \sum_{q=1}^Q A_{DistLB,q,i,t} * \Delta C_{poolsP,Dist,q,i,t} \quad (17)$$

Where:

$\Delta C_{P,DistPA,i,t}$	Net carbon stock change as a result of natural disturbance in the project case in the project area in stratum i at time t ; t CO ₂ -e
$\Delta C_{P,DistLB,i,t}$	Net carbon stock change as a result of natural disturbance in the project case in the leakage belt in stratum i at time t ; t CO ₂ -e
$A_{DistPA,q,i,t}$	Area impacted by natural disturbance in the project area stratum i converted to at time t ; ha
$A_{DistLB,q,i,t}$	Area impacted by natural disturbance in the leakage belt stratum i converted to natural disturbance strata q at time t ; ha
$\Delta C_{pools,Dist,q,i,t}$	Net carbon stock changes in all pools as a result of natural disturbance in the natural disturbance strata q in stratum i at time t ; t CO ₂ -e ha ⁻¹
q	1,2,3,... U post-natural disturbance strata
i	1, 2, 3 ... M project strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD project activity

The emission per unit area is equal to the difference between the stocks before and after the natural disturbance minus any wood products created from timber extraction following the natural disturbance:

$$\Delta C_{poolsDist,q,i,t} = C_{BSL,i} - C_{P,Dist,q,i} - C_{Dist,wp,i} \quad (18)$$

¹⁴Annex Monitoring\Standard Operating Procedures\Rio Bravo SOP Field Measurements_July-6-2011.docx

¹⁵Annex Monitoring\Standard Operating Procedures\Rio Bravo SOP Field Measurements_July-27-2011.docx

Where:

$\Delta C_{pools,Dist,q,i,t}$	Net carbon stock changes in all pools as a result of natural disturbance in the project case in disturbance strata q in stratum i at time t ; t CO ₂ -e ha ⁻¹
$C_{BSL,i}$	Carbon stock in all pools in the baseline case in stratum i ; t CO ₂ -e ha ⁻¹
$C_{P,Dist,q,i}$	Carbon stock in all pools in post-natural disturbance, disturbance strata q in stratum i ; t CO ₂ -e ha ⁻¹
$C_{Dist,WP,i}$	Carbon stock sequestered in wood products from harvests following natural disturbance in stratum i ; t CO ₂ -e ha ⁻¹
q	1,2,3,... Q post-natural disturbance strata
i	1, 2, 3 ... M strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD project activity

Although fire did take place in areas near to the project area, no fires occurred following the hurricane within the project boundaries. Therefore the area burned is set to zero:

$$A_{burn,q,i,t} = 0$$

3.3.5.3.5 Monitoring areas undergoing carbon stock enhancement

Since selective logging took place across the Project Area prior to the initiation of the project in 1996, the forest is continuing to increase its carbon stock over time.

However, this increase in carbon stocks is conservatively ignored and no strata are monitored for carbon stock enhancement.

3.3.5.3.6 Monitoring project emissions

Carbon emissions are also generated in the project scenario through usage of machineries that consume fossil fuels, potential biomass burning occurring within the project boundaries, and fertilizers used within the project boundary.

Monitoring of emissions from fossil fuel consumption was conducted by keeping track of the annual amount of fuel consumed by PFB and by logging contractors to conduct operations in the project area.

Fires within the project boundary have been monitored over time. No fires were recorded within the project boundary. The occurrence of fires has been monitored using the MODIS Burned Area Monthly L3 Global 500m (MCD45A1) was used to investigate the risk of wildfire inside the project boundary. The MCD45A1 is a monthly Level-3 gridded 500-meter satellite imagery product, which contains burning and date information at a pixel level. The monthly MCD45A1 product is based on three months of atmospherically and geometrically corrected, cloud-screened daily reflectance data. The algorithm that creates the product analyzes daily imagery of surface reflectance dynamics to locate changes, uses that information to detect the approximate date of burning, and maps the spatial extent.

Although fire did take place in areas near to the project area, no fires occurred following the hurricane within the project boundaries.

As Rio Bravo Climate Action Project plans do not include fertilization of remnant forest, no emissions from fertilization take place.

The emissions due to the project are estimated following the methods in the VCS Methodology applied.

$$GHG_{P,E,i,t} = E_{FC,i,t} + E_{BiomassBurn,i,t} + N_2O_{direct-N,i,t} \quad (19)$$

Where:

$GHG_{P,E,i,t}$	Greenhouse gas emissions as a result of deforestation activities within the project area in the project case in stratum i in year t ; t CO ₂ -e
$E_{FC,i,t}$	Emission from fossil fuel combustion in stratum i within the project area in year t ; t CO ₂ -e
$E_{BiomassBurn,i,t}$	Non-CO ₂ emissions due to biomass burning in stratum i in year t ; t CO ₂ -e
$N_2O_{direct-N,i,t}$	Direct N ₂ O emission as a result of nitrogen application on the alternative land use in stratum i within the project area in year t ; t CO ₂ -e
i	1, 2, 3 ... M strata
t	1, 2, 3 ... t^* years elapsed since the start of the REDD VCS project activity

Emissions from fossil fuel consumption

The Program for Belize keeps records of fuel purchased for maintaining the project, such as utilizing vehicles including trucks, all terrain vehicles (ATV), and tractors, generators, lawnmowers. Additionally, a survey was applied to the logging contractor to identify fuel consumption for conducting logging practices (e.g. chainsaw, skidder, loaders and trucks). PfB fuel purchase records and results of the survey were compiled and the annual fuel consumption within Rio Bravo Climate Action Project area was estimated. Fuel consumption was assumed to remain steady in forthcoming years (2012 to 2015).

The emissions from fossil fuel consumption were estimated as:

$$E_{FC,i,t} = \sum_{a=1}^A Fuel_{a,i,t} \times EF_a \quad (1)$$

Where:

$E_{FC,i,t}$	Net CO ₂ -e emissions of Fuel Consumption in stratum i in year t ; t CO ₂ -e
$Fuel_{a,i,t}$	Amount of Fuel of type a consumed in stratum i in year t ; terrajoule (TJ)
EF_a	Emission Factor of Fuel type a ; tCO ₂ -e/TJ
a	1,2,3,... A fuel types (e.g. diesel, gasoline, etc.)

The amount of fuel of a particular kind combusted in a given year ($Fuel_{a,t}$) can be estimated as:

$$Fuel_{a,i,t} = Liters_{Fuel_{a,i,t}} \times Density_{Fuel_a} \times NCV_{Fuel_a} \div 10^6 \quad (2)$$

Where:

$Fuel_{a,t}$	Amount of Fuel type a consumed in stratum i in year t ; TJ
$Liters_{Fuel_{a,t}}$	Quantity of Fuel of type a consumed in stratum i in year t ; ltr
$Density_{Fuel_a}$	Density of Fuel type a ; kg/ltr
NCV_{Fuel_a}	Net Calorific Value of Fuel type a ; TJ/Gg

Default values provide by E-FFC module for EF_a , $Density_{Fuel_a}$ and NCV_{Fuel_a} were used to conduct calculations.

3.3.5.3.7 Total Project Emissions

Once the emissions from each component is monitored and estimated, the total project emissions are summed together based on the methods delineated in the Methodology Module.

$$\Delta C_P = \sum_{t=1}^{t^*} \sum_{i=1}^M \left(\Delta C_{P,DefPA,i,t} + \Delta C_{P,Deg,i,t} + \Delta C_{P,DistPA,i,t} + GHG_{P-E,i,t} - \Delta C_{P,Enh,i,t} \right) \quad (20)$$

Where:

ΔC_P	Net greenhouse gas emissions within the project area under the project scenario ; t CO ₂ -e
$\Delta C_{P,DefPA,i,t}$	Net carbon stock change as a result of deforestation in the project area in the project case in stratum <i>i</i> at time <i>t</i> ; t CO ₂ -e
$\Delta C_{P,Deg,i,t}$	Net carbon stock change as a result of degradation in the project area in the project case in stratum <i>i</i> at time <i>t</i> ; t CO ₂ -e
$\Delta C_{P,DistPA,i,t}$	Net carbon stock change as a result of natural disturbance in the project area in the project case in stratum <i>i</i> at time <i>t</i> ; t CO ₂ -e
$GHG_{P-E,i,t}$	Greenhouse gas emissions as a result of deforestation and degradation activities within the project area in the project case in stratum <i>i</i> in year <i>t</i> ; t CO ₂ -e
$\Delta C_{P,Enh,i,t}$	Net carbon stock change as a result of forest growth and sequestration during the project in areas projected to be deforested in the baseline ¹⁶ in stratum <i>i</i> at time <i>t</i> ; t CO ₂ -e
<i>i</i>	1, 2, 3 ... <i>M</i> strata
<i>t</i>	1, 2, 3, ... <i>t</i> * years elapsed since the start of the REDD project activity

3.3.6 Application of Leakage Module

This report addresses the GHG emission potentially caused by activity shifting leakage of the planned deforestation carbon project “Rio Bravo”. Activity shifting leakage is the process of displacement of baseline deforestation from the project site to another location within Belize. The methods to measure leakage are outlined in the VCS module VMD0009, “Estimation of emissions from activity shifting for avoided planned deforestation” (LK-ASP), version 1.0.

The estimation of leakage follows the methods outlined in Part 2 of the module, “Where only a class of deforestation agents can be identified”. Part 2 as this carbon project is based on class agents of deforestation. The module outlines a 4 step procedure for assessment of leakage.

