Rotunda Forest Carbon Project – Monitoring Report

Document Prepared by GreenRaise Consulting GmbH

Project Title	Rotunda Forest Carbon Project
Version	2.0
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1. Project Details

1.1. Summary Description of the Implementation Status of the Project

The objective of the carbon offset project is to achieve greenhouse gas (GHG) emission reductions and removals through the cessation of commercial harvesting. The project will implement the methodologies outlined with the Verified Carbon Standard (VCS) VM0012 – Improved Forest Management in Temperate and Boreal Forests (LtPF), v1.2.

The project is located on freehold 1,556-hectare property within the Hunedoara County of Romania. Prior to the implementation of the project, the lands were managed under the forest management plan "Fondului Forestier Proprietate Privata Apartinand S.C. Rotunda S.R.L., Miercurea Ciuc".

Through the use of the Operational-Scale Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) - Version 1.2, carbon emission offsets will be calculated by comparing a project scenario of the cessation of commercial harvesting, to a baseline scenario. The most plausible baseline scenario consists of the continuation of allowable commercial harvesting for the next 100 years. Under the baseline scenario a harvest schedule is implemented with the typical regional practice of clearcut logging and comparable regional practices.

The project scenario consists of conservation management activities, wherein SC Rotunda SRL (Rotunda) undertakes the carbon offset project and ecosystem protection. The project scenario consists of a low level of timber removal as part of conservation management activities for ecosystem/habitat enhancement and risk management. Under this monitoring period, the gross total of GHG emission reductions is equal to 7,657 tCO_2e.

As of January 25, 2021, the project status is "Listed" in preparation for pursuing the status of "Under Validation".

1.2. Sectoral Scope and Project Type

Sectoral Scope 14

Improved Forest Management (IFM)

Logged to Protected Forest (LtPF)

The Rotunda Forest Carbon Project is not a grouped project.

1.3. Project Proponent

Table 1: Project Proponent information

Organization name	SC Rotunda SRL
Contact person	Nikolaus Pongracz
Role in the project	Project Proponent, Listing Representative
Title	General Manager
Address	Bulevardul Timisorarei nr. 10, SPII/A, Miercurea Ciuc Harghita, Romania
Telephone	n/a
Email	n/a
Organization name	Global Forest Support GmbH
Role in the project	Project Proponent, Authorized Representative
Contact person	Jason Zimmermann
Title	Director
Address	1010 Vienna, Rudolfsplatz 9/8, Austria
Telephone	+1 604 619 1585
Email	jason@green-raise.com

1.4. Other Entities Involved in the Project

Table 2: Other entity information

Organization name	GreenRaise Consulting GmbH
Role in the project	Authorized Representative, Project Developer
Contact person	Jason Zimmermann
Title	Director
Address	1010 Vienna, Rudolfsplatz 9/8, Austria
Telephone	+1 604 619 1585
Email	jason@green-raise.com

1.5. Project Start Date

The project start date is January 1, 2018. As of January 1, 2018, S.C. Rotunda S.R.L. was issued a Forest Management Plan enabling the commencement of legal harvesting within the Rotunda estate. From January 1, 2018 – July 29, 2019 harvesting activities on the project property occurred in a minimal capacity and as of July 30, 2019, harvesting activities were ceased for the purpose of initiating a forest protection program (the Rotunda Forest Carbon Project).

1.6. Project Crediting Period

The project crediting period is from 01/01/2018 to 12/31/2047 with a total length of 30 years.

1.7. Project Location

The Rotunda property is located in western Romania adjacent to the Retezat Mountains in Hunedoara County (Figure 1). The Rotunda property is a total area of 1,556 hectares comprised of non-contiguous parcels. The property is bounded by Lake Gura Apelor, state owned lands, private lands, public grazing properties and public forest lands. The property has been surveyed.

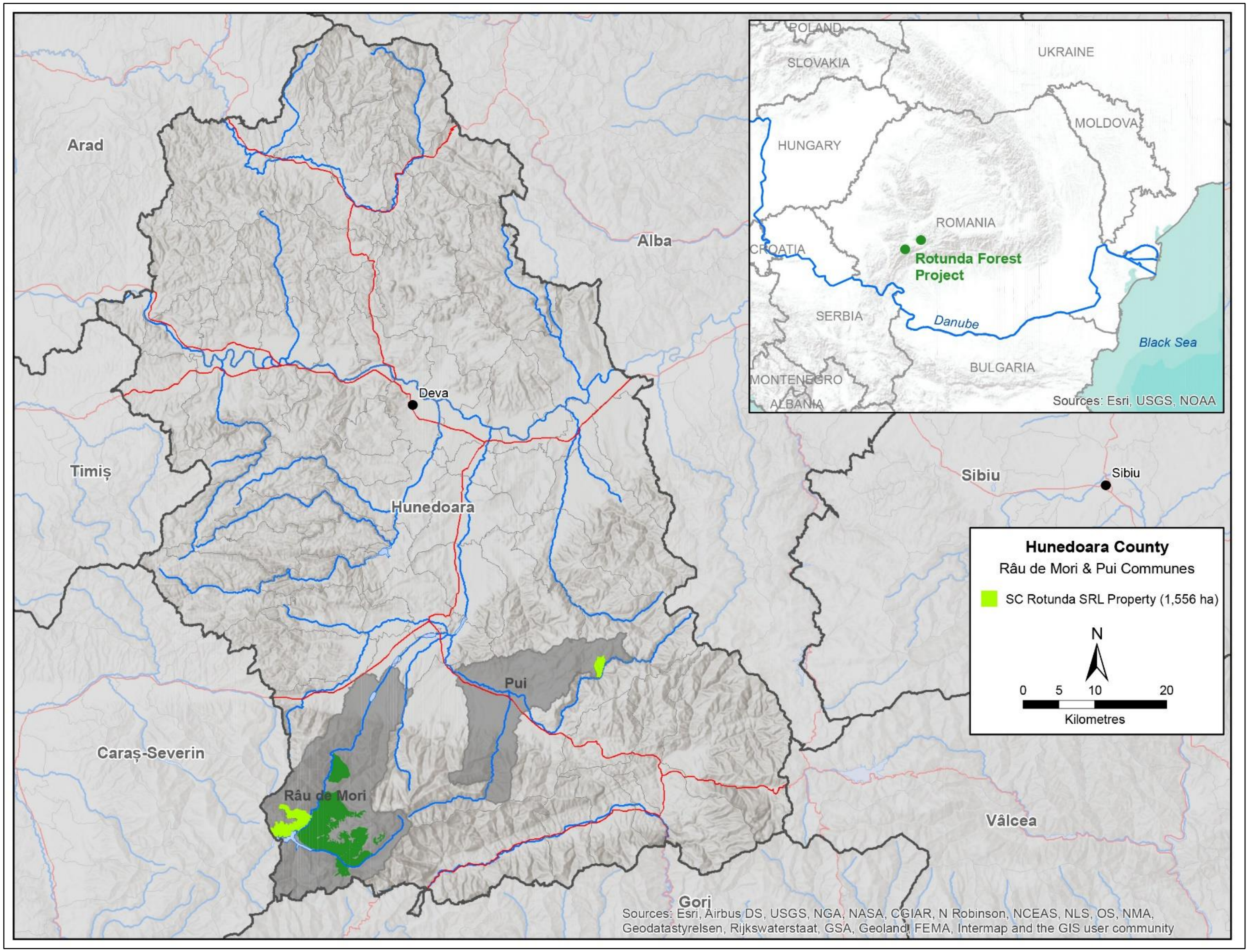

Figure 1: Overview location of SC Rotunda SRL estate (shown in green) and the Rotunda Forest Carbon Project (shown in light green).

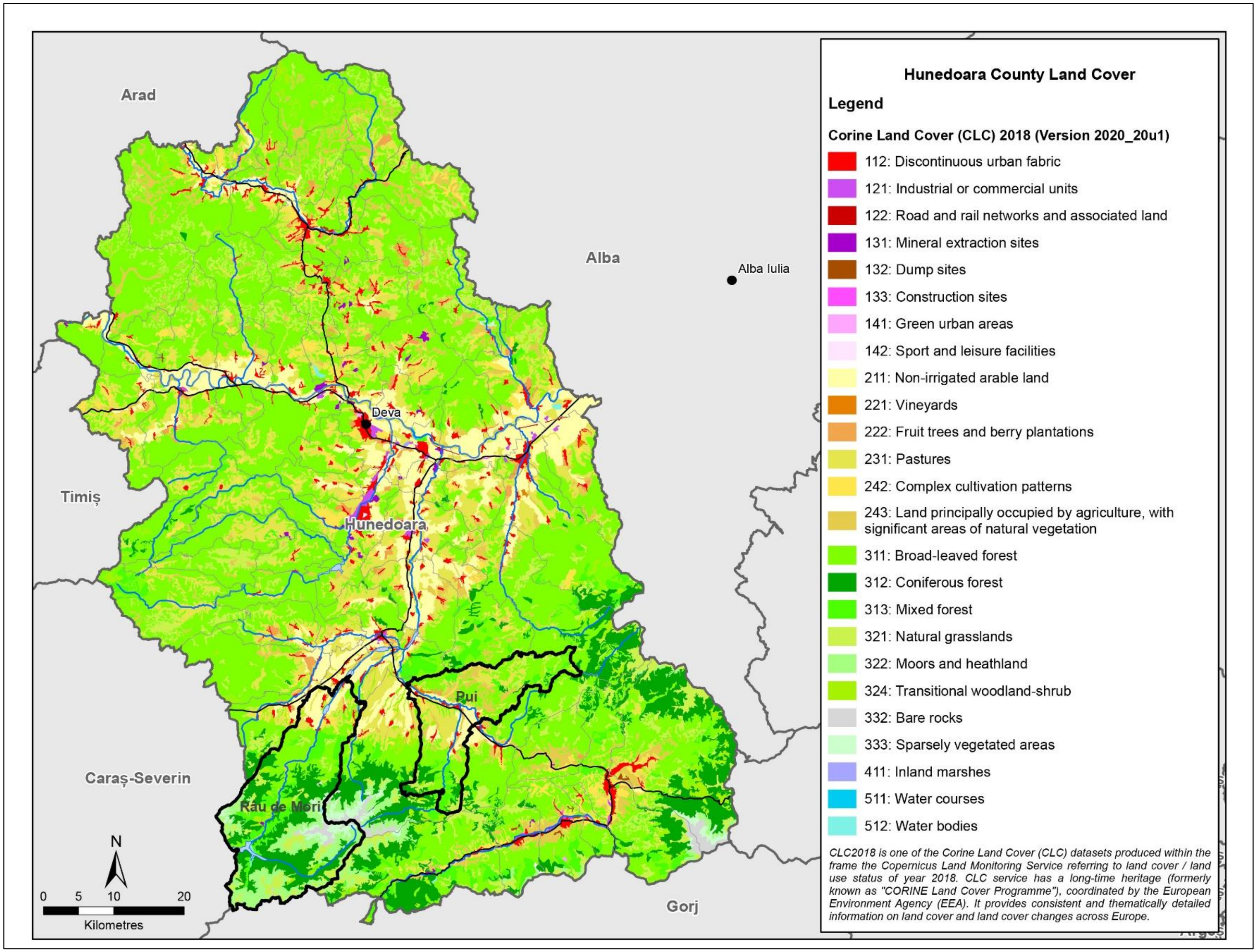

Figure 2: Landcover overview of Hunedoara County (location of Rotunda project).