3.3.6.1 Step 1 Identify commodity produced by baseline class of agent

The first step of the module is to identify the commodity that would have been cultivated had the agent been able to acquire the project area. This was accomplished by analysis of responses to a survey conducted by Winrock International. The one goal of the survey was to determine how new areas of agriculture production are created and what land management methods are used to create these agricultural lands. The survey was conducted by Dareece Chuc between March 17 and March 27, 2009. Ms. Chuc surveyed landholders and farmers in northern Belize with the goal of gaining insight about land acquisitions, land uses, and agricultural production¹⁷.

¹⁶ For areas with a degradation baseline (i.e. using BL-DFW) this parameter shall be set to zero, for areas with baseline set by BL-UP and BL-PL this parameter may be conservatively set to zero.

¹⁷Annex Land Use Management Survey\Survey of Agricultural Expansion and Management in Northern Belize.docx

From the answers to the survey questions, it was determined that beans and/or corn were the commodities most likely to be planted by the agents. Both of these crops require similar conditions to flourish, temperate climate, precipitation, and soil quality.

3.3.6.2 Step 2 Assess proportion of available areas that are forested

This step of the module is used to determine the areas in Belize potentially available for production of corn or beans. To do this an analysis with a GIS was conducted that queried data on land cover, precipitation, elevation, and soil type for locations with similar characteristics as that of current agriculture locations. Data for soils comes from the Harmonized World Soil Database (HWSD)¹⁸. Data for land cover comes from Belizean Ecosystems¹⁹. Data for annual precipitation comes from the WorldClim²⁰. Data for elevation comes from the International Centre for Tropical Agriculture's hole-filled seamless SRTM data version 4²¹. Because Belize is such a small country, it was assumed that any location inside the country has the potential for access to markets.

The elevation characteristics in agriculture areas (Figure 2):

- Elevation ranges from 1 – 917
- Mean elevation is 79 meters
- Median elevation is 49 meters
- Elevation standard deviation is 96 meters

The precipitation characteristics in agriculture areas (Figure 3):

- Precipitation ranges from 1,222 – 4,085
- Mean precipitation is 2,094 meters
- Median precipitation is 1,738 meters
- Precipitation standard deviation is 728 meters

The identified soil types in agriculture areas (Figure 4):

- Chromic Cambisols
- Dystric Cambisols
- Dystric Planosols
- Eutric Cambisols
- Eutric Gleysols
- Haplic Acrisols
- Rendzic Leptosols
- Vertic Cambisols

In the GIS, these data were spatially overlaid to identify locations where all three data layers intersected. Next the protected areas of Belize²² were removed from the intersection. (Figure 6). The result was a map of the areas potentially available for conversion to agriculture for corn or beans. The proportion of that area that is forested is 54.52% (PF_c).

¹⁸ FAO/IIASA/ISRIC/ISSCAS/JRC, 2009. Harmonized World Soil Database (version 1.1). FAO, Rome, Italy and IIASA, Laxenburg, Austria.

¹⁹ Meerman, J. and W. Sabido. 2001. Central American Ecosystems: Belize. Programme for Belize, Belize City. 2 volumes 50 + 88 pp.

²⁰ Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal of Climatology 25: 1965-1978.

²¹ Jarvis A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), available from <http://srtm.csi.cgiar.org>.

²² Meerman J. C., 2001, Belize Protected Areas Map Shapefile.



Figure 2 Elevation

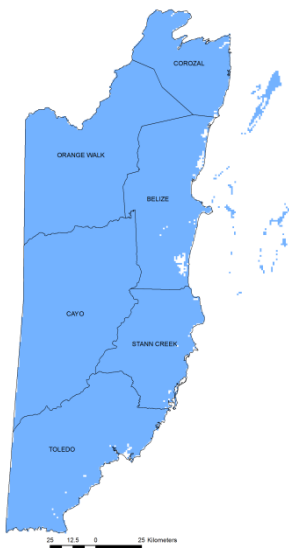


Figure 3 Precipitation



Figure 4 Soil Types

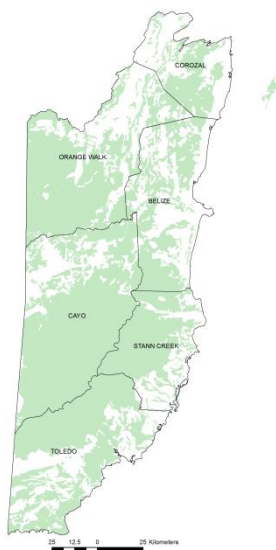


Figure 5 Forested Areas



Figure 6 Protected Areas

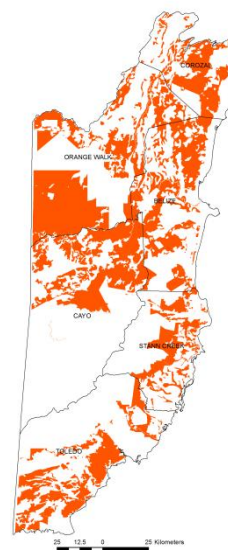


Figure 7 Final Forested Alternative Areas

3.3.6.3 Step 3 Evaluate project area relative to other forested areas for commodity production in the country

This step states that an assessment of the productivity of the project area and the eligible alternative areas be assessed. This was done by analysis of soil quality at the project site and in the alternative areas using the HWSD data. Soil quality, sometimes referred to as fertility, is a measurement of the soil's

ability to supply mineral nutrients to crops. Soil quality cannot be measured directly²³. Instead, three soil attributes that served as quality indicators were used. All three of the soil attributes used can be found in the HWSD data. The indicators are measurable properties of soil or plants that provide information about how well the soil can function. Indicators can be physical, chemical, and biological properties, processes, or characteristics of soils. They can also be morphological or visual features of plants. The indicators used in this analysis were soil attributes; one physical type (bulk density), one chemical type (pH), and one characteristic (soil organic matter). These are typical indicators of soil quality used by the United States Department of Agriculture (USDA) and USDA's Natural Resources Conservation Service (NRCS) as well as soil scientists, and agronomist around the world.

The values for each of the soil quality indicators were queried from the HWSD data. Within the Rio Bravo Climate Action Project, in the HWSD the three indicators: organic content, pH, and bulk density do not vary across the project area. The project area value for each indicator is listed in Table 1. The HWSD database covering the 'forested alternative area' in Belize, was then extracted from the HWSD data. The area-weighted mean value for each indicator within the 'forested alternative area' was then calculated²⁴. The area-weighted means for each of the three indicators for forested alternative areas is within $\pm 15\%$ of the project area (Table 1).

Table 1 Area-weighted average soil quality values within forested alternative areas in Belize in comparison with soil quality values found within project area

	Organic Content (% weight)			pH			Bulk Density (g cm ⁻³)		
	Mean	+15%	-15%	Mean	+15%	-15%	Mean	+15%	-15%
Block 13	1.81	2.08	1.54	8.3	9.55	7.06	1.12	1.29	0.95
Parcel 6									
Block 14	1.81	2.08	1.54	8.3	9.55	7.06	1.12	1.29	0.95
Parcel 3									
Forested Alternative Areas	1.67			7.3			1.18		

3.3.6.4 Step 4 Assess proportional leakage factor

The final step of the methodology is to assess the proportional leakage factor based on whether the project site productivity is less than, greater than or equal to the productivity of alternative lands. In the case of this project, the project site is equal to the alternative lands because the four soil quality indicators for the project are within $\pm 15\%$ of the indicators in alternative lands. The result is that the leakage factor ($LK_{CP-ME,c,i}$) is 0.4.

3.3.6.5 Step 5: Calculate estimated leakage

The above analysis is then used to calculate the amount of leakage that is assigned to the project.

$$\Delta C_{LK-AS,planned} = \sum_{t=1}^{t^*} \sum_{i=1}^M \sum_{c=1}^C \left(\%_{planned,i,t} * A_{planned,i} \right) * \Delta C_{BSL,i} * PF_c * LK_{CP-ME,c,i} \quad (21)$$

Where:

²³ <http://soils.usda.gov/sqi/assessment/assessment.html>

²⁴ See: Supplementary Documents\Annex R Leakage\Rio Bravo - Leakage Analysis.xlsx

$\Delta C_{LK-AS,planned}$	Net CO ₂ emissions due to activity shifting leakage for projects preventing planned deforestation; t CO ₂ -e
$D\%_{planned,i,t}$	Projected annual proportion of land that will be deforested in stratum i at year t ; %
$A_{planned,i}$	Total area of planned deforestation over the baseline period for stratum i ; ha
$\Delta C_{BSL,i}$	Net carbon stock changes in all pools in baseline stratum i ; t CO ₂ -e ha ⁻¹
PF_c	Proportion of available area for production of commodity c that is currently forested; dimensionless
$LK_{CP-ME,c,i}$	Leakage factor for displacement of class of planned deforestation agents; dimensionless
c	1, 2, 3, ... C commodities
i	1, 2, 3, ... M strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD project activity

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

The total emissions taking place in the baseline have been estimated. Details on how these numbers have been calculated can be found in a Supplementary Document²⁵.

Table 2 Cumulative Baseline GHG Emissions per year (ΔC_{BSL})

	Stratum 1: Lowland Forest	Stratum 2: Upland Forest	Stratum 3: Upland Forest - South	Stratum 1: Lowland Forest	Stratum 2: Upland Forest	Stratum 3: Upland Forest - South	Total Cumulative	Total VCS Eligible Cumulative
	GHG Emission Reductions (t CO ₂ -e)			Cumulative t CO ₂ e			GHG Emission Reductions (t CO ₂ -e)	
1996	36,532	246,150	51,053	36,532	246,150	51,053	282,682	
1997	36,532	246,150	51,053	73,064	492,300	102,105	565,365	
1998	36,532	246,150	51,053	109,596	738,451	153,158	848,047	
1999	36,532	246,150	51,053	146,128	984,601	204,210	1,130,729	
2000	36,532	246,150	51,053	182,660	1,230,751	255,263	1,413,411	
2001	36,532	246,150	51,053	219,192	1,476,901	306,315	1,696,094	
2002	36,532	246,150	51,053	255,724	1,723,052	357,368	1,978,776	282,682

²⁵ Rio Bravo - Application of Baseline Report (Supplementary Documents\Annex Application of Baseline\Rio Bravo - Application of Baseline Report.docx)

2003	36,532	246,150	51,053	292,256	1,969,202	408,420	2,261,458	565,365
2004	36,532	246,150	51,053	328,788	2,215,352	459,473	2,544,140	848,047
2005	36,532	246,150	51,053	365,320	2,461,502	510,525	2,826,823	1,130,729
2006	50,505	340,273	70,579	415,825	2,801,775	581,104	3,217,600	1,521,507
2007	50,505	340,273	70,579	466,330	3,142,048	651,683	3,608,378	1,912,284
2008	41,765	281,220	58,366	508,095	3,423,267	710,049	3,931,363	2,235,269
2009	0	0	0	508,095	3,423,267	710,049	3,931,363	2,235,269
2010	0	0	0	508,095	3,423,267	710,049	3,931,363	2,235,269
2011	0	0	0	508,095	3,423,267	710,049	3,931,363	2,235,269
2012	0	0	0	508,095	3,423,267	710,049	3,931,363	2,235,269
2013	0	0	0	508,095	3,423,267	710,049	3,931,363	2,235,269
2014	0	0	0	508,095	3,423,267	710,049	3,931,363	2,235,269
2015	0	0	0	508,095	3,423,267	710,049	3,931,363	2,235,269

4.2 Project Emissions

4.2.1.1 Monitoring Deforestation

Based on Cherrington 2010²⁶, it was found that a low amount of deforestation took place per year since the start of the project.

Field verification of this deforestation was conducted in July 2011²⁷. At all locations verified deforestation had occurred.

Table 3 Net Emissions as a result of deforestation in the project case in the project area in each stratum

Year	Stratum 1: Lowland Forest			Stratum 2: Upland Forest			Stratum 3: Upland Forest - South		
	Area of def.	Net Emissions from Def.	Cumulative Emissions	Area of def.	Net Emissions from Def.	Cumulative Emissions	Area of def.	Net Emissions from Def.	Cumulative Emissions
	ha	t CO2e	t CO2e	ha	t CO2e	t CO2e	ha	t CO2e	t CO2e
1996	1.46	775	775	7.12	5,598	5,598	0	0	0
1997	1.46	775	1,550	7.12	5,598	11,196	0	0	0
1998	1.46	775	2,326	7.12	5,598	16,794	0	0	0
1999	1.46	775	3,101	7.12	5,598	22,392	0	0	0
2000	1.46	775	3,876	7.12	5,598	27,990	0	0	0
2001	0.01	5	3,881	0.11	87	28,078	0	0	0
2002	0.01	5	3,886	0.11	87	28,165	0	0	0
2003	0.01	5	3,891	0.11	87	28,253	0	0	0
2004	0.01	5	3,895	0.11	87	28,340	0	0	0
2005	0	0	3895	0	0	28,340	0	0	0
2006	0	0	3895	0	0	28,340	0	0	0
2007	0	0	3895	0	0	28,340	0	0	0

²⁶ Cherrington, E., E. Ek, P. Cho, B.F. Howell, B.E. Hernandez, E.R. Anderson, A.I. Flores, B.C. Garcia, E. Sempris, D.E. Erwin. 2010. Forest Cover and Deforestation in Belize: 1980-2010. SERVIR, Catalac. 42 pp

²⁷ Annex Monitoring\Deforestation\Rio Bravo - Field verification of deforestation.docx

2008	0	0	3895	0	0	28,340	0	0	0
2009	0	0	3895	0	0	28,340	0	0	0
2010	0	0	3895	0	0	28,340	0	0	0
2011	0	0	3895	0	0	28,340	0	0	0
2012	0	0	3895	0	0	28,340	0	0	0
2013	0	0	3895	0	0	28,340	0	0	0
2014	0	0	3895	0	0	28,340	0	0	0
2015	0	0	3895	0	0	28,340	0	0	0

4.2.1.2 Monitoring degradation

4.2.1.2.1 Monitoring degradation through illegal wood extraction

The emissions caused by degradation through illegal logging were estimated based on the area impacted by such activity (Adeg), and by estimating of the carbon stocks of species targeted by illegal loggers. Through monitoring of illegal logging conducted by ranger patrols, the Programme for Belize determined areas most susceptible as well as species extracted. Rio Bravo Management Plan²⁸ established monitoring protocols for rangers that require patrolling of the project area on at least monthly basis.

Although the actual location of illegal logging is known for some years, a conservative approach has been taken to estimate the emissions resulting emissions. A 500 m buffer has been placed around all roads and logging roads. This buffer covers 3,382 ha, or 53% of the project area.

To conservatively estimate the emissions resulting from any potential illegal logging that may take place, forest inventory data has been used to estimate the biomass of mahogany and cedar trees within the project area.²⁹, (Table 5).

Table 4 Buffer area where illegal logging of mahogany and cedar is assumed to occur

Parcel	Strata	Area (ha)
Block 13 Parcel 6	Upland Forest	2,870
Block 14 Parcel 3	Upland Forest	511

²⁸ Rio Bravo Management Area Management Plan (edition v). 2006.

²⁹ Annex Monitoring\Selective Logging Data\Forest_inventory\ RioBravo_ForestInventory1999_2010.xlsx

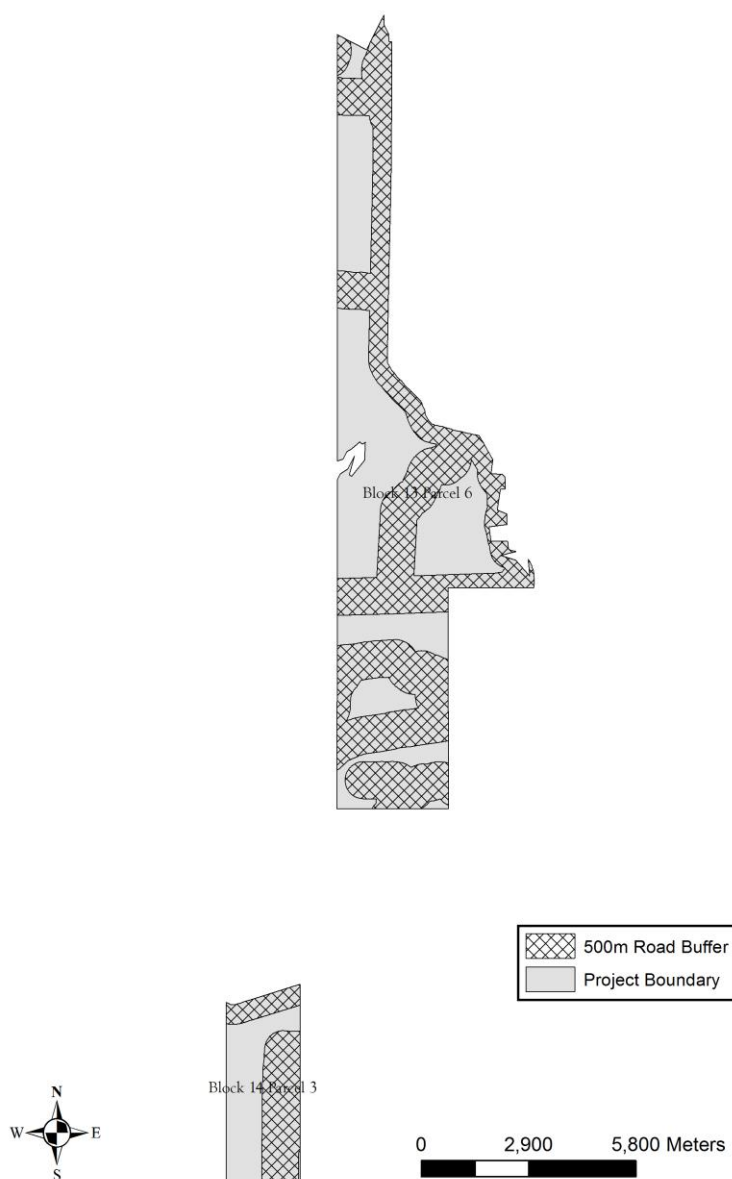


Figure 8. Locations of illegal logging detected during project period along with a 500 meter buffer.

Table 5 Estimated biomass of Mahogany and Cedar trees per hectare, based on forest inventory data

		average:	95% CI	95% CI
		t CO ₂ e ha ⁻¹		as % of mean
Mahogany	AB	21.8	7.5	34%
	BB	5.2	1.8	34%
Cedar	AB	0.4	0.3	75%
	BB	0.1	0.1	75%

Total	AB	22.2	7.8	34%
	BB	5.3	1.9	34%
	Total	27.6	9.7	39%

To estimate total emissions resulting from illegal logging degradation, the upper bounds of the 95% CI of total biomass of mahogany and cedar per hectare was combined with the estimated area of access points for illegal logging to conservatively estimate total emissions from illegal logging. The estimated emissions originating from illegal logging were conservatively assumed to occur all in the first two years of the project as opposed to spread out over multiple years.