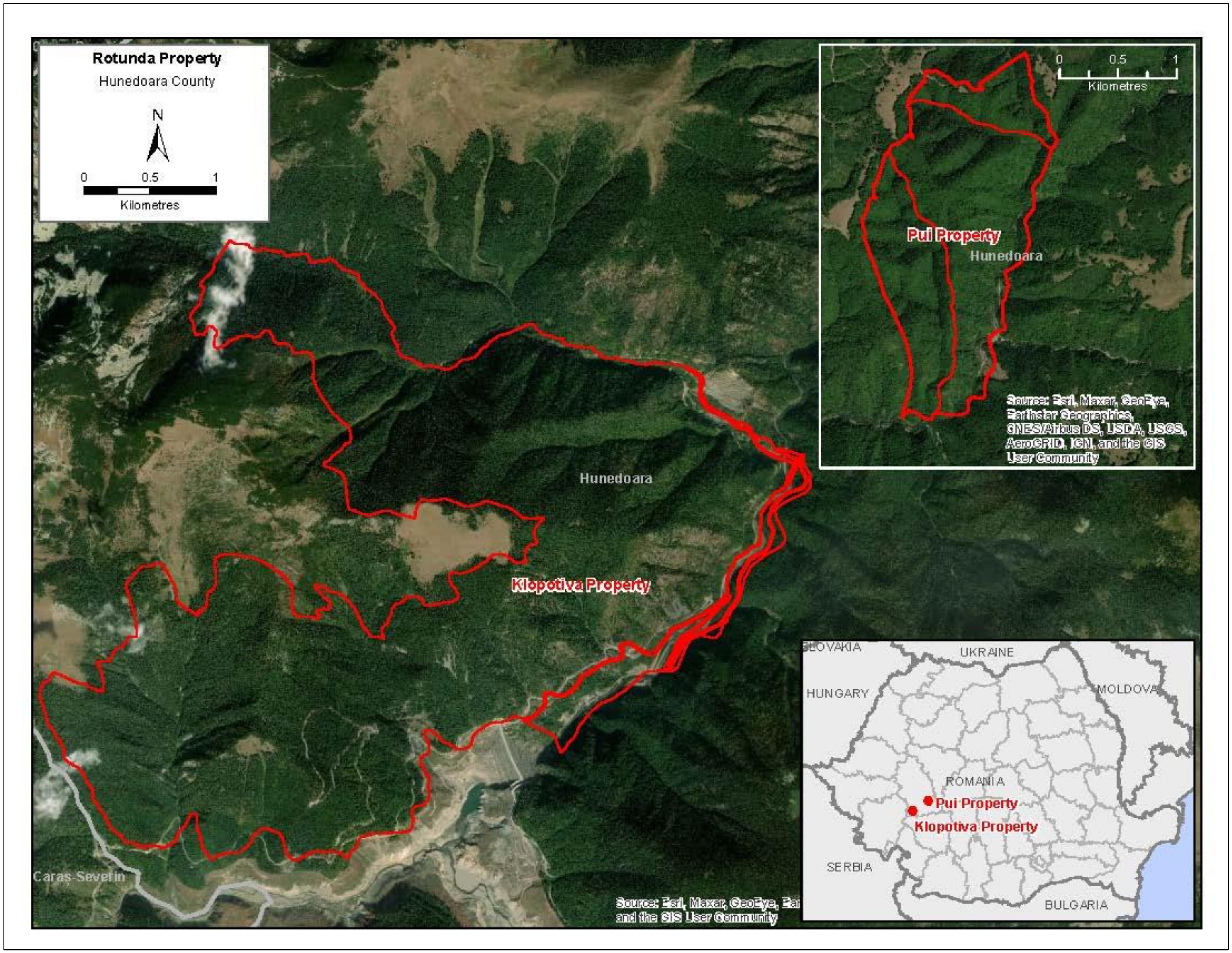

Figure 3: Detailed overview of Rotunda Forest Carbon Project property.

1.8. Title and Reference of Methodology

The methodology selected for the project is VM0012: Improved Forest Management in Temperate and Boreal Forests (LtPF) v1.2. Additional tools to be applied include:

- AFOLU Non-Permanence Risk Tool: VCS Version 3 (Procedural document 19 October 2016, v3.3)
- VT0001 – Tool for Demonstrating and Assessment of Additionality in VCS Agriculture, Forestry, and Other Land Use (AFOLU) Project Activities – Version 3.0, Sectoral scope 14.

1.9. Participation under Other GHG Programs

Not applicable.

1.10. Other Forms of Credit

Not applicable

1.11. Sustainable Development

As a member of the United Nations, Romania has committed to achieving development targets set out in by the Sustainable Development Summit. The Sustainable Development Goals outline 17 target areas, including (#15) to "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss". The focus of conservation and improved forest management within the Verra VM0012 standards directly contribute to the accomplishment of this goal. In addition, the implementation of this project also addresses factors related to the "Taking urgent action to combat climate change and its impacts" (#13) through the development of carbon offsets and alternative revenue streams.

The monitoring and reporting involved within this project can also lead to more accurate estimates of carbon sequestration and storage within forested lands in Romania. This information is vital to estimating national carbon emissions.

2. Safeguards

2.1. No Net Harm

There are no known or anticipated potential negative and socio-economic impacts related to the Rotunda Forest Carbon Project, specifically due to the nature of the project being the retention of natural forests. Following the procedures described within the GreenRaise, Greenhouse Gas – Safeguards Standard Operating Procedure (SOP) a Life Cycle and Aspects analysis was conducted. Refer to Section 2.5 below for a full description of this process.

2.2. Local Stakeholder Consultation

Local stakeholder consultation was conducted for a 30-day period from November 20, 2020 and December 20, 2020, prior to project validation. Consultation was conducted both via electronic documents delivered by email, as well as an in person meeting held on November 23, 2020 at the office of the Ocolul Silvic Retezatul Clopotiva Râu de Mori forestry District. The meeting was chaired by Nikolaus Pongracz of SC Rotunda SRL. Attendance was taken at local stakeholder meetings and is kept on file. Stakeholder Information relating to the project design and implementation, results of monitoring, any risks, costs or benefits to local stakeholders, all relevant law and regulations covering workers' rights in Romania, and the validation and verification process was provided via the GreenRaise website (https://green-raise.com/projects/). Links to the Verra Project Registry are also provided on the GreenRaise website. If required throughout the life of the project, any additional information that is required to be communicated to local stakeholders will follow the same process of electronic correspondence via email and information provided via the GreenRaise website.

An online form was made available on the GreenRaise website and was used to collect stakeholder comments and feedback. All responses from this form were automatically entered into a Consultation Database managed by GreenRaise. This form will remain accessible to the public throughout the lifetime of the project, allowing for continual stakeholder engagement.

All public comments received through the online comment form were recorded within the Consultation Database. Response, and any required project design updates to the project design relating to comments received from Stakeholders were also tracked within the Consultation Database. The Consultation Database will be made available to the VVB during project Validation and Verification. Refer to the GreenRaise GHG - Safeguards SOP for additional details relating to Stakeholder consultation processes.

To date, no comments have been received through the local stakeholder consultation process.

2.3. AFOLU-Specific Safeguards

Refer to the GreenRaise GHG – Safeguards SOP for details relating to the process used to determine local stakeholder identification. Additionally, the SOP outlines the Life Cycle and Aspect Analyses used to determined risks to local stakeholders and their resources.

Table 3 below outlines the identified aspects, impacts, potential risks, risk category (based on Table 1 within the GHG-Safeguards SOP), risk ranking (based on the Risk Ranking Matrix within the GHG – Safeguards SOP) and mitigation measures applied (if any).

Grievance Redress Procedure

GreenRaise has developed a Grievance Redress procedure which is outlined within the GHG – Safeguards SOP. Similar to the process for Stakeholder Consultation, the Grievance Procedures as well as a Grievance Submission Form are posted on the GreenRaise website (https://green-raise.com/projects/). All grievances submitted to GreenRaise will be tracked utilizing the Grievance Record Database.

Table 3: Aspects Analysis Results

Activity	Aspect	Impact	Potential Risk to local Stakeholders	Risk Category	Risk Rating and Justification	Mitigation Measures (implemented by project proponent)
Halting/ reduction of harvesting activities: Reduced Impact Logging (RIL), Logged to Protected Forest (LtPF), Extended Rotation Age / Cutting Cycle (ERA)	Reduced/ no requirement for harvesting labour	Loss of income/ livelihood	Loss of income to local communities could result in the degradation of local communities (i.e., reduction in community resources, loss of community members due to moving, etc.).	Social/ Socio economic	**Low** – Baseline harvest is low volume of timber; labour requirements are minimal.	Mitigation Measures are not required risks being designated as "Low Risk".
	Reduction/ no requirement for energy (fuel) consumption	Loss of income/ livelihood	Loss of income to local economy due to reduced need for fuel.	Social/ Socio economic	**Low** – Baseline harvest is low volume of timber; fuel requirements are minimal	
	Reduction of fuelwood produced	Loss of wood for heating/ fuel purposes	Loss of access to fuel source for home heating	Social/ Socio economic	**Low** – Continued hygiene harvests are intended to produce fuel wood for local communities.	
	Public Access reduced or denied	Public recreation opportunities reduced or denied	Increase in illegal trespass instances. Reduced public health (mental and	Social/ Socio economic Traditional/ Human Rights	**Low** – Public access will not be reduced in project scenario	

Activity	Aspect	Impact	Potential Risk to local Stakeholders	Risk Category	Risk Rating and Justification	Mitigation Measures (implemented by project proponent)
			physical) due to reduced access to recreation			
		Public access for foraging/ hunting purposes reduced or denied	Increase in illegal trespass instances. Reduced access to food sources		**Low** – Public access will not be reduced in project scenario	
	Reduction in harvesting/ controlled burns for purposes of fire prevention	Increase risk of forest fire	Local communities exposed to higher risk of forest fire.	Environmental	**Low** – Rotunda Forest Carbon Project area is not located near local communities.	
	Complete termination of project area maintenance	Road failure	Increased landslide risk to local communities. Watershed/ water quality degradation due to landslides and lack of sediment control.	Environmental	**Low** – Rotunda will continue maintenance of the project area (i.e., completing hygiene cuttings)	
		Pest or Disease Outbreak	Spread of disease to local community forests. Watershed/ water quality degradation due to transition to	Environmental		

Activity	Aspect	Impact	Potential Risk to local Stakeholders	Risk Category	Risk Rating and Justification	Mitigation Measures (implemented by project proponent)
			low productivity stands			
		Public safety	Increase in accident or injury within project area accessible to public	Social/ Socio - economic	**Low** – Rotunda will continue maintenance of the project area (i.e., completing hygiene cuttings)	
	Property rights are undefined/ disputed	Loss of property rights	Project encroaches on private property Project encroaches on government property Project relocates people off their lands	Legal Social/ Socio economic	**Low** – Rotunda property rights have been verified and are not disputed	Additional measures: refer to *Respect for Local Stakeholder Resources: Property Rights (GHG Safeguards SOP)*

Activity	Aspect	Impact	Potential Risk to local Stakeholders	Risk Category	Risk Rating and Justification	Mitigation Measures (implemented by project proponent)
	Participation in project design, implementation, and/or consultation	Safety of local stakeholders	Increased risk to stakeholder safety due to opposing opinions, cultural/ religious differences, land holder grievances or disputes, government or local oppression of freedom of expression.	Social/ Socio economic	**Low** – Refer to Universal Control; There is no evidence of the suppression of freedom of speech within Romania.	Universal Control = All stakeholder contact information (Name, Address, etc.) will be kept confidential. Stakeholder responses will be number coded as to keep public record of responses anonymous.