Table 6 Estimated net Emissions as a result of degradation through wood extraction in the project case in the project area in each stratum

	Stratum 1: Lowland Forest			Stratum 2: Upland Forest			Stratum 3: Upland Forest - South		
Year	Area of deg.	Net Emissions from deg.	Cumulative Emissions	Area of deg.	Net Emissions from deg.	Cumulative Emissions	Area of deg.	Net Emissions from deg.	Cumulative Emissions
	ha	t CO ₂ -e	t CO ₂ -e	ha	t CO ₂ -e	t CO ₂ -e	ha	t CO ₂ -e	t CO ₂ -e
1996	158	3371	3,371	1099	23443	23,443	434	9263	9,263
1997	158	3371	6,742	1099	23443	46,887	434	9263	18,527
1998	0	0	6,742	0	0	46,887	0	0	18,527
1999	0	0	6,742	0	0	46,887	0	0	18,527
2000	0	0	6,742	0	0	46,887	0	0	18,527
2001	0	0	6,742	0	0	46,887	0	0	18,527
2002	0	0	6,742	0	0	46,887	0	0	18,527
2003	0	0	6,742	0	0	46,887	0	0	18,527
2004	0	0	6,742	0	0	46,887	0	0	18,527
2005	0	0	6,742	0	0	46,887	0	0	18,527
2006	0	0	6,742	0	0	46,887	0	0	18,527
2007	0	0	6,742	0	0	46,887	0	0	18,527
2008	0	0	6,742	0	0	46,887	0	0	18,527
2009	0	0	6,742	0	0	46,887	0	0	18,527
2010	0	0	6,742	0	0	46,887	0	0	18,527
2011	0	0	6,742	0	0	46,887	0	0	18,527
2012	0	0	6,742	0	0	46,887	0	0	18,527
2013	0	0	6,742	0	0	46,887	0	0	18,527
2014	0	0	6,742	0	0	46,887	0	0	18,527
2015	0	0	6,742	0	0	46,887	0	0	18,527

4.2.1.2.2 Monitoring degradation due to implementation of third-party certified selective logging practices

The PfB conducts logging activities on the Upland Forest stratum only. Logging takes place in several different areas within the Rio Bravo Climate Action Project area. These areas are gridded to facilitating management practices (Figure 9). Logging operations within the Rio Bravo Climate Action Project areas are currently FSC certified. The volume of timber extracted averaged has varied over the years from 0 to 600 m³ harvested across the Rio Bravo Climate Action Project area per year (Table 6).

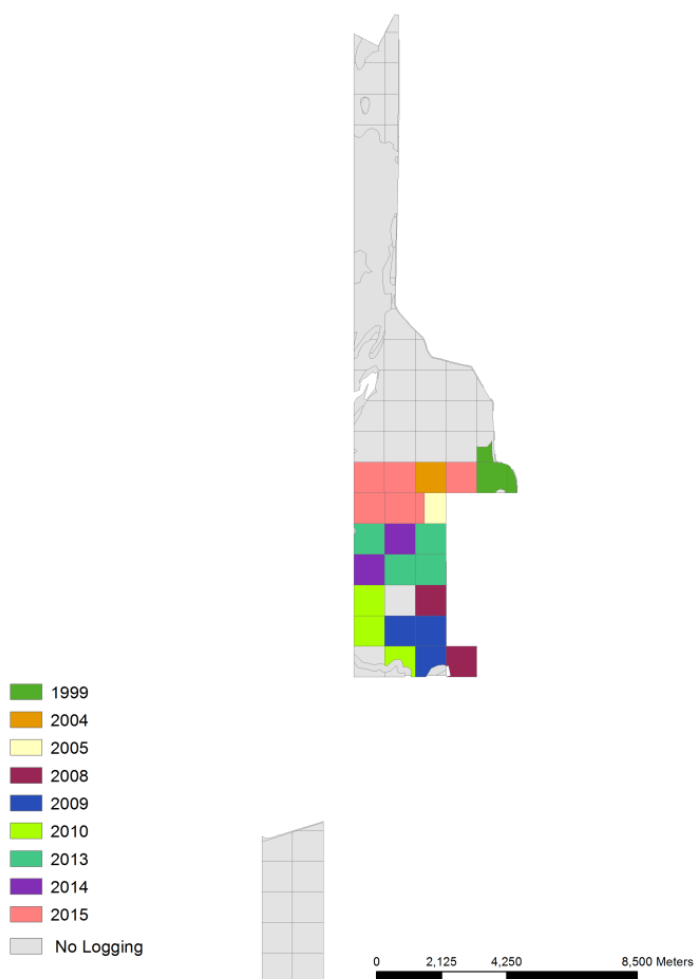


Figure 9 Location of Selective Logging Blocks by year

4.2.1.2.2.1 Emissions arising in the logging gap

The volume of timber harvested within the Rio Bravo Climate Action Project is calculated in board foot and sold to various local mills. Volume harvested is verified by SmartWood for the selective logging certification. The total volume harvested per year has been calculated and is shown below. Logging does not take place within the project boundary in all years. The area to be logged between 2012-2015 is based on selective logging management plans.

The actual net project emissions arising in the logging gap is then calculated as delineated in the methodology.

Table 7: Timber harvested volume in the Rio Bravo Climate Action Project area. Source: The Programme for Belize.

Year	Area	Volume	Biomass of carbon stock extracted ($C_{EXT,i,t}$)	Actual net emissions from logging gap (C_{LG})	
				Stratum 2 Upland Forest	Stratum 3 Upland Forest – South
	(ha)	(m^3)	t CO ₂ e	t CO ₂ e	

1996	-	0	0	0
1997	-	0	0	0
1998	-	0	0	0
1999	145	134	139	229
2000	0	-	0	0
2001	0	-	0	0
2002	0	-	0	0
2003	-	0	0	0
2004	101	134	139	229
2005	70	94	97	160
2006	0	-	0	0
2007	0	-	0	0
2008	100	42	43	0
2009	279	533	551	0
2010	263	573	593	0
2011	0	-	0	0
2012	0	-	0	0
2013	400	567	586	0
2014	201	284	294	0
2015	429	607	628	0

4.2.1.2.2.2 Emissions arising through logging infrastructure

Data to estimate emissions from logging infrastructure (skid trails, logging roads and logging decks) were obtained from the "Post Harvest Assessment" that PfB conducts after each logging season, direct measurements, and GIS data derived from field measurements. Field measurements, reported in Post-Harvest Assessments, were used to estimate the length of skid trails, logging deck areas, and the average width of roads. Direct measurement of the machinery used to create skid trails was used to estimate the width of skid trails³⁰. A survey was applied to all mills that purchase timber from Rio Bravo Climate Action Project to determine the destination of the timber harvested, thus allowing for estimation of emissions removals as a result of carbon storage into long-term wood products³¹.

Table 8 Parameters used to calculate the mean live carbon stock of trees and non-tree biomass assumed to be killed per unit area in the creation of skid trails in stratum i and the soil carbon changes

Carbon Pool	Stratum 2: Upland Forest			Stratum 3: Upland Forest - South		
	Mean Stock t CO ₂ ha ⁻¹	95% CI	95% CI as % of mean	Mean Stock t CO ₂ ha ⁻¹	95% CI	95% CI as % of mean
C _{AB_tree_dest,i}	134.1	18.9	14%	107.3	15.2	14%
C _{BB_tree_dest,i}	32.2	4.5	14%	25.7	3.6	14%
C _{AB_non-tree,i}	1.35	0.62	46%	1.1	0.5	46%
C _{BB_non-tree,i}	0.68	0.31	46%	0.5	0.2	46%

³⁰Supplementary Documents\Annex O Monitoring>Selective Logging Data\SurveyofLoggingActivities.JPG

³¹Annex Monitoring>Selective Logging Data\Wood_Products\

$C_{dest,i}$	168.31	15.12	12%	134.6	12.1	12%
$C_{SOC,i,t=0}$	716.77	142.32	20%	573.4	113.9	20%

Table 9 Length of skid trails and change in carbon stock resulting from skid trail creation

Year	Area Logged (ha)	Length of Skid Trails L_{SKID} m	Change in carbon stocks from skid trails ΔC_{SKID} t CO ₂ e
1996			0
1997			0
1998			0
1999	323	36,892	3,736
2000			0
2001			0
2002			0
2003			0
2004	101	11,511	1,314
2005	70	8,034	917
2006			0
2007			0
2008	100	3,500	354
2009	279	37,000	3,747
2010	263	22,625	2,291
2011			0
2012			0
2013	400	45,694	4,627
2014	201	22,907	2,320
2015	529	60,417	5,000

Table 10 Area and emissions from roads and logging decks created during selective logging

Year	Area of Roads $A_{ROAD,i,t}$ ha	Area of Decks $A_{DECKS,i,t}$ Ha	ΔC_{ROADS} t CO ₂ e	ΔC_{DECKS} t CO ₂ e
1996			0	0
1997			0	0
1998			0	0
1999	0.27	2	254	1,904
2000			0	0
2001			0	0
2002			0	0
2003			0	0
2004	0.34	2	403	2,381
2005	0.34	2	403	2,381
2006			0	0
2007			0	0
2008	0.79	0	753	0
2009	0.55	0.85	523	809
2010	1.10	2	1,050	1,904

2011			0	0
2012			0	0
2013	1.22	2	1,166	1,904
2014	1.00	2	951	1,904
2015	0.35	2	329	1,904

4.2.1.2.2.3 Total emissions from degradation due to third-party certified selective logging

Total emissions resulting from selective logging were then calculated as the combination of emissions from logging gaps, logging infrastructure, and harvested wood products. Selective logging did not take place in all years. Emissions for 2012-2015 are projected based on harvest management plans delineating compartments to be logged and the average volume extracted per hectare in the past.

Table 11 $\Delta C_{P, SelLog, i, t}$ Net Emissions a result of Degradation from selective logging in the project case in the project area in each stratum (Stratum 1 Lowland Forest is not shown as no logging is taking place in this stratum)

Year	Stratum 2: Upland Forest				Stratum 3: Upland Forest - South			
	Logging Gaps C_{LG}	Logging Infra-structure C_{LR}	Harvested Wood Products C_{WP}	Total Emissions from Selective Logging $\Delta C_{P, SelLog, i, t}$	Logging Gaps C_{LG}	Logging Infra-structure C_{LR}	Harvested Wood Products C_{WP}	Total Emissions from Selective Logging $\Delta C_{P, SelLog, i, t}$
	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e	t CO ₂ e
1996	0	0	0.0	0	0	0	0.0	0
1997	0	0	0.0	0	0	0	0.0	0
1998	0	0	0.0	0	0	0	0.0	0
1999	0	0	0.0	0	229	5,894	2.9	6,120
2000	0	0	0.0	0	0	0	0.0	0
2001	0	0	0.0	0	0	0	0.0	0
2002	0	0	0.0	0	0	0	0.0	0
2003	0	0	0.0	0	0	0	0.0	0
2004	229	4,098	2.9	4,324	0	0	0.0	0
2005	160	3,700	2.0	3,859	0	0	0.0	0
2006	0	0	0.0	0	0	0	0.0	0
2007	0	0	0.0	0	0	0	0.0	0
2008	0	0	0.0	0	72	1,107	0.9	1,178
2009	0	0	0.0	0	908	5,079	11.5	5,975
2010	0	0	0.0	0	977	5,246	12.4	6,210
2011	0	0	0.0	0	0	0	0.0	0
2012	0	0	0.0	0	0	0	0.0	0
2013	0	0	0.0	0	966	7,697	12.3	8,651
2014	0	0	0.0	0	484	5,175	6.2	5,653
2015	0	0	0.0	0	1,035	7,233	13.1	8,254

4.2.1.3 Monitoring areas undergoing natural disturbance

Since the start of the project, three hurricanes in Belize were experienced inside the project boundary. The first was Hurricane Mitch which struck in October-November of 1999. However, the hurricane

caused no snapped stems or uprooted trees. The main impact was standing water in the lowland areas of the forest³².

The second hurricane was Keith which struck in October of 2000. Although stronger than in 1999, this hurricane again caused no snapped stems or uprooted trees but did temporarily cause some temporary standing water. Program for Belize found no systematic difference in dead or live carbon stocks between plots measured prior and after the hurricane³³.

The third hurricane, Richard, occurred on October 24, 2010. Program for Belize is conducted field work to gather data on the extent of damage in the hurricane affected areas. As shown in Figure 10, only one project parcel was affected by the hurricane. As a result, field work was only done in Parcel 14 Block 3. The results of the field data collection show that about half the tree biomass were not damaged by the hurricane or by any subsequent fires (Table 7).

³² Brown, Sandra, Matt Delaney, David Shoch. 2001. Year 2001 Carbon Monitoring Analysis and Status Report for the Rio Bravo Carbon Sequestration Pilot Project.

³³ Ibid.

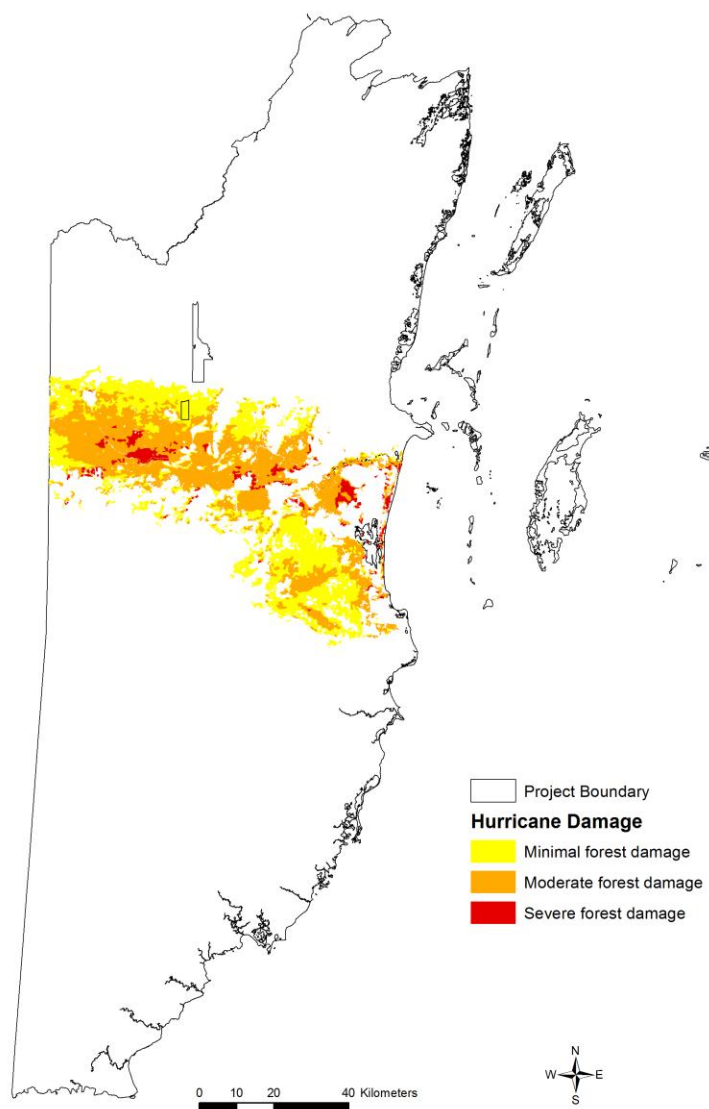


Figure 10 Cherrington's hurricane Richard damage assessment, version 3

Table 12 Carbon stocks of live trees undamaged by hurricane within plots measured

Plot ID	AB tree t CO ₂ e ha ⁻¹	BB tree t CO ₂ e ha ⁻¹
3	341	82
4	50	12
6	144	35
10b	496	119
11b	241	58
12b	162	39
13b	74	18
14b	159	38
15b	287	69

1b	280	67
3b	340	81
4b	235	56
5b	217	52
6b	248	59
7b	316	76
8b	281	67
9b	364	87

Table 13 Field measurements of carbon stocks following hurricane in Block 14, Parcel 3

	# plots	AB tree t CO ₂ e ha ⁻¹	AB StDev t CO ₂ e ha ⁻¹	95% CI	95% CI as % of mean	BB tree t CO ₂ e ha ⁻¹	BB StDev t CO ₂ e ha ⁻¹	95% CI
All Trees	17	404.28	149.21	76.71	19%	97.03	35.81	18.41
Alive Trees	17	248.97	110.84	56.99	23%	59.75	26.60	13.68
Damaged, Suspected Alive	15	162.70	130.70	72.38	44%	39.05	31.37	17.37
Damaged, Suspected Dead	9	27.64	16.79	12.91	47%	6.63	4.03	3.10
Dead	4	44.04	48.91	77.83	177%	10.57	11.74	18.68

Table 14 $\Delta C_{P,DistPA,i,t}$ Net Emissions as a result of natural disturbance (hurricane) in the project case in the project area in each stratum

Year	Stratum 1: Lowland Forest and Stratum 3: Upland Forest - South t CO ₂ e	Stratum 2: Upland Forest	Stratum 1: Lowland Forest and Stratum 3: Upland Forest - South Cumulative t CO ₂ e	Stratum 2: Upland Forest
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0

2009	0	0	0	0
2010	0	162,262	0	162,262
2011	0	0	0	162,262
2012	0	0	0	162,262
2013	0	0	0	162,262
2014	0	0	0	162,262
2015	0	0	0	162,262

4.2.1.4 Monitoring areas undergoing carbon stock enhancement

Since selective logging has taken place across the Project Area prior to the initiation of the project, the forest is continuing to increase its carbon stock over time.

However, this increase in carbon stocks is conservatively ignored and no strata are monitored for carbon stock enhancement.

4.2.1.5 Monitoring project emissions

Detailed accounting of fossil fuel use have not been accounted for each year. Instead an estimate of yearly emissions has been made based on recent fossil fuel use.³⁴ No fertilizers have been used in the project activity within the project boundary.

4.2.1.5.1 Fossil Fuel Emissions

The records of fuel purchases were used to calculate fossil fuel emissions resulting from direct Program for Belize activities. In addition, the emissions resulting from selective logging operations were estimated based on the average amount of fuel use during logging operations.

Table 15 Parameters used in fossil fuel emission estimations

Density _{Fuel diesel} (kg/ltr)	0.8439
NCV _{Fuel diesel} (TJ/Gg)	43.38
EF _{diesel} (tCO ₂ e/Tj)	74.1

Table 16 Fuel used and resulting emissions per year

	RBCMA fuel (liters)	Logging Operations (liters)	Fuel diesel, upland (TJ)	E _{FC, upland} (tCO ₂ e)
1996	37,951		1.4	103
1997	37,951		1.4	103
1998	37,951		1.4	103
1999	37,951	61,607	3.6	270
2000	37,951		1.4	103
2001	32,025		1.2	87
2002	5,348		0.2	15
2003	21,789		0.8	59
2004	13,259	61,607	2.7	203

³⁴ Annex Monitoring\Fuel Consumption

2005	16,844	61,607	2.9	213
2006	21,234		0.8	58
2007	20,371		0.7	55
2008	25,888	61,607	3.2	237
2009	24,957	61,607	3.2	235
2010	35,531	61,607	3.6	264
2011	35,531		1.3	96
2012	35,531		1.3	96
2013	35,531	61,607	3.6	264
2014	35,531	61,607	3.6	264
2015	35,531	61,607	3.6	264

4.2.1.5.2 Emissions from Biomass Burning

MODIS Monthly Global Burned Area data was used to monitor fire damage in the project area. According to the MODIS data, no fires have taken place within the Project Boundary and therefore, no emissions have resulted from fire.