3. Implementation Status

3.1. Implementation Status of the Project Activity

Timber harvest operations within the Rotunda land base were ceased in 2019. Since this time, industrial activities were restricted to the development of one road to improve site access, with no other operations occurring. As such, the project start date has been set as 01/01/2018. Project monitoring began in December 2020 with the implementation of permanent sample plots in the field. Spatial monitoring was also started at this time, with the implementation of spatial tracking for disturbances which affect ≥4ha cumulatively. No market leakage is anticipated for this project as additional lands are not available for compensatory forest harvesting. Non-permanence risk factors and forestry related aspects related to them shall be monitored by local forest professionals on a regular basis, as necessary.

3.2. Deviations

3.2.1. Methodology Deviations

The monitoring methodology required two deviations for completion. The first was the combination of permanent sample plots (PSPs) used during field sampling for Analysis Units (AU) 3 and 7. These AUs represent softwood stands on poor sites in management units J and M, as defined by the Rotunda forest inventory. Analysis Unit 3 only covers 1.34 ha of non-continuous land, inhibiting the permanent sample plot establishment goal of 4 plots per AU. To correct this, the area of AU 3 was combined with AU 7 to create a combined area of 337.2 ha. This combination was only made for field plot measurements. The second deviation is related to the number of plots completed at submission. The target PSP establishment was 4 PSPs per analysis unit. As sampling was initiated in December 2020, a total of 24 plots were established on the land base. Winter conditions prevented the completion of all plots, so the remaining 4 plots are to be established once weather conditions do not impact worker safety and sampling operations. Despite the reduction in sampling plots completed, each analysis unit had a minimum of 2 plots established for field measurements. Neither of the deviations listed impact the conservativeness of GHG emission reductions or removals, or any other part of the monitoring methodology.

3.2.2. Project Description Deviations

Not applicable.

3.3. Group Projects

Not applicable.

4. Data and Parameters

4.1. Data and Parameters Available at Validation

Data / Parameter	ABSL,i, APRJ,i
Data unit	Hectares
Description	Respective areas of baseline and project polygon, i for all project instances
Source of data	Spatial inventory data
Value applied	Each polygon has an area
Justification of choice of data or description of measurement methods and procedures applied	2018 Rotunda Management Plan
Purpose of the data	Required for baseline and project calculations
Comments	Includes delineation and identification of non-timber harvesting landbase area polygons.

Data / Parameter	CF
Data unit	t C t-1 d.m.
Description	Carbon fraction of dry matter
Source of data	IPCC 2006
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	Best available data
Purpose of the data	Required for baseline and project calculations
Comments	Imbedded in CBM-CFS3 EU-AIDB

Data / Parameter	Ri
Data unit	unitless
Description	Root:shoot ratio in polygon, i
Source of data	CBM-CFS3 EU-AIDB default values
Value applied	CBM-CFS3 variants calculates belowground biomass as a function of species and tree size.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 data is widely reviewed and accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,NATURAL,i,t, fPRJ,NATURAL,i,t
Data unit	unitless (0 < fBSL,NATURALi, fPRJ,NATURAL,i,t < 1)
Description	The proportion of biomass that dies from natural mortality in polygon, i, year, t, in the baseline and project cases, respectively.
Source of data	Modeled by CBM-CFS3 using CBM-CFS3 EU-AIDB for Spatial Unit (SPU) 220
Value applied	Default settings in CBM-CFS3 for Spatial Unit (SPU) 220.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,HARVEST,i,t, fPRJ,HARVEST,i,t
Data unit	unitless (0 < fBSL,HARVESTi, fPRJ,HARVEST,i,t < 1)
Description	The proportion of biomass removed by harvesting from polygon, i, in year, t, in the baseline and project cases, respectively.
Source of data	Calculated by CBM-CFS3.
Value applied	Default settings in CBM-CFS3 for Spatial Unit (SPU) 220
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,DAMAGE,i,t, fPRJ,DAMAGE,i,t
Data unit	unitless (0 < fBSL,DAMAGEi, fPRJ,DAMAGE,i,t < 1)
Description	The proportion of additional biomass removed by for road and landing construction in polygon, i, year, t, in the baseline and project cases, respectively.
Source of data	As described in the management plan for road development. Monitoring data on an ex-post basis in the project scenario. (See page 11 of the management Plan for details.) 10.32km
Value applied	Variable on an ex-post basis in the project scenario - digitized in the project scenario on an ex-post basis if visible in remote sensing, or captured by standing stocking estimates. Captured within the Clearing component of the baseline scenarios.
Justification of choice of data or description of measurement methods and procedures applied	Estimated based on expert opinion based on regional experience.

Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,BLOWDOWN,i,t, fPRJ,BLOWDOWN,i,t
Data unit	unitless (0 < fBSL,BLOWDOWNi, fPRJ,BLOWDOWN,i,t < 1)
Description	The proportion of live aboveground tree biomass subject to blowdown in polygon, i, year, t, in the baseline and project cases, respectively.
Source of data	Included within the natural mortality factors calculated in fBSL,NATURAL,i,t, fPRJ,NATURAL,i,t by CBM-CFS3 Also captured by spatial monitoring if >4ha, which would be incorporated as a new polygon on an ex-post basis.
Value applied	Zero for the baseline and project ex-ante calculations (part of the natural mortality modeling in CBM-CFS3).
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,BRANCH,i,t, fPRJ,BRANCH,i,t
Data unit	unitless (0 < fBSL,BRANCHi, fPRJ,BRANCH,i,t < 1)
Description	The proportion of aboveground tree biomass comprised of branches > 2 in diameter in polygon, i, year, t, in the baseline and project cases, respectively.
Source of data	Calculated within CBM-CFS3
Value applied	Variable, see source of data.

Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	fBSL,BUCKINGLOSS,i,t, fPRJ,BUCKINGLOSS,i,t
Data unit	unitless (0 < fBSL,BUCKINGLOSSi, fPRJ,BUCKINGLOSS,i,t < 1)
Description	The proportion of the log bole biomass left on site after assessing and/or merchandizing the log bole for quality, in polygon, i, year, t, in the baseline and project cases, respectively.
Source of data	CBM-CFS3 default values for SPU220.
Value applied	CBM-CFS3 default values for SPU220.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,SNAGFALLDOWN,i,t, fPRJ,SNAGFALLDOWN,i,t
Data unit	unitless (0 < fBSL,SNAGFALLDOWNi, fPRJ,SNAGFALLDOWN,i,t < 1)
Description	The proportion of snag biomass in polygon, i, year, t, that falls over, in the baseline and project cases, respectively.
Source of data	Modeled by CBM-CFS3

Value applied	Variable, depending on species and dbh. Modeled by species and age class within CBM-CFS3.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,LWDECAY,i,t, fPRJ,LWDECAY,i,t
Data unit	unitless (0 < fBSL,LWDECAYi, fPRJ,LWDECAY,i,t < 1)
Description	The annual proportional loss of lying dead biomass due to decay, in polygon i, year, t in the baseline and project cases, respectively.
Source of data	Modeled by CBM-CFS3
Value applied	CBM-CFS3 default settings for SPU220.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,SWDECAY,i,t, fPRJ,SWDECAY,i,t
Data unit	unitless (0 < fBSL,SWDECAYi, fPRJ,SWDECAY,i,t < 1)
Description	The proportional loss of snag biomass due to decay, in polygon, i, year, t, in the baseline and project cases, respectively.
Source of data	Modeled by CBM-CFS3

Value applied	CBM-CFS3 default settings for SPU220.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	fBSL,DBGDECAY,i,t, fPRJ,DBGDECAY,i,t
Data unit	unitless (0 < fBSL,DGBDECAYi, fPRJ,DBGDECAY,i,t < 1)
Description	The proportional loss of dead belowground biomass due to decay, in polygon i, year, t, in the baseline and project cases, respectively.
Source of data	Modeled by CBM-CFS3
Value applied	CBM-CFS3 default settings for SPU220.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

Data / Parameter	EM
Data unit	%
Description	An estimate of model error based on the relative area-weighted difference between model-predicted values of carbon storage and those values measured in field plots
Source of data	Model output and field data (see Equation 60a)
Value applied	0.77%

Justification of choice of data or description of measurement methods and procedures applied	Value determined using approach described in the VM0012 Methodology
Purpose of the data	Calculation of baseline & project emissions
Comments	

Data / Parameter	EI
Data unit	%
Description	An estimate of Inventory sampling error calculated as the 90% confidence limit of the area-weighted differences between the model-predicted values of carbon storage and those values measured in field plots
Source of data	Model output and field data (see Equation 60c)
Value applied	1.97%
Justification of choice of data or description of measurement methods and procedures applied	Value determined using approach described in the VM0012 Methodology
Purpose of the data	Calculation of baseline & project emissions
Comments	

Data / Parameter	EP
Data unit	%
Description	An estimate of total project error used to determine the uncertainty factor.
Source of data	Model output and field data (see Equation 60f)
Value applied	2.75%

Justification of choice of data or description of measurement methods and procedures applied	Value determined using approach described in the VM0012 Methodology
Purpose of the data	Calculation of baseline & project emissions
Comments	

Data / Parameter	ERy,ERR,
Data unit	%
Description	The uncertainty factor calculated for year 'y' (See Section 4.4.3)
Source of data	Model output and field data (see Equation 60f)
Value applied	1.5%
Justification of choice of data or description of measurement methods and procedures applied	Value determined using approach described in the VM0012 Methodology
Purpose of the data	Calculation of baseline & project emissions
Comments	

Data / Parameter	MLF_y
Data unit	%
Description	The market leakage factor determined for year 'y'
Source of data	Determined based upon the approach defined in Section 3.3
Value applied	0%
Justification of choice of data or description of measurement methods and procedures applied	Value determined using the latest version of the VCS Market Leakage Tool as defined in Agriculture, Forestry and Other Land Use (AFOLU) Requirements v3.6 and specified in the VM0012 Methodology
Purpose of the data	Calculation of leakage