In 2011, fires spread across Belize. According to the assessment of where fires occurred was conducted by Meerman (2011), no fires occurred in the project area (Figure 9). Field survey's found that no fire took place in Block 14, Parcel 3 in the areas where the 2010 hurricane damaged carbon stocks.

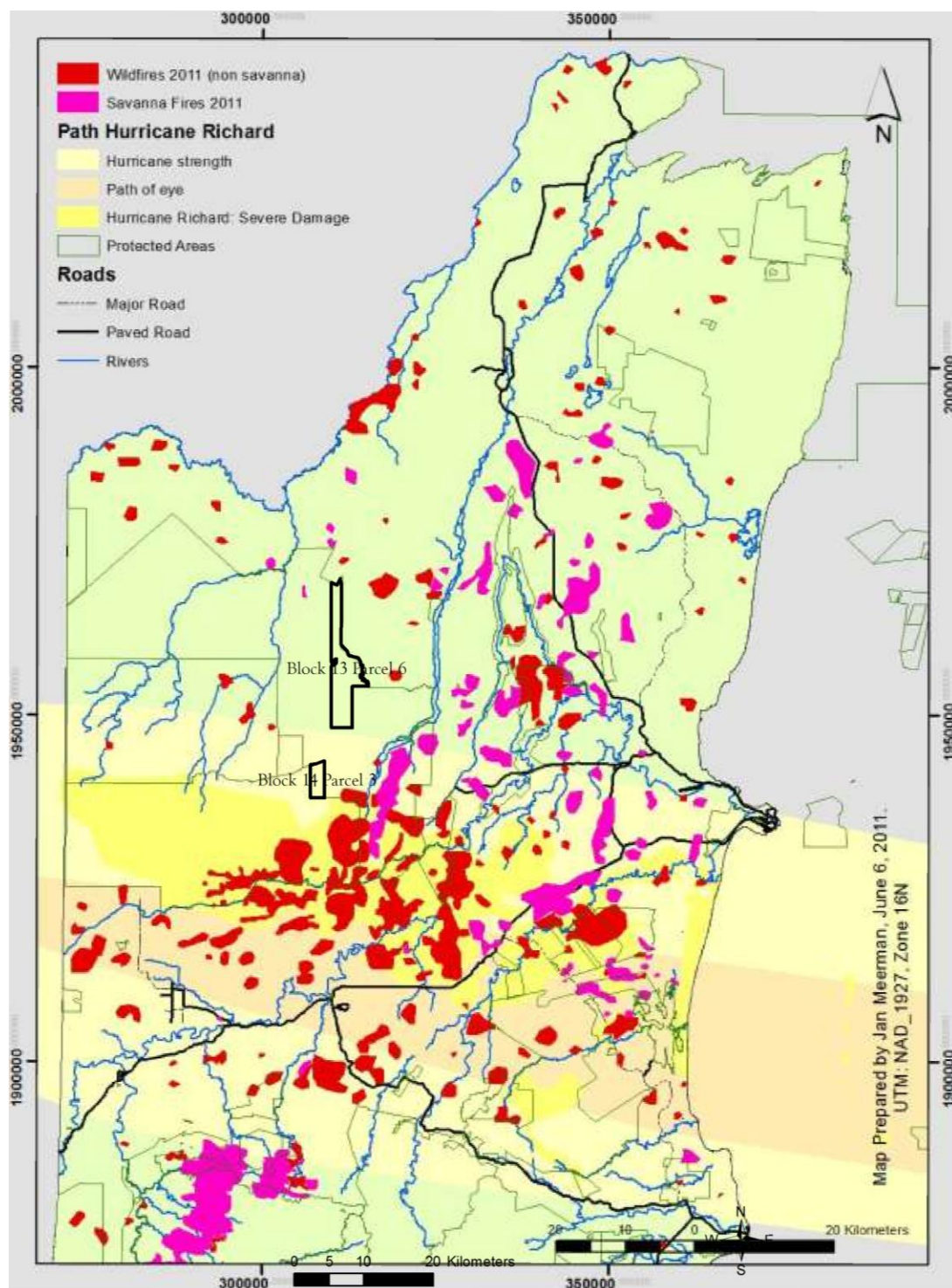


Figure 11. Meerman³⁵'s map of fire and hurricane damage

³⁵ Meerman, Jan. 2011. Provisional Report on the Belize 2011 Wildfires.

Table 17 $\Delta C_{P,DegF,i,t}$ Net Emissions as a result of degradation from Fire in the project case in the project area in each stratum

Year	Stratum 1: Lowland Forest			Stratum 2: Upland Forest			Stratum 3: Upland Forest - South		
	Area of deg	Net Emissions	Cum. Emissions	Area of deg	Net Emissions	Cum. Emissions	Area of deg	Net Emissions	Cum. Emissions
	ha	t CO ₂ e	t CO ₂ e	ha	t CO ₂ e	t CO ₂ e	ha	t CO ₂ e	t CO ₂ e
1996	0.00	0	0	0.00	0	0	0.00	0	0
1997	0.00	0	0	0.00	0	0	0.00	0	0
1998	0.00	0	0	0.00	0	0	0.00	0	0
1999	0.00	0	0	0.00	0	0	0.00	0	0
2000	0.00	0	0	0.00	0	0	0.00	0	0
2001	0.00	0	0	0.00	0	0	0.00	0	0
2002	0.00	0	0	0.00	0	0	0.00	0	0
2003	0.00	0	0	0.00	0	0	0.00	0	0
2004	0.00	0	0	0.00	0	0	0.00	0	0
2005	0.00	0	0	0.00	0	0	0.00	0	0
2006	0.00	0	0	0.00	0	0	0.00	0	0
2007	0.00	0	0	0.00	0	0	0.00	0	0
2008	0.00	0	0	0.00	0	0	0.00	0	0
2009	0.00	0	0	0.00	0	0	0.00	0	0
2010	0.00	0	0	0.00	0	0	0.00	0	0
2011	0.00	0	0	0.00	0	0	0.00	0	0
2012	0.00	0	0	0.00	0	0	0.00	0	0
2013	0.00	0	0	0.00	0	0	0.00	0	0
2014	0.00	0	0	0.00	0	0	0.00	0	0
2015	0.00	0	0	0.00	0	0	0.00	0	0

4.2.1.5.3 Total project GHG emissions

Since there are no emissions from fertilizer or biomass burning, project GHG emissions from non-CO₂ gases are equal to the emissions from fossil fuel combustion

Table 18 $GHG_{P-E,i,t}$ GHG Emissions resulting from fossil fuels, biomass burning, and nitrogen application

Year	Stratum 1: Lowland Forest	Stratum 2: Upland Forest	Stratum 3: Upland Forest - South	Stratum 1: Lowland Forest	Stratum 2: Upland Forest	Stratum 3: Upland Forest - South
	t CO ₂ e			Cumulative t CO ₂ e		
1996	26	51	26	26	51	26
1997	34	69	26	60	120	51
1998	34	69	26	94	189	77

1999	90	180	68	184	369	145
2000	34	69	26	219	437	170
2001	29	58	22	248	495	192
2002	5	10	4	253	505	196
2003	20	39	15	272	544	211
2004	68	135	51	340	680	261
2005	71	142	53	411	822	315
2006	19	38	14	430	860	329
2007	18	37	14	448	897	343
2008	79	158	59	528	1,055	402
2009	78	157	59	606	1,212	461
2010	88	176	66	694	1,387	527
2011	32	64	24	726	1,452	551
2012	32	64	24	758	1,516	575
2013	88	176	66	0	1,692	641
2014	88	176	66	0	1,867	707
2015	88	176	66	0	2,043	773

4.2.1.6 Total Project Emissions

Each of the component emissions are then summed together to arrive at the total amount of emissions resulting from the project per year.