Comments	

Data / Parameter	Component Ratio Method (Biomass Expansion Factors)
Data unit	Unitless
Description	Used to convert height and DBH into biomass of component pools. Utilized to calculate biomass measured in field plots.
Source of data	Modeled by CBM-CFS3 (FVS CRM).
Value applied	CBM-CFS3 default settings for SPU220.
Justification of choice of data or description of measurement methods and procedures applied	CBM-CFS3 is widely accepted.
Purpose of the data	Required for calculation of baseline and project emissions
Comments	

4.2. Data and Parameters Monitored

Data / Parameter	APRJ,i
Data unit	Hectares
Description	Area of forest land in polygon, i
Source of data	Latest version of the spatial inventory data.
Description of measurement methods and procedures to be applied	GIS inventory data updated from GPS coordinates and Remote Sensing data.
Frequency of monitoring/recording	Prior to every verification period
Value monitored	See inventory data
Monitoring equipment	Visual, satellite, aerial photos, LiDAR data
QA/QC procedures to be applied	Standard GIS QA/QC procedures. GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)

Purpose of the data	Required for project calculations
Calculation method	Determined from GIS software
Comments	

Data / Parameter	APSP,i,
Data unit	Hectares
Description	Area of permanent sample plot in polygon, i
Source of data	Field measurement
Description of measurement methods and procedures to be applied	Fixed radius permanent sample plot design
Frequency of monitoring/recording	Plot measurements are repeated on 5-year intervals
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	GPS, measuring tape
QA/QC procedures to be applied	GPS of plot center. GreenRaise Standard Operating Procedures (SOP) followed, including check cruising processes.
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Measured
Comments	

Data / Parameter	$DBH_{i,t}$
Data unit	cm
Description	Diameter at breast height measured for each tree in the sample plot at time, t
Source of data	Field measure
Description of measurement methods and procedures to be applied	Field measurements in permanent sample plots. Measurement with DBH tape for trees ≥ 5cm in DBH.
Frequency of monitoring/recording	Individual plot tree re-measurements are repeated on 5-year intervals

Value monitored	See compiled plot data MS Excel File
Monitoring equipment	DBH tape, data logger
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Measured
Comments	

Data / Parameter	$Height_{i,t}$
Data unit	m
Description	Tree height measured for each tree in the sample plots at time, t
Source of data	Field measure
Description of measurement methods and procedures to be applied	Field measurements in permanent sample plots. Measurement with vertex to nearest 0.1m for trees ≥ 5cm DBH.
Frequency of monitoring/recording	Individual plot tree re-measurements are repeated on 5-year intervals
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	Vertex IV type Hypsometer, a transit, a clinometer, a relaskop, a laser or other instrument designed for the measuring height.
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Measured
Comments	

Data / Parameter	BAG i,t
Data unit	t d.m. ac^{-1}

Description	Aboveground live tree biomass in polygon, i, year, t, in the project case.
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Calculated from Heighti,t, DBHi,t, and APSPi,
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Above ground biomass for each tree within a permanent sample plot will be calculated using plot data entered into CBM-CFS3.
Comments	

Data / Parameter	BBG i,t
Data unit	t d.m. ac^{-1}
Description	Belowground live tree biomass in polygon, i, year, t, in the project case.
Source of data	Derived from above ground biomass calculations within permanent sample plots.
Description of measurement methods and procedures to be applied	Calculated using plot data in CBM-CFS3
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	

QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Calculated using plot data in CBM-CFS3
Comments	

Data / Parameter	BTOTAL i,t
Data unit	t d.m. ac^{-1}
Description	Sum of BAGi,t and BBGi,t
Source of data	Derived from above ground biomass calculations within permanent sample plots.
Description of measurement methods and procedures to be applied	Sum of BAGi,t and BBGi,t
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored	Calculated using plot data in CBM-CFS3
Monitoring equipment	
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Sum of BAGi,t and BBGi,t
Comments	

Data / Parameter	CLB i,t
Data unit	t C ac^{-1}
Description	Total carbon storage in live tree biomass in polygon, i, year, t, in the project case.
Source of data	Permanent sample plots.

Description of measurement methods and procedures to be applied	Calculated from BTOTALi,t and CF
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	As calculated by CBM-CFS3 from plot data, or BTOTALi,t * CF
Comments	

Data / Parameter	CDOM i,t
Data unit	t C ac^{-1}
Description	Total carbon storage in dead organic matter in polygon, i, year, t, in the project case.
Source of data	Permanent sample plots.
Description of measurement methods and procedures to be applied	Calculated from DOMSNAGi,t and DOMLDWi,t and CF
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	As calculated by CBM-CFS3 from plot data. Or (DOMSNAGi,t + DOMLDWi,t)* CF
Comments	

Data / Parameter	fPRJ,NATURAL,i,t

Data unit	unitless (0 < fPRJ,NATURAL,i,t < 1)
Description	The proportion of biomass that dies from natural mortality in polygon, i, year, t, in the project case.
Source of data	Permanent sample plots, remote sensing
Description of measurement methods and procedures to be applied	Height and dbh of dead trees in permanent sample plots will be recorded. Areas of stand replacing fires will be delineated if >1.0hectares.
Frequency of monitoring/recording	Annually in the case of fires, every 5 years in the case of individual plot trees
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	Observation
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for project calculations
Calculation method	Observation in plot, and/or calculated by CBM-CFS3 and/or GIS/GPS delineation
Comments	

Data / Parameter	fPRJ,HARVEST,i,t
Data unit	unitless (0 < fPRJ,HARVEST,i,t < 1)
Description	The proportion of biomass removed by harvesting from polygon, i, in year, t, in the project case.
Source of data	Rotunda harvesting records
Description of measurement methods and procedures to be applied	Volume derived from harvesting records. Modeled estimates of total biomass in polygon, i, used to derive parameter.
Frequency of monitoring/recording	Annually
Value monitored	See harvest areas
Monitoring equipment	GPS, remote sensing
QA/QC procedures to be applied	Data will be verified by ground-truthing and comparison with remote sensing information.
Purpose of the data	Required for project calculations
Calculation method	Modeled by CBM-CFS3 based on actual removals
Comments	

Data / Parameter	fPRJ,DAMAGE,i,t
Data unit	unitless (0 < fPRJ,DAMAGE,i,t < 1)
Description	The proportion of additional biomass removed for road and landing construction in polygon, i, year, t, in the project case.
Source of data	Remote sensing
Description of measurement methods and procedures to be applied	A real estimate of removals derived from remote sensing data and construction records.
Frequency of monitoring/recording	Annually
Value monitored	See GIS delineations construction records
Monitoring equipment	Aerial photos
QA/QC procedures to be applied	Data will be verified by ground-truthing or remote sensing information.
Purpose of the data	Required for project calculations
Calculation method	Areal estimate of removals is multiplied by average carbon density within a polygon.
Comments	

Data / Parameter	DOMSNAG,i,t
Data unit	t d.m. ac^{-1} (d.m. = dry matter)
Description	Total mass of dead organic matter contained in standing dead wood in polygon, i, year, t in the project case.
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Calculated from Heighti,t, DBHi,t, and APSP,i of dead trees measured in permanent sample plots
Frequency of monitoring/recording	Every 5 years
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	n/a
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor

Calculation method	Calculated by CBM-CFS3 from plot data
Comments	

Data / Parameter	DOMLDW,i,t
Data unit	t d.m. ac^{-1} (d.m. = dry matter)
Description	Total mass of dead organic matter contained in lying dead wood in polygon, i, year, t in the project case.
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Calculated from the line intersect method (GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP))
Frequency of monitoring/recording	Every 5 years
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	Tape and visual inspection
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Calculated using the following field- measured parameters Li,t, dni,t, DLDWc,i,t , and N i,t
Comments	

Data / Parameter	VLDW,i,t
Data unit	m^3 ha^{-1}
Description	Total volume of dead organic matter contained in lying dead wood in polygon, i, year, t in the project case.
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Calculated from the line intersect method (GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)).
Frequency of monitoring/recording	Every 5 years
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	Tape and visual inspection

QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Calculated using the following field- measured parameters Li,t, DLDWc,i,t , and N i,t
Comments	

Data / Parameter	Li,t
Data unit	m
Description	Calculation of lying dead wood: Length of the transect used to determine volume of lying dead wood in the sample plot, at time, t (default 100m)
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Field measurements
Frequency of monitoring/recording	Every 5 years
Value monitored	50m per transect
Monitoring equipment	Tape
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	
Comments	

Data / Parameter	Dn,i,t
Data unit	cm
Description	Calculation of lying dead wood: Diameter of each piece n of dead wood along the transects in the sample plot at time, t
Source of data	Permanent sample plots

Description of measurement methods and procedures to be applied	Lying dead wood must be sampled using the line intersect method (Harmon & Sexton, 1996). Two 50-m lines are established bisecting each plot and the diameters of the lying wood (> 4 in diameter) intersecting the lines are measured. Minimum measurement diameter must not be less than 5 cm.
Frequency of monitoring/recording	Every 5 years
Value monitored	See compiled plot data MS Excel File
Monitoring equipment	Caliper, diameter tape
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	
Comments	

Data / Parameter	Ni,t
Data unit	unitless
Description	Total number of wood pieces intersecting the transect in the sample plot, in time t.
Source of data	Field Measurement
Description of measurement methods and procedures to be applied	Lying dead wood is sampled using the line intersect method (Harmon & Sexton, 1996). Two 50-m lines are established bisecting each plot and the total number of wood pieces intersecting transect are counted.
Frequency of monitoring/recording	Every 5 years
Value monitored	See Plot Data MS Excel file.
Monitoring equipment	Visual observation
QA/QC procedures to be applied	GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedures (SOP)
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	
Comments	

Data / Parameter	EM
Data unit	%
Description	An estimate of model error
Source of data	Model output and field data
Description of measurement methods and procedures to be applied	Calculated value determined difference between of model- predicted values of carbon storage and those values measured in field plots (see Equation 60a)
Frequency of monitoring/recording	At each verification
Value monitored	0.77%
Monitoring equipment	N/A
QA/QC procedures to be applied	N/A
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Equation (60a)
Comments	

Data / Parameter	EI
Data unit	%
Description	An estimate of Inventory sampling error
Source of data	Model output and field data
Description of measurement methods and procedures to be applied	Calculated as the 90% confidence limit of the area-weighted differences between the model-predicted values of carbon storage and those values measured in field plots
Frequency of monitoring/recording	At each verification
Value monitored	1.97%
Monitoring equipment	
QA/QC procedures to be applied	
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Equation (60c)
Comments	

Data / Parameter	EP
Data unit	%
Description	An estimate of total project error calculated as the sum of the model and inventory error terms
Source of data	Model output and field data
Description of measurement methods and procedures to be applied	Calculated as the sum of EM and EI (Equation 60e)
Frequency of monitoring/recording	At each verification
Value monitored	2.75%
Monitoring equipment	
QA/QC procedures to be applied	
Purpose of the data	Required for determination of Uncertainty Factor
Calculation method	Equation (60f)
Comments	

Data / Parameter	ERy,ERR
Data unit	%
Description	The uncertainty factor calculated for year ‘y’
Source of data	Model output and field data
Description of measurement methods and procedures to be applied	Calculated value
Frequency of monitoring/recording	At each verification
Value monitored	1.5%
Monitoring equipment	
QA/QC procedures to be applied	
Purpose of the data	Required for project calculations
Calculation method	
Comments	

Data / Parameter	MLFy
Data unit	%

Description	The market leakage factor determined for year 'y'
Source of data	Model output and field data
Description of measurement methods and procedures to be applied	Determined based upon the approach defined in Section 3.3
Frequency of monitoring/recording	At each verification
Value monitored	0%
Monitoring equipment	
QA/QC procedures to be applied	
Purpose of the data	Calculation of leakage
Calculation method	Value determined using the latest version of the VCS Market Leakage Tool as defined in Agriculture, Forestry and Other Land Use (AFOLU) Requirements v3.6 and specified in the VM0012 Methodology
Comments	

4.3. Monitoring Plan

The objective of the project monitoring plan is to reliably monitor changes in carbon stocks related to the calculation of VCU's prior to each verification. In particular, the program will monitor changes in spatial forest inventory conditions and collect field data on carbon stocks to compare against modeled carbon stocks and to calculate an uncertainty factor.

Ongoing monitoring is the primary operational task for the project, which will be completed by the carbon project manager and Rotunda onsite supervisor. Additional field monitoring may require the hiring of external field crews, all of which will be experienced in forest mensuration. The Rotunda onsite supervisor and carbon project manager will be responsible for the adequate training of these external contractors, ensuring that all individuals involved are familiar with the sampling standard operating procedures.

At each verification, reported on an annualized basis, the project will make the following inventory updates, as applicable:

1. Collect geo-referenced information on new project activities, including any forest management or silvicultural activities on any project instance that materially affects GHG emissions.
2. Annually monitor for forest disturbances through remote sensing, field observation, and/ or aerial observation.

The inventory will be updated at a minimum, for:

1. Natural disturbance events > 4 hectares (for example, fires, high mortality pest and disease areas, blowdown areas, slides, etc.).
2. Project activities (e.g., timber harvesting/ thinning, road construction/ reclamation, reforestation/restoration, etc.). A minimum polygon size of 1 hectare can be used but is not a mandatory minimum.

3. Unplanned anthropogenic disturbances (for example, non-de minimis illegal or unplanned harvests) affecting a non-de minimis amount of carbon stocks.

These monitored spatial elements will be updated in the project GIS inventory database and the Rotunda inventory database (or equivalent) annually, or at minimum at each verification on an annualized basis.

Other Monitoring Requirements:

Rotunda will also document the following:

1. Activity shifting leakage (monitored annually, reported at each verification) – the project will report and assess the activity shifting leakage risks based on the timber harvest levels on lands owned or controlled by Rotunda that are outside the project area.
2. Market leakage calculations (at each verification, applied annually) - market leakage calculations will be confirmed at each verification using the latest plot inventory data and best available regional leakage area analysis.

At verification, the project will update the inventory, uncertainty calculations, and carbon calculations from field plot measurement data as outlined in Sections 0 and **Error! Reference source not found.**. The project may also undertake the following monitoring related tasks as appropriate:

1. Refine the project analysis units based on new forest inventory data or to meet the needs of future project instances;
2. Refine or calibrate carbon models based on updated inventory data, as appropriate;
3. Update or modify inventory polygons base on updated remote sensing, forest inventory data, or field truthing, or as a result of project activities or disturbances.

All inventory, data, and modeling changes must be applied equally to the baseline and project carbon calculations, as applicable.

Carbon Stock Field Plot Monitoring

The Rotunda Rural Forest Carbon Project was initiated with inventory work completed in 2017 using a fixed radius and geo-located plot network for monitoring changes in stand-level forest volume and merchantable timber. A statistical inventory was carried out over 212.47 ha or approximately 14% of the 1,556 ha in the Forest Fund.

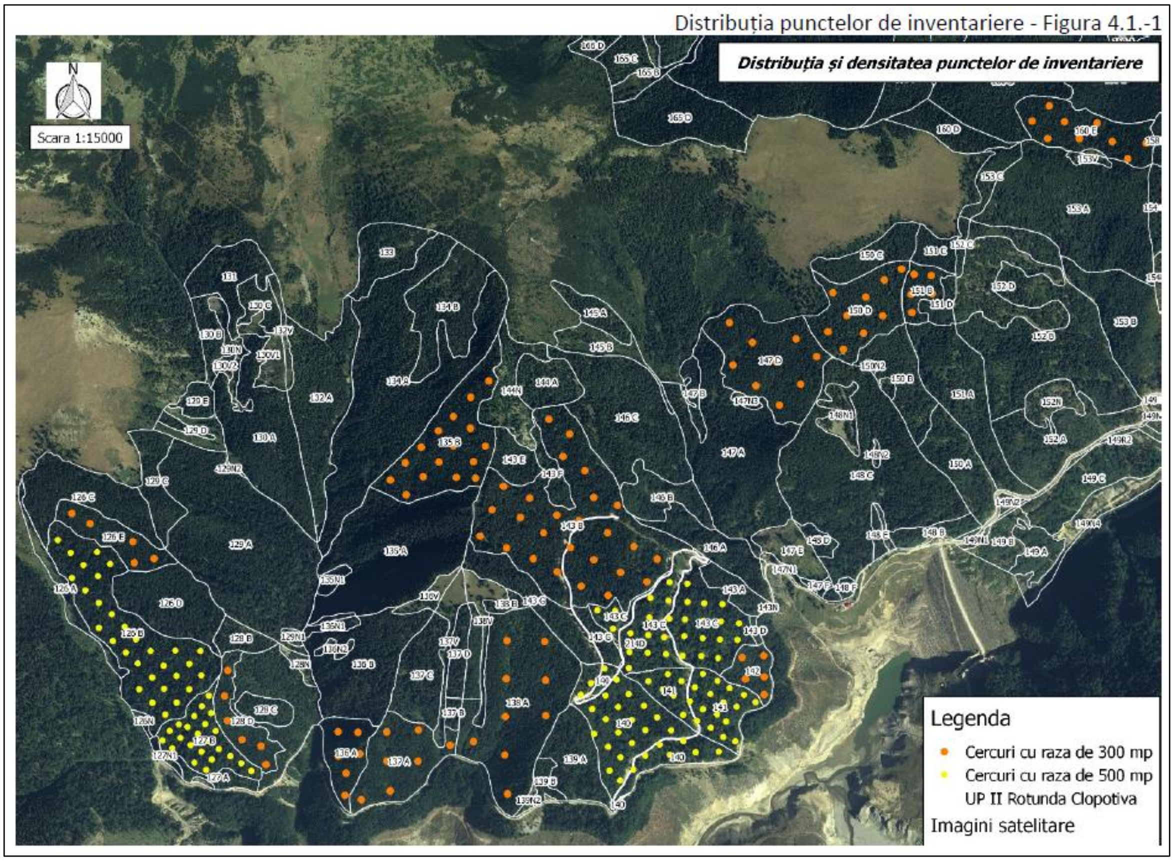

Figure 4: Fixed radius plots utilized for forest inventory calculations in 2017.

All historical and Rotunda monitoring to date has been incorporated into the property inventory and GIS data updates used in this project design document.

The new plot monitoring program for carbon stocks established new permanent sample plots within the analysis units. Each plot collected data on overstory trees, dead standing trees, and lying deadwood. As part of ongoing project monitoring the project will periodically review the need for additional permanent sample plots or incorporation of other forest and carbon inventory updates or improvements over time. The methodology does not specify a number of plots, with error over the target (10% @ 90%CI) being accounted for in the uncertainty factor deduction (Section 5.4).

Monitoring Carbon Plot Sampling Design Overview:

The establishment of new permanent sample plots was initiated in December 2020 by the Rotunda forest managers and qualified forest contractors. A total of 28 PSPs were planned for establishment within the project area, with each analysis unit containing 4 plots. Analysis units 3 (management unit J, softwood stands on poor sites) and 7 (management unit M, softwood stands on poor sites) were combined due to the spatial restrictions and small total area (1.34 ha) of management unit 3. Subsequently, the plots established in the new combined analysis unit were used for verification of carbon estimates modelled in analysis units 3 and 7.

Although 28 plots were planned for measurement, weather conditions restricted access to the entire project area. Crews were able to establish and measure 24 plots at the time of project submission, with the intent of completing the sampling protocol when weather conditions permit.

For additional plot monitoring information, please refer to the GreenRaise GHG – Monitoring Standard Operating Procedure.

Plot Layout - Permanent plot locations were located using UTM coordinates randomly selected via GIS analysis tools. Plot locations were buffered by 60m from anthropogenic features such as roads and cutblocks, and from the analysis unit boarder. Buffering was completed to minimize the possible influence of edge effects on plot locations. A minimum buffer distance of 50m was also implemented between plots to ensure an appropriate distribution.

Size and Shape of Sample Plots – Permanent sample plots will be circular with a fixed radius of 11.29m ($400m^2$).

Plot measurements – plots are installed, measured, and re-measured following the latest version of the GreenRaise Greenhouse Gas – Monitoring Standard Operating Procedure (SOP). Plot measurements include live trees (aboveground live biomass); standing dead trees (aboveground dead biomass); and lying dead wood (aboveground dead biomass).

Given the dynamics of forest processes, the permanent plots will be re-measured at intervals not exceeding 5 field season years, beginning at the year of installation. As noted, permanent plots may be established over multiple years, and such re-measurement schedules will be tracked for each plot based on its establishment year.

Biomass Estimations from Plot Data:

Trees – standing live and dead tree biomass is calculated from plot data using the CBM-CFS3 model.

Lying Deadwood – the mass of lying deadwood was measured in the plots using the line intersect method. Following the Plot SOP, two permanently marked 50m transect lines were placed at right angles across the plot center. The diameters of all pieces of wood ≥5cm diameter that intersect the line were measured and assigned to one of three density classes: sound (1), intermediate (2), and rotten (3).

The volume per unit area was calculated for each density class using Equations 60a-c (pg 75), as described in the VM0012 methodology.

The density of lying deadwood in the classes was assumed to be 0.58, 0.37, 0.24 (t m-3) for hard woods (Muller-Using and Bartsch 2009), and 0.45, 0.39, and 0.22 (t m-3) for soft woods (Petrillo et al. 2016) in the sound, intermediate, and rotten classes, respectively. The total mass of lying deadwood was calculated as the average of all transects.

Volume (m3 /ha) =π 2 * [($d_1^2 + d_2^2$ …….d_n^2) / 8L]

Where d_1, d_2, d_n = diameter (cm) of each of the n pieces intersecting the line, and L = the length of the line.

Quality Assurance/Quality Control Measures (QA/QC):

Rotunda has standard operating procedures for: (1) collecting reliable field measurements; (2) verifying laboratory procedures; (3) verifying data entry and analysis techniques; and (4) data maintenance and archiving.

QA/QC for Field Measurements - the plot network was installed by trained field crews with previous experience installing similar permanent plots and forestry related experience. The GreenRaise Greenhouse Gas Monitoring SOP requires blind check-cruises of a minimum of 10% of the plots, with 100% re-measurement of all variables which meet met the minimum DBH, height, and tree count accuracy thresholds (+/- 10% standard error at 90% confidence interval). This meets the methodology QA/QC 10% check cruise requirement. Data results will be reported in the project monitoring plan for each verification.