Table 19 Net GHG Emissions for each component within each stratum in the project area under the Project Scenario

Year	Stratum 1: Lowland Forest					$\Delta C_{P,PlannedDeforestationAreas,i,t}$ t CO ₂ e
	Net Emissions from Deforestation	Net emissions from Degradation	Net Emissions from Natural Disturbance	GHG Emissions	Net Enhancements	
	$\Delta C_{P,DefPA,i,t}$	$\Delta C_{P,Deq,i,t}$	$\Delta C_{P,DistPA,i,t}$	GHG _{P-E,i,t}	$\Delta C_{P,Enh,i,t}$	
	t CO ₂ e					
1996	775	3,371	0	25.7	0	4,172
1997	775	3,371	0	34.3	0	4,180
1998	775	0	0	34.3	0	810
1999	775	0	0	90.0	0	865
2000	775	0	0	34.3	0	810
2001	5	0	0	29.0	0	34
2002	5	0	0	4.8	0	10
2003	5	0	0	19.7	0	25
2004	5	0	0	67.7	0	73
2005	0	0	0	70.9	0	71
2006	0	0	0	19.2	0	19
2007	0	0	0	18.4	0	18

2008	0	0	0	79.1	0	79
2009	0	0	0	78.3	0	78
2010	0	0	0	87.8	0	88
2011	0	0	0	32.1	0	32
2012	0	0	0	32.1	0	32
2013	0	0	0	87.8	0	88
2014	0	0	0	87.8	0	88
2015	0	0	0	87.8	0	88

Year	Stratum 2: Upland Forest					$\Delta C_{P,PlannedDeforestationAreas,i,t}$ t CO ₂ e
	Net Emissions from Deforestation	Net emissions from Degradation	Net Emissions from Natural Disturbance	GHG Emissions	Net Enhancements	
	$\Delta C_{P,DefPA,i,t}$	$\Delta C_{P,Deg,i,t}$	$\Delta C_{P,DistPA,i,t}$	GHG _{P-E,i,t}	$\Delta C_{P,Enh,i,t}$	
	t CO ₂ e					
1996	5,598	23,443	0	51.5	0	29,093
1997	5,598	23,443	0	68.6	0	29,110
1998	5,598	0	0	68.6	0	5,667
1999	5,598	0	0	180.0	0	5,778
2000	5,598	0	0	68.6	0	5,667
2001	87	0	0	57.9	0	145
2002	87	0	0	9.7	0	97
2003	87	0	0	39.4	0	127
2004	87	4,324	0	135.4	0	4,546
2005	0	3,859	0	141.9	0	4,001
2006	0	0	0	38.4	0	38
2007	0	0	0	36.8	0	37
2008	0	0	0	158.2	0	158
2009	0	0	0	156.5	0	157
2010	0	0	162,262	175.7	0	162,438
2011	0	0	0	64.3	0	64
2012	0	0	0	64.3	0	64
2013	0	0	0	175.7	0	176
2014	0	0	0	175.7	0	176
2015	0	0	0	175.7	0	176

	Stratum 3: Upland Forest - South
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Year	Net Emissions from Deforestation	Net emissions from Degradation	Net Emissions from Natural Disturbance	GHG Emissions	Net Enhancements	$\Delta C_{P,PlannedDeforestationAreas,i,t}$
	$\Delta C_{P,DefPA,i,t}$	$\Delta C_{P,Deg,i,t}$	$\Delta C_{P,DistPA,i,t}$	$GHG_{P-E,i,t}$	$\Delta C_{P,Enh,i,t}$	
	t CO ₂ e					t CO ₂ e
1996	0	9,263	0	25.7	0	9,289
1997	0	9,263	0	25.7	0	9,289
1998	0	0	0	25.7	0	26
1999	0	6,120	0	67.5	0	6,188
2000	0	0	0	25.7	0	26
2001	0	0	0	21.7	0	22
2002	0	0	0	3.6	0	4
2003	0	0	0	14.8	0	15
2004	0	0	0	50.8	0	51
2005	0	0	0	53.2	0	53
2006	0	0	0	14.4	0	14
2007	0	0	0	13.8	0	14
2008	0	1,178	0	59.3	0	1,237
2009	0	5,975	0	58.7	0	6,034
2010	0	6,210	0	65.9	0	6,276
2011	0	0	0	24.1	0	24
2012	0	0	0	24.1	0	24
2013	0	8,651	0	65.9	0	8,717
2014	0	5,653	0	65.9	0	5,719
2015	0	8,254	0	65.9	0	8,320

Table 20 Net GHG Emissions for each component within each stratum in the project area under the Project Scenario

Year	Net Emissions from Deforestation	Net emissions from Degradation	Net Emissions from Natural Disturbance	GHG Emissions	Net Enhancements	Total Cumulative	Total VCS Eligible Cumulative
	$\Delta C_{P,DefPA,i,t}$	$\Delta C_{P,Deg,i,t}$	$\Delta C_{P,DistPA,i,t}$	$GHG_{P-E,i,t}$	$\Delta C_{P,Enh,i,t}$	$\Delta C_{P,planned,t}$	$\Delta C_{P,planned}$
	t CO ₂ e					t CO ₂ e	
1996	6,373	36,078	0	102.9	0	42,554	42,554
1997	6,373	36,078	0	128.7	0	42,580	85,133
1998	6,373	0	0	128.7	0	6,502	91,635
1999	6,373	6,120	0	337.6	0	12,831	104,466

2000	6,373	0	0	128.7	0	6,502	110,968	
2001	92	0	0	108.6	0	201	111,169	
2002	92	0	0	18.1	0	110	111,280	110
2003	92	0	0	73.9	0	166	111,446	277
2004	92	4,324	0	253.9	0	4,670	116,115	4,946
2005	0	3,859	0	266.0	0	4,125	120,240	9,071
2006	0	0	0	72.0	0	72	120,312	9,143
2007	0	0	0	69.1	0	69	120,381	9,212
2008	0	1,178	0	296.7	0	1,474	121,856	10,686
2009	0	5,975	0	293.5	0	6,269	128,124	16,955
2010	0	6,210	162,262	329.4	0	168,802	296,926	185,757
2011	0	0	0	120.5	0	120	297,047	185,877
2012	0	0	0	120.5	0	120	297,167	185,998
2013	0	8,651	0	329.4	0	8,980	306,147	194,978
2014	0	5,653	0	329.4	0	5,982	312,130	200,960
2015	0	8,254	0	329.4	0	8,583	320,713	209,544

4.3 Leakage

Based on the analysis conducted in section 3.3.6, the leakage factor is set at 0.4.

Table 21 Parameters used to calculate leakage within one year for each baseline period

	Baseline Period: 1995-2004			Baseline Period: 2005-2014		
	Stratum 1: Lowland Forest	Stratum 2: Upland Forest	Stratum 3: Upland Forest - South	Stratum 1: Lowland Forest	Stratum 2: Upland Forest	Stratum 3: Upland Forest - South
$D\%_{planned,i,t}$	7.19%	7.19%	7.19%	9.94%	9.94%	7.19%
$\Delta C_{BSL,i}$	532	786	627	532	786	627
PF_c	52%	52%	52%	52%	52%	52%
$LK_{CP-ME, c,i}$	0.4	0.4	0.4	0.4	0.4	0.4

Table 22 Estimated Leakage caused by project activities per year (ΔC_{LK})

Year	Stratum 1: Lowland Forest	Stratum 2: Upland Forest	Stratum 3: Upland Forest - South	Net GHG Emissions	ΔC_{LK} Total Cumulative	ΔC_{LK} VCS Eligible Cumulative
			t CO ₂ e			
1996	16,099	38,016	12,913	67,028	67,028	
1997	16,099	38,016	12,913	67,028	134,056	
1998	16,099	38,016	12,913	67,028	201,084	
1999	16,099	38,016	12,913	67,028	268,112	

2000	16,099	38,016	12,913	67,028	335,140	
2001	16,099	38,016	12,913	67,028	402,167	
2002	16,099	38,016	12,913	67,028	469,195	67,028
2003	16,099	38,016	12,913	67,028	536,223	134,056
2004	16,099	38,016	12,913	67,028	603,251	201,084
2005	16,099	38,016	12,913	67,028	670,279	268,112
2006	22,256	52,556	17,853	92,664	762,944	360,776
2007	22,256	52,556	17,853	92,664	855,608	453,441
2008	18,405	43,461	14,763	76,630	932,238	530,071
2009	0	0	0	0	932,238	530,071
2010	0	0	0	0	932,238	530,071
2011	0	0	0	0	932,238	530,071
2012	0	0	0	0	932,238	530,071
2013	0	0	0	0	932,238	530,071
2014	0	0	0	0	932,238	530,071
2015	0	0	0	0	932,238	530,071

4.4 Summary of GHG Emission Reductions and Removals

4.4.1 Total Net GHG Emission reductions resulting from project activities

The total net greenhouse gas emissions reductions of the REDD project activity are calculated as follows:

$$C_{REDD,t} = \Delta C_{BSL} - \Delta C_P - \Delta C_{LK} \quad (22)$$

Where:

$C_{REDD,t}$	Total net greenhouse emission reductions at time t ; t CO ₂ -e
ΔC_{BSL}	Net greenhouse gas emissions under the baseline scenario; t CO ₂ -e
ΔC_P	Net greenhouse gas emissions within the project area under the project scenario; t CO ₂ -e (from M-MON)
ΔC_{LK}	Net greenhouse gas emissions due to leakage; t CO ₂ -e

Table 23 Total Net GHG Emission Reductions resulting from Rio Bravo Climate Action Project

	$\Delta C_{BSL,planned}$ Net GHG Emissions under baseline		$\Delta C_{P,Planned}$ DeforestationAreas Net GHG emissions under project		ΔC_{LK} Net GHG emissions due to leakage		C_{REDD} Total Net GHG Emission Reductions	
	Total Cumul.	VCS Eligible Cumul.	Total Cumul.	VCS Eligible Cumul.	Total Cumul.	VCS Eligible Cumul.	Total Cumul.	VCS Eligible Cumul.
	t CO ₂ e							
1996	333,735	0	42,554	0	67,028	0	224,153	0
1997	667,470	0	85,133	0	134,056	0	448,280	0
1998	1,001,204	0	91,635	0	201,084	0	708,485	0
1999	1,334,939	0	104,466	0	268,112	0	962,361	0