QA/QC for Laboratory Measurements - no laboratory measurements were taken for the Rotunda sampling, and so this section is not applicable.

QA/QC for Data Entry – Field data is collected on digital data recorders and is transferred electronically to minimize data entry and transfer errors. If there are anomalies that cannot be resolved noted within plot data, the plot will be re-measured, or data will be omitted from the analysis.

QA/QC for Data Archiving - Rotunda has document control procedures which apply to the carbon monitoring data, including retaining the following for 2 years past the duration of the project: original electronic copies of the field measurement, check plots, and related data summaries; copies of monitoring data analyses, models, model input and output files, carbon calculations required for this methodology, GIS inventory dated by year, and copies of the monitoring reports; records of the version and relevant change history of software or data storage media changed between monitoring periods.

Addressing Non-Conformities

Non-conformities regarding plot monitoring and spatial analysis will be addressed upon submission. Rotunda forest managers and hired contractors will be responsible for addressing non-conformities. Issues will be solved by returning to the plot to re-affirm measurements, or to ground verify concerns regarding spatial data. Other non-conformities will be addressed, as necessary. Non-conformities will then be reviewed to verify effective completion.

5. Quantification of GHG Emission Reductions and Removals

5.1. Baseline Emissions

Validating Inventory Requirements

The Rotunda Forest Carbon Project meet the Valid Starting Inventory Requirements from the methodology (methodology criteria in italics):

1. *Pertaining directly to the entire project area; the Rotunda inventory data (2017) covers the entire project area, and meets this criteria.*
2. *Created, updated, or validated <10 years ago; and,*

The latest base inventory (2017 field season) was created and received approval under the Romania Forest Fund in 2018. The inventory meets these criteria.

3. *Documentation is available describing the methods used to create, update, or otherwise validate the starting inventory, including statistical analysis, field data, and/or other evidence.*

The inventory methods and related inventory updates are regulated by the provisions of the Forest Code (Law 46/2008 with subsequent completions and modifications, respectively Law 175/2017).; which therefore meets the criteria.

Baseline Scenario Area Stratification

STEP 1 - Stratify to create homogeneous units.

The Rotunda forest inventory is contained within a Geographic Information System dataset. The number of polygons is 56, with the average area of 27.78 ha is based on Management requirements of the Romanian Forest Fund. The Inventory covers the entire property of UP II Rotunda Clopotiva on an area of 1555.82 ha.

The polygons are homogeneous based on forest cover species, stand age, productivity class, and other stand attributes including operability. The Carbon modeling is specific to the forest lands intended for regulated harvesting. Romanian Forestry law regulates minimum harvest age and harvest intensity. Regulation of primary forest products (SUP ‘J’) covers 427.71ha. Additional harvest opportunities are feasible on constrained sites and forests under the special conservation regime (SUP ‘M) and covers and additional 1,062.21ha.

For modelling purposes, inventory polygons were further refined into Analysis Units based on leading species, productivity class and intended legal harvest regime (SUP J-primary or SUP M-conservation). Carbon curves were developed for and assigned to each of the analysis units as described below.

Table 4: Description of Forest Analysis Units Defined in the Project Area

AU	Name	Description
1	Conifer-Good - J	Spruce Leading on good sites (I - II) & primary harvest (30% cut)
2	Conifer-Moderate - J	Spruce Leading on moderate sites (III) & primary harvest (30% cut)
3	Conifer-Poor -J	Spruce Leading on poor sites (IV - V) & primary harvest (30% cut)
4	Deciduous-All - J	Deciduous Leading on all sites (I - V) & primary harvest (30% cut)
5	Conifer-Good - M	Spruce Leading on good sites (I - II) & conservation (10% cut)
6	Conifer-Moderate - M	Spruce Leading on moderate sites (III) & conservation (10% cut)
7	Conifer-Poor - M	Spruce Leading on poor sites (IV - V) & conservation (10% cut)
8	Deciduous-All - M	Deciduous Leading on all sites (I - V) & conservation (10% cut)

Model Selection and Use

The Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) is an inventory-based, yield-curve-driven model that simulates the stand- and landscape-level C dynamics of above- and belowground biomass, dead organic matter (DOM; litter and dead wood) and mineral soil (Kurz et al., 2009). The CBM-CFS3 is a stand- and landscape-level modeling framework that can be used to simulate the dynamics of all forest carbon stocks required under the United Nations Framework Convention on Climate Change. It is compliant with the carbon estimation methods outlined in the guidelines of the Intergovernmental Panel on Climate Change. The model uses much of the same information that is required for forest management planning activities (e.g., forest inventory, growth and yield curves, natural and human-induced disturbance information, forest management schedule, and land-use change information), supplemented with information from national ecological parameter databases.

The model, developed by the Canadian Forest Service, was recently applied to 26 EU countries, mainly using National Forest Inventories (NFI) input data, to estimate the European Union (EU) forest Carbon dynamics from 2000 to 2012, including the effects of natural disturbances and land-use change (Pilli et al., 2016a, b).

The (CBM-CFS3) has been adapted, tested, and applied to forests of 26 EU countries over the last 7 years for EU policy making and scientific research. The overall purpose of this exercise is to increase the transparency of how the EU Archive Index Database (EU-AIDB) was parameterized while supporting both the policy making and research communities interested in applying the CBM-CFS3 with ecological parameters specific to the EU context. In addition to preparing model input data reflecting various management and disturbance scenarios for CBM-CFS3 projects, an essential step was to update the original AIDB with information specific to the EU context and create an EU-AIDB. The AIDB is the Microsoft Access database behind the CBM-CFS3 that stores default ecological information and parameters pertaining to the forest ecosystems of a country, among other functions.

The EU-JRC (Joint Research Centre) developed an EU-Archive Index Database (AIDB) (https://data.jrc.ec.europa.eu/dataset/jrc-cbm-eu-aidb)

CBM is a robust model pre-populated with many well-referenced default settings for the EU. These model assumptions, algorithms, and default values are well tested and based on validation by the Canadian Forest Service Experts and those of the EU-JRC (Joint Research Centre) utilizing experts opinion, referenced research, and data from the EU National Forest Inventory reports

Preparation of Stand-level Carbon Curves in CBM

The CBM model was used to create a series of stand attribute curves for each analysis unit to predict/ simulate forest development, merchantable timber volume, and carbon storage and dynamics by carbon pool over time. Data from project inventory plots were used to set a representative yield curve for the analysis units (AUs).

The objective was to calibrate the CBM forest type for each Analysis Unit to generally match the actual species mix found in the carbon monitoring plots (at age ~110 years being the minimum final felling age), which are then being represented by the simplified AU groupings with forest types based on species composition, site productivity and disturbance regime/ harvest history.

The AIDB spatial units (SPU220) Romania was used for each analysis unit. A SPU in the EU-AIDB is the spatial resultant from the intersection of 204 European administrative regions (defined at the Nomenclature of territorial units for statistics - NUTS 1 and NUTS 2 levels for most of the EU countries), and 35 ecological boundaries representing climatic units.

The CBM 'MAKELIST' is a preprocessing program that is used to format the inventory information for input into the CBM-CFS3 and to initialize the DOM carbon pools. These pools include carbon from aboveground and belowground dead tree biomass (e.g., coarse woody debris; litter, fibric, and humic layers; and mineral soil). MAKELIST uses the same algorithms and parameters as the CBM-CFS3 and simulates each stand record through a number of natural disturbance cycles (grow, burn, grow, burn, etc.) until the slow DOM carbon pool at the end of two successive rotations meets a user-defined criterion (for which the default tolerance is 0.1%). By default, MAKELIST assumes that the historical natural disturbance regime is stand-replacing fire, and it therefore grows stands for X years.

Biomass Carbon Modeling

Total biomass flows for each analysis unit were calculated using equations embedded in the CBM-CFS3 and output by representative carbon curves and tracked by carbon pool (see Table 2 below). The model simulates detailed forest growth and development over time and links this forest development to detailed biomass accumulation and decay functions to track carbon biomass by pool through time. The SPU220 Romania includes validated and referenced default parameters well suited to the project area (Pilli et al., 2016a). The CBM convert the merchantable volume per ha reported by the growth curves (i.e., YT, yield tables) to tonnes of dry biomass through species-specific allometric equations (used as Biomass Expansion and Conversion Factors, without any additional value of wood density).

The CBM-CFS3 carbon pools are divided into pools as noted in the table below. This project considers the following four carbon pools:

1. Aboveground Tree Biomass (including Standing dead trees and the subset Merchantable Carbon/ Wood Products pool)
2. Belowground Biomass
3. Dead Wood (including Litter Pool)

Although the model does address the Soil Carbon Pool it is considered optional in VCS AFOLU IFM projects. As a conservative approach and considering there are no afforestation projects associated with the project changes to soil carbon from harvesting are assumed to be *de minimis*.

Table 5: CBM Carbon Pool allocation ss detailed with Kurz et al., 2009 (Table 2)

Table 2 – Correspondence between pools in the Carbon Budget Model of the Canadian Forest Sector 3—version 1.1 (CBM-CFS3) and recommended pools by the Intergovernmental Panel on Climate Change Good Practice Guidance (GPG) (IPCC, 2003). SW = softwood, HW = hardwood, DOM = dead organic matter.

CBM-CFS3 pool	Description	GPG pool
Merchantable + bark (SW or HW)	Live stemwood of merchantable size[a] plus bark	Aboveground biomass
Other wood + bark (SW or HW)	Live branches, stumps and small trees including bark	Aboveground biomass
Foliage (SW or HW)	Live foliage	Aboveground biomass
Fine roots (SW or HW)	Live roots, approximately <5 mm diameter	Belowground biomass
Coarse roots (SW or HW)	Live roots, approximately ≥5 mm diameter	Belowground biomass
Snag stems DOM (SW or HW)	Dead standing stemwood of merchantable size including bark	Dead wood
Snag branches DOM (SW or HW)	Dead branches, stumps and small trees including bark	Dead wood
Medium DOM	Coarse woody debris on the ground	Dead wood
Aboveground fast DOM	Fine and small woody debris plus dead coarse roots in the forest floor, approximately ≥5 and <75 mm diameter	Litter
Aboveground very fast DOM	The L horizon[b] comprised of foliar litter plus dead fine roots, approximately <5 mm diameter	Litter
Aboveground slow DOM	F, H and O horizons[b]	Litter
Belowground fast DOM	Dead coarse roots in the mineral soil, approximately ≥5 diameter	Dead wood
Belowground very fast DOM	Dead fine roots in the mineral soil, approximately <5 mm diameter	Soil organic matter
Belowground slow DOM	Humified organic matter in the mineral soil	Soil organic matter

[a] Definition of merchantable size dimensions are model parameters, see Table 3.
[b] Soil Classification Working Group (1998).

Harvested Wood Product Modeling

The CBM-CFS3 tracks Aboveground Tree Biomass (and the subset Merchantable Carbon/ Wood Products pool) harvested wood products (HWP) in Tonnes of Carbon (t C) and satisfies the requirements of Step 1 of the methodology.

VM0012 requires calculation of 3 harvested wood pools:

1. Short-lived wood products (SL HWP), which are defined as wood products in use for <3 years; and assumed to be emitted immediately.
4. Medium-lived wood products (ML HWP), which are defined as wood products in use for 3-100 years; and assumed to be emitted on a 20-year straight line decay curve.
5. Long-lived wood products (LL HWP), which are wood products in use for 100+ years.

Note: products in landfill are assumed to be “in use” and treated as per these 3 HWP pools.

Historical harvest in Rotunda between 2008 and 2019 indicates the following breakdown by product type (k) categories: Softwoods 89% sawlog & 11% pulpwood; Hardwoods 60% sawlogs & 40% pulpwood.

For the purposes of Step 2 (Carbon contained in harvested timber after milling) Forest Product Conversion Factors for the EU Region published by the United Nations Economic Commission for Europe was used to determine the total carbon in harvested timber that will enter the wood products pool by product type accounting for mill efficiencies and estimated product disposition percentages ($CBSL,_{MILL,h}$; t C). The gross quantity of carbon contained in harvested timber for each of the four product types (k) described in Step 1 must be decremented to account for losses during processing and is calculated within HWP PRJ Roaded_20201130 excel spread sheet.

For the final step 3 (Carbon storage in medium-term and long-term wood products) the total carbon lost in short-lived products and stored in medium-term and long-term products used Smith, et al (2006) reference tables and factors to calculate the result is a fraction of the Wood Products pool being emitted or stored annually based on each In-Use category based on product, decay and storage factors.

These HWP modelling calculations are applied equally to any timber harvesting in either the Baseline or Project Scenario.

Overview of Baseline and Project Scenarios using CBM-CFS3 Outputs and a Microsoft Excel Application

The CBM-CFS3 model and supporting Excel spreadsheets were developed to house the data and perform and track the carbon modeling results by polygon and carbon pool over time and across the Baseline Scenario (and Project Scenario) activities by project instance. Data from the CBM-CFS3 output Delta Ecosystem Reports and Merchantable Carbon/ Wood Products Reports were exported into excel spreadsheets. These carbon reports consist of tables that contain carbon pool and harvested wood products pool information in 10-year increments (as a result of inventory information) across all site classes and analysis units, which are interpolated evenly to 1-year increments. They include both project and baseline scenarios. Polygon-based forest inventory data, in a tabular format, were used to populate the model.

Each polygon included sufficient information to allow filtering into its assigned analysis unit (Table 1). The legal harvest regime (e.g. SUP J) was used to link each specific polygon with other descriptive tables including disturbance type and intensity in each baseline scenario. The analysis unit field was used in combination with polygon area to match up the modeled inventory polygon to the correct carbon yield curve data.

The CBM-CFS3 derived stand and carbon curves are modeled on an assumed fully stocked representative stand in each AU and applies carbon and merchantable volume outcomes for each polygon based on the analyzed percentage of full stocking. The model includes discrete sections that represent the project and specific baseline disturbances/ activities (partial cutting 30%, thinning and conservation cutting along with hygiene cuts). The CBM-CFS3 then simulates and tracks the fate of carbon in all applicable carbon pools over time by polygon, including for Wood Products pool after any scheduled or monitored activity in either scenario. Carbon calculations can then be summarized for the project and baseline scenarios for each project year across all project instances.

Baseline emissions are calculated by applying a Baseline disturbance to each AU, and then modeling the baseline activities and the related carbon flows using CBM-CFS3. The methods described are equivalent to the equations and processes outlined in VM0012.

Calculating Baseline Scenario Live Biomass Gain

For the Common Practice Baseline Scenario (as described in Section 3.4), a set of assumed baseline activities (disturbances) was developed based on harvest details within the current management plan. All baseline management activities are assumed to occur/begin at year 1.

Live biomass gain ($\Delta C_{BSL,G,t}$, Eqn 4,5a-b) is calculated by CBM-CFS3 based on the project area stratifications, regionally specific forest dynamics (SPU220), and the related carbon curves discussed above, and tracked and reported by carbon pool (Aboveground Live, Belowground Live), and reported in the Delta Ecosystem Reports and Merchantable Carbon/ Wood Products Reports which is then tracked by polygon, by year in the Access database. Additional details about related model default values, functionality, and parameters are found in Kull (2016) & Kurz (2009).

Calculating Baseline Scenario Live Biomass Loss

Live biomass loss ($\Delta C_{BSL,L,t}$, Eqn 6,7,8,9) is calculated by CBM-CFS3 based on the project area stratifications, regionally specific forest dynamics (SPU220) and the related carbon curves discussed above. Default parameters and algorithms within CBM-CFS3 model and track all stand dynamics, including natural tree mortality, harvesting scenario felling/removals, blowdown, and any other biomass loss. Generally, mortality related live biomass is shifted into dead biomass pools by CBM-CFS3 (Aboveground Standing Dead (snags), Aboveground Downed and Dead Wood (DOM), Belowground DOM), which are reported in the Delta Ecosystem Reports. Harvesting related biomass loss is tracked and reported as Merchantable Carbon/ Wood Products Reports. Additional details about related model default values, functionality, and parameters are found in Kull (2016) & Kurz (2009).

Calculating Baseline Scenario Dead Organic Matter Dynamics

Dead organic matter dynamics ($\Delta C_{BSLDOM,t}$, Eqn 10,11a-b,12,13,14a-b,15,16,17a-d) are calculated by CBM-CFS3 based on the project area stratifications, regionally specific forest dynamics (SPU220) and the related carbon curves discussed above. Default parameters and algorithms within CBM-CFS3 model and track all stand dead wood dynamics, including standing dead, downed dead, and below ground dead organic matter. CBM-CFS3 uses the SPU220 variant data and related parameters to model and track dead organic matter between carbon pools (Aboveground Dead (i.e. Stem Snags), Belowground Dead, Aboveground Slow DOM (VM0012 calls this Lying Dead Wood)), and decay within each pool.

Additionally, CBM-CFS3 tracks dead organic matter dynamics related to harvesting or other events when applied. The project uses the default decay factors and dead matter dynamics that are set within the CBM-CFS3 model and specific to the SPU220 variant dataset. The results of dead organic matter dynamics are reported in the Delta Ecosystem Reports. Additional details about related model default values, functionality, and parameters are found in Kull (2016) & Kurz (2009). Generally, carbon stocks are transitioned between dead biomass pools, and emitted as they decayed.

Calculating Baseline Scenario Harvested Wood Products (HWP)

Harvested Wood Product dynamics ($\Delta C_{BSLHWP,t}$, Eqn 18,19,20,21,22,23a-c,24) are calculated with a combination of CBM-CFS3 output and additional calculations in the project Excel Spreadsheets following regional factors derived from EU reports.

The CBM-CFS3 report does not match the requirements of VM0012, and as such the project has adapted CBM-CFS3 outputs for application against the relevant factors to follow VM0012.

The project utilizes CBM-CFS3 data to begin the HWP calculations and to connect to carbon pool tracking and reporting, then transitions, using the local data, to allocate harvested material to product type (k). The project starts with Merchantable Carbon/ Wood Products Reports. CBM-CFS3 outputs HWP using the same categories and measures for product type categories described in VM0012 Step 1 and uses species specific allometric formulas.

Note this is conservative as the Wood Products pool is a gross carbon volume in merchantable log sizes (before deductions for waste and utilization), whereas the Smith analysis starts with removed timber volume (i.e. after waste and utilization).

Historical harvest in Rotunda between 2008 and 2019 indicates the following breakdown by product type (k) categories: Softwoods 89% sawlog & 11% pulpwood; Hardwoods 60% sawlogs & 40% pulpwood.

For the purposes of Step 2 (Carbon contained in harvested timber after milling) Forest Product Conversion Factors for the EU Region published by the United Nations Economic Commission for Europe was used to determine the total carbon in harvested timber that will enter the wood products pool by product type accounting for mill efficiencies and estimated product disposition percentages ($CBSL_{,MILL,h}$; t C). The gross quantity of carbon contained in harvested timber for each of the four product types (k) described in Step 1 must be decremented to account for losses during processing and is calculated within HWP PRJ Roaded_20201130 excel spreadsheet.

Step 3 calculates (Carbon storage in medium-term and long-term wood products) the total carbon lost in short-lived products and stored in medium-term and long-term products was using reference tables and factors from Smith, et al (2006). The result is a fraction of the Wood Products pool being emitted or stored annually for each In-Use category based on product, decay, and storage factors.

Constants from Smith, et al (2006) Table 6 – the Northeast Softwoods, Saw Logs and Pulpwood; along with the Northeast Hardwood tables were applied. The respective volumes were calculated by species and product type (hardwood sawlog and pulpwood are added back together to use these tables). Constants were used from the relevant “In Use” column to finalize calculations for the following HWP categories:

a) Short-lived HWP – multiplied (Year 1 – 3 look-up factor) for each of the tables against the respective remaining In-Use carbon volumes. This calculates the fraction of net Merch Carbon Removed that is In-Use as Short-lived HWP. Following VM0012, the sum of al Short-lived HWP is assumed to be emitted immediately.
b) Long-lived HWP – applied the look-up factor for Year 100 for each of the tables against the respective remaining In-Use carbon volumes. This calculates the fraction of net Merch Carbon Removed that is In-Use as Short-lived HWP. Following VM0012, the sum of all Long-lived HWP is assumed to be permanently stored.
c) Medium-Lived HWP – the difference between the carbon remaining In-Use at Year 3 and at Year 100 is then calculated using each table look-up factors and carbon volumes, respectively to calculate the Medium-Lived HWP. The sum of all Medium-Lived HWP is then modelled to emit on a straight line 20-year decay curve, starting in year 0 and being fully emitted in year 20.

Note that the remaining Merch Carbon Removed after accounting for Short-, Medium-, and Long-lived HWP is emitted immediately as a combination of emissions due to waste carbon being used for Energy and Emitted w/o Energy.

Note that the project has not included the optional emissions from equipment fossil fuels ($\Delta C_{BSL,EMITFOSSIL,t}$, Eqn 25,26a-b,27), and any related variable is assumed to be zero.

Baseline Scenario GHG Emissions Calculation Summary

The CBM-CFS3 model and the supporting spreadsheets were used based on spatial forest inventory data to calculate and track all annual changes in both the live biomass ($\Delta C_{BSL,LB,t}$) and dead organic matter pools (($\Delta C_{BSL,DOM,t}$) for the baseline scenario in a method consistent with the formulas in VM0012. Carbon storage changes in harvested wood products **(**$\Delta C_{BSl,HWP,t}$), summarized net carbon balances, and other deductions and buffer discounts were determined in the supporting spreadsheets.

The total annual carbon balance in year, t, for the baseline scenario (ΔCBSL,t, in t C yr-1) was calculated as:

$$\Delta C_{BSL,t} = \Delta C_{BSL,P,t} \qquad (1)$$

where:

$\Delta C_{BSL,P,t}$ is the annual change in carbon stocks in all pools in the baseline across the project activity area (including all project instances); t C yr-1.