2000	1,668,674	0	110,968	0	335,140	0	1,222,566	0
2001	2,002,409	0	111,169	0	402,167	0	1,489,072	0
2002	2,336,144	333,735	111,280	110	469,195	67,028	1,755,669	266,596
2003	2,669,879	667,470	111,446	277	536,223	134,056	2,022,210	533,137
2004	3,003,613	1,001,204	116,115	4,946	603,251	201,084	2,284,247	795,174
2005	3,337,348	1,334,939	120,240	9,071	670,279	268,112	2,546,829	1,057,757
2006	3,798,705	1,796,296	120,312	9,143	762,944	360,776	2,915,449	1,426,376
2007	4,260,061	2,257,652	120,381	9,212	855,608	453,441	3,284,072	1,794,999
2008	4,641,412	2,639,003	121,856	10,686	932,238	530,071	3,587,318	2,098,246
2009	4,641,412	2,639,003	128,124	16,955	932,238	530,071	3,581,050	2,091,977
2010	4,641,412	2,639,003	296,926	185,757	932,238	530,071	3,412,248	1,923,176
2011	4,641,412	2,639,003	297,047	185,877	932,238	530,071	3,412,127	1,923,055
2012	4,641,412	2,639,003	297,167	185,998	932,238	530,071	3,412,007	1,922,935
2013	4,641,412	2,639,003	306,147	194,978	932,238	530,071	3,403,027	1,913,954
2014	4,641,412	2,639,003	312,130	200,960	932,238	530,071	3,397,044	1,907,972
2015	4,641,412	2,639,003	320,713	209,544	932,238	530,071	3,388,461	1,899,389

4.4.2 Calculation of VCS Buffer

The number of credits to be held in the permanence risk buffer (as per the VCS) is determined as a percentage of the total carbon stock benefits. This is equal to the net emissions in the baseline minus emissions from fossil fuel use and fertilizer use minus the net emissions in the project case minus emissions from fossil fuels and fertilizer use. Leakage emissions do not factor into the buffer calculations.

$$Buffer_{TOTAL} = Buffer_{PLANNED} + Buffer_{UNPLANNED} + Buffer_{DEGRAD-FW/C} \quad (23)$$

$$Buffer_{PLANNED} = \left(\left(\Delta C_{BSL,planned} - \sum_{t=1}^{t^*} \sum_{i=1}^M \epsilon_{FC,i,t} + N_2 O_{direct,i,t} \right) - \left(\Delta C_{P.(PlannedDeforestationAreas)} - \sum_{t=1}^{t^*} \sum_{i=1}^M \epsilon_{FC,i,t} + N_2 O_{direct,i,t} \right) \right) * (-Buffer\%) \quad (24)$$

$$Buffer_{UNPLANNED} = 0$$

$$Buffer_{DEGRAD-FW/C} = 0$$

Where:

$Buffer_{PLANNED}$	Buffer withholding for planned deforestation project areas; t CO ₂ -e
$Buffer_{UNPLANNED}$	Buffer withholding for unplanned deforestation project areas; t CO ₂ -e
$Buffer_{DEGRAD-FW/C}$	Buffer withholding for degradation through extraction of fuelwood project areas; t CO ₂ -e
$\Delta C_{BSL,planned}$	Net greenhouse gas emissions in the baseline from planned deforestation; t CO ₂ -e
$\Delta C_{BSL,unplanned}$	Net greenhouse gas emissions in the baseline from unplanned deforestation; t CO ₂ -e

$\Delta C_{BSL,degrad-FW/C}$	Net greenhouse gas emissions in the baseline from degradation caused by fuelwood collection and charcoal making; t CO ₂ -e
ΔC_P	Net greenhouse gas emissions within the project area under the project scenario; t CO ₂ -e
$E_{FC,i,t}$	Emission from fossil fuel combustion in stratum i in year t ; t CO ₂ -e
$N_2O_{direct-N,i,t}$	Direct N ₂ O emission as a result of nitrogen application on the alternative land use within the project boundary in stratum i in year t ; t CO ₂ -e
Buffer%	Buffer withholding percentage; %
i	1, 2, 3, ... M strata
t	1, 2, 3, ... t^* years elapsed since the start of the REDD VCS project activity

Information on the calculation of Buffer% can be found in the document: "Rio Bravo Non-Permanence Risk Report"³⁶

Table 24. Risk Rating

Risk Category	Risk Rating
a) Internal Risk	0
b) External Risk	0
c) Natural Risk	3.5
Overall Risk Rating (a + b + c)	3.5

However, the VCS states that the minimum buffer level shall be 10%. Therefore a 10% buffer was applied. Years when the buffer is negative are not included in the cumulative buffer withholding values.

Table 25 Buffer Withholding Options

	Buffer _{planned,t}	Buffer _{planned}	
	Buffer W/holding	Total Cum. Buffer W/holding	VCS Eligible Cumulative Buffer W/holding
	t CO ₂ e		
1996	29,126	29,126	
1997	29,126	58,252	
1998	32,734	90,985	
1999	32,117	123,103	
2000	32,734	155,836	
2001	33,362	189,198	
2002	33,364	222,562	33,364
2003	33,363	255,925	66,727
2004	32,927	288,852	99,653
2005	32,982	321,834	132,636
2006	46,134	367,968	178,770
2007	46,134	414,103	224,904
2008	38,011	452,114	262,916
2009	-603	452,114	262,916

³⁶ Annex Risk Assessment\Rio Bravo Non-Permanence Risk Report.doc

	Buffer _{planned,t}	Buffer _{planned}	
	Buffer W/holding	Total Cum. Buffer W/holding	VCS Eligible Cumulative Buffer W/holding
	t CO ₂ e		
2010	-16,854	452,114	262,916
2011	-2	452,114	262,916
2012	-2	452,114	262,916
2013	-872	452,114	262,916
2014	-572	452,114	262,916
2015	-832	452,114	262,916

4.4.3 Uncertainty Analysis

Uncertainty was estimated for emissions from both the baseline and the project scenario. Total project uncertainty is 16%, therefore an uncertainty deduction is required.

Table 26 Ex-post and with-project uncertainty of emissions and in project area

Carbon Pool	Stratum 1: Lowland Forest		Stratum 2: Upland Forest		Stratum 3: Upland Forest - South	
	Total Emissions	95% CI as % of mean	Total Emissions	95% CI as % of mean	Total Emissions	95% CI as % of mean
	t CO ₂ e		t CO ₂ e		t CO ₂ e	
C _{AB_Tree,i}	1,944	16%	21,714	15%	42,100	15%
C _{BB_Tree,i}	475	40%	3,290	15%	-	15%
C _{AB_nontree,i}	9	20%	49	46%	-	46%
C _{BB_nontree,i}	10	20%	24	46%	-	46%
C _{SOC,i}	1,446	40%	11,396	20%	-	20%
C _{WP,i}	26		131		-	
C _{deg}	6,742	43%	46,887	43%	18,527	43%
C _{AB_tree - post hurricane}			129,810	23%	-	0%
C _{BB_tree - post hurricane}			32,452	23%	-	0%
C _{BSL_road,sdecks}			7,798	13%	7,233	13%
C _{dest} +ΔC _{SOC_sk,i}			389	11%	1,035	11%
E _{BB}			-		-	
E _{P,SS,i}	10,652		253,941		68,894	
Uncertainty _{P,i}	28%		15%		15%	
Uncertainty _P	12%					

Table 27 Uncertainty in the Baseline, in the Project Scenario, and total C_{REDD_ERROR} for both baseline periods

1996-2005	2006-2015
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Uncertainty _{BSL}	8%	8%
Uncertainty _P	12%	12%
C _{REDD ERROR}	14.16%	14.16%

Table 28 Adjusted_C_{REDD,t} Cumulative total net GHG emission reductions at time t adjusted to account for uncertainty

	Adjusted_C _{REDD,t}	
	Total Cum.	VCS Elig. Cum.
	t CO ₂ -e	
1996	224,153	
1997	448,280	
1998	708,485	
1999	962,361	
2000	1,222,566	
2001	1,489,072	
2002	1,755,669	266,596
2003	2,022,210	533,137
2004	2,284,247	795,174
2005	2,546,829	1,057,757
2006	2,915,449	1,426,376
2007	3,284,072	1,794,999
2008	3,587,318	2,098,246
2009	3,581,050	2,091,977
2010	3,412,248	1,923,176
2011	3,412,127	1,923,055
2012	3,412,007	1,922,935
2013	3,403,027	1,913,954
2014	3,397,044	1,907,972
2015	3,388,461	1,899,389

4.4.4 Calculation of Verified Carbon Units

To estimate the number of Verified Carbon Units (VCUs) for the monitoring period $T = t_2 - t_1$, the applied methodology uses the following equation:

$$VCU_t = \left(Adjusted_C_{REDD,t_2} - Adjusted_C_{REDD,t_1} \right) - Buffer_{TOTAL} \quad (25)$$

Where:

VCU_t	Number of Verified Carbon Units at time $t = t_2 - t_1$; VCU
$Adjusted_C_{REDD,t_2}$	Cumulative total net GHG emissions reductions at time t_2 adjusted to account for uncertainty; t CO ₂ -e
$Adjusted_C_{REDD,t_1}$	Cumulative total net GHG emissions reductions at time t_1 ; t CO ₂ -e
$Buffer_{TOTAL}$	Total permanence risk buffer withholding; t CO ₂ -e

Table 29 Total Net GHG Emission Reductions resulting from Rio Bravo Climate Action Project

Total VCUs (t CO ₂ -e)		
Year	Annual Accrual	VCS Cumulative
2002	233,233	233,233
2003	233,178	466,411
2004	229,110	695,521
2005	229,600	925,121
2006	322,486	1,247,606
2007	322,489	1,570,095
2008	265,235	1,835,330
2009	-6,269	1,829,062
2010	-168,802	1,660,260

5 ADDITIONAL INFORMATION

See cited supplementary documents for additional information.