The annual change in carbon stocks in all pools in the baseline across the project activity area ($\Delta C_{BSL,P,t}$; t C yr^{-1}) was calculated as:

$$\Delta C_{BSL,P,t} = \Delta C_{BSL,LB,t} + \Delta C_{BSL,DOM,t} + \Delta C_{BSl,HWP,t} \qquad (2)$$

where:

$\Delta C_{BSL,LB,t}$ = annual change in carbon stocks in living tree biomass (above- and belowground); t C yr^{-1}

$\Delta C_{BSL,DOM,t}$ = annual change in carbon stocks in dead organic matter; t C yr^{-1}

$\Delta C_{BSl,HWP,t}$ is the annual change in carbon stocks associated with harvested wood products, t C yr^{-1}.

The annual change in carbon stocks in living tree biomass (above- and belowground) in the baseline scenario ($\Delta C_{BSL,LB,t}$; t C yr^{-1}) was calculated as:

$$\Delta C_{BSL,LB,t} = \Delta C_{BSL,G,t} - \Delta C_{BSL,i,t} \quad (3)$$

where:

$\Delta C_{BSL,G,t}$ = annual increase in tree carbon stock from growth; t C yr^{-1}

$\Delta C_{BSL,L,t}$ = annual decrease in tree carbon stock from a reduction in live biomass; t C yr^{-1}.

The annual change in carbon stocks in dead organic matter (DOM) ($\Delta C_{BSL,DOM}$; t C yr^{-1}) in the baseline scenario was calculated as:

$$\Delta C_{BSL,DOM,t} = \Delta C_{BSL,LDW,t} + \Delta C_{BSL,SNAG,t} + \Delta C_{BSL,DBG,t} \quad (10)$$

where:

$\Delta C_{BSL,LDW,t}$ = change in lying dead wood (LDW) carbon stocks in year, t; t C yr^{-1}

$\Delta C_{BSL,SNAG,t}$ = change in snag carbon stock in year, t; t C yr^{-1}

$\Delta C_{BSL,DBG,t}$ = change in dead below-ground biomass carbon stock in year, t; t C yr^{-1}.

The annual change in emissions associated with the production of harvested wood products (HWP), $\Delta C_{BSl,HWP,t}$, is calculated as:

$$\Delta C_{BSl,HWP,t} = \Delta C_{BSL,STORHWP,t} - \Delta C_{BSL,EMITFOSSIL,t}, \quad (18)$$

$\Delta C_{BSL,STORHWP,t}$ = the annual change in harvested carbon that remains in storage after conversion to wood products (t C yr^{-1})

$\Delta C_{BSL,EMITFOSSIL,t}$ = the annual change in fossil fuel emissions from harvesting (logging and log transport) and processing of the various wood products. The project has not included the optional equipment emissions carbon pool and hence this variable = 0.

5.2. Project Emissions

Project emissions and carbon flows are calculated in the same manner as the baseline emissions discussed in the Section 4.1. Calculations use the same forest inventory data, analysis units and polygons, and modeling tools under the Project Scenario activities. Project and Baseline Scenarios and polygon versions of each are tracked and calculated simultaneously in the supporting spreadsheets using the same parameters, outputs, and analysis under each scenario. In the project scenario, carbon flows are modeled using project activities which includes only hygiene cutting with a focus on maintaining forest health throughout the term of the project.

Project activities affecting GHG emissions were carried out during the initial project period (2018-2020) however, no project scenario activities were projected on an ex-ante basis except for hygiene cutting. Future years may include various project forest management activities that affect ex-post carbon stocks and which will be monitored and reported on in future verifications (e.g. salvage due to significant fire or forest health loss). Project activities will be based on actual monitoring results (see Section 5) and any resulting emissions netted against emission reductions.

The methods described are equivalent to the equations and processes outlined in VM0012.

Development of Project Scenarios and Assumptions

The project scenario is modeled as conservation with hygiene cutting, focusing on maintaining forest health. No other activities affecting carbon stocks are scheduled on an ex-ante basis, aside from normal forest growth and development as modeled by CBM-CFS3.

Determination of Actual Onsite Carbon Stocks

Ex-ante Project Scenario carbon stocks are calculated in the same manner as the baseline emissions discussed in Section 5.1. Calculations are completed using the same forest inventory data, analysis units and polygons, and modeling tools under the Project Scenario activities.

Ex-Post Calculations of Carbon Stocks

Ex-post carbon stocks in the Project Scenario are determined at each verification following the steps outlined in VM0012. Each monitoring report will detail the data and calculations for ex-post onsite carbon stocks at the time of verification. However, as the project start date (2018) is prior to validation, the initial period (2018-2020) ex-ante carbon stocks are also the ex-post carbon stocks.

Project carbon stocks from 2021 forward are on an estimated ex-ante basis.

The ex-post carbon calculations are made for the Baseline and Project Scenarios as outlined in Section 5.1 and 0, with updates to carbon inventory, spatial data, project instances, and other data for each verification period.

For the 2018-2020 period, the project begins from, and carbon stocks are calculated from, the latest set of inventory and spatial data, which inherently include ex-post monitoring for that period.

Crews installed 28 permanent carbon plots in 2020-2021 (See Section **Error! Reference source not found.**5.1) with representation across all Analysis Units to monitor inventory and model accuracy. Additional permanent sample plots may be installed to improve inventory accuracy, spatial coverage, and Analysis Unit representation as deemed necessary. The initial ex-post carbon stock spatial forest inventory and analysis is using the latest available ortho-imagery, LiDAR data, and other GIS datasets, in conjunction with site visits from Rotunda staff to confirm the status of project activities and disturbances. The modeling related to these data has been applied across both the Project Scenario and Baseline Scenarios. The uncertainty calculations (Section 5.4) in the first verification period are up to date for the latest inventory plot data and modeling results.

In future verification periods, the project will calculate ex-post carbon stocks by addressing any spatial changes to the project area, then updating the forest inventory and carbon modeling results, including for any other monitoring results or updates.

Additional carbon plots may be installed to improve inventory accuracy, spatial coverage, and/or Analysis Unit representation. Ex-post carbon calculations will be undertaken using the latest imagery, LiDAR, and GIS datasets for the project area. Project activities and disturbances will be monitored by remote sensing or field visits and updated into the forest inventory prior to the following verification period. All modeling and inventory updates and calibrations will be applied equally across the Project and Baseline Scenarios. The uncertainty factor, leakage assessments, and non-permanence risk factors will be recalculated using the latest forest inventory, plot data, and project information.

Calculating Project Scenario Live Biomass Gain

Live biomass gain ($\Delta C_{PRJ,G,t}$, Eqn 32,33a-b) is calculated the same as in the Baseline Scenario, Section 3.1, using project scenario polygons and data.

Calculating Project Scenario Live Biomass Loss

Live biomass loss ($\Delta C_{PRJ,L,t}$, Eqn 34,35,36,37) is calculated the same as in the Baseline Scenario, Section 3.1, using project scenario polygons and data.

Calculating Project Scenario Dead Organic Matter Dynamics

Dead organic matter dynamics ($\Delta C_{PRJ,DOM,t}$, Eqn 38,39a-b,40,41,42a-b,43,44,45a-d) are Calculated the same as in the Baseline Scenario, Section 3.1, using project scenario polygons and data.

Calculating Project Scenario Harvested Wood Products (HWP)

Harvested Wood Product dynamics ($\Delta C_{PRJ,HWP,t}$, Eqn 46,47,48,49,50a-c,51) are calculated the same as in the Baseline Scenario, Section 3.1 with respect to any timber harvesting in the project scenario. Currently there is no timber harvesting in the project scenario, although it may occur in the future. Note that the project has not included the optional emissions from equipment fossil fuels ($\Delta C_{PRJ,EMITFOSSIL,t}$, Eqn 52,53,54,55), and any related variable is assumed to be zero.

Project Scenario GHG Emissions Calculation Summary

The CBM-CFS3 and supporting spreadsheets were used in combination with the spatial forest inventory data to calculate and track annual changes in both the biomass ($\Delta C_{PRJ,LB,t}$) and dead organic matter pools ($\Delta C_{PRJ,DOM,t}$) for the project scenario. Changes in carbon storage in harvested wood products ($\Delta C_{PRJ,HWP,t}$) and summarized net carbon balances and buffer discounts were determined within the applicable spreadsheets.

The total annual carbon balance in year, t, for the project scenario ($\Delta C_{PRJ,t}$, in t C yr^{-1}) was calculated as:

$$\Delta \mathbf{C}_{PRJ,t} = \Delta \mathbf{C}_{PRJ,P,t} \qquad \textbf{(29)}$$

where:

$\Delta C_{PRJ,P,t}$ is the annual change in carbon stocks in all pools in the baseline across the project activity area; t C yr^{-1}.

The annual change in carbon stocks in all pools in the project scenario across the project activity area ($\Delta C_{PRJ,P,t}$; t C yr^{-1}) was calculated as:

$$\Delta \mathbf{C}_{PRJ,P,t} = \Delta \mathbf{C}_{PRJ,LB,t} + \Delta \mathbf{C}_{PRJ,DOM,t} + \Delta \mathbf{C}_{PRJ,HWP,t} \qquad \textbf{(30)}$$

where:

$\Delta C_{PRJ,LB,t}$ = annual change in carbon stocks in living tree biomass (above- and belowground); t C yr^{1}

$\Delta C_{PRJ,DOM,t}$ = annual change in carbon stocks in dead organic matter; t C yr^{-1}

$\Delta C_{PRJ,HWP,t}$ is the annual change in carbon stocks associated with harvested wood products, t C yr^{1}.

The annual change in carbon stocks in living tree biomass (above- and belowground) in the project scenario ($\Delta C_{PRJ,LB,t}$; t C yr^{-1}) was calculated as:

$$\Delta C_{PRJ,LB,t} = \Delta C_{PRJ,G,t} - \Delta C_{PRJ,L,t} \quad (31)$$

where:

$\Delta C_{PRJ,G,t}$ = annual increase in tree carbon stock from growth; t C yr^{-1}

$\Delta C_{PRJ,L,t}$ = annual decrease in tree carbon stock from a reduction in live biomass; t C yr^{-1}.

The annual change in carbon stocks in dead organic matter (DOM) ($\Delta C_{PRJ,DOM}$; t C yr^{-1}) in the project scenario was calculated as:

$$\Delta C_{PRJ,DOM,t} = \Delta C_{PRJ,LDW,t} + \Delta C_{PRJ,SNAG,t} + \Delta C_{PRJ,DBG,t} \qquad (38)$$

where:

$\Delta C_{PRJ,LDW,t}$ = change in lying dead wood (LDW) carbon stocks in year, t; t C yr^{-1}

$\Delta C_{PRJ,SNAG,t}$ = change in snag carbon stock in year, t; t C yr^{-1}

$\Delta C_{BSL,DBG,t}$ = change in below-ground carbon stock in year, t; t C yr^{-1}.

The annual change in the carbon stored in harvested wood products (HWP), ($\Delta C_{PRJ,HWP,t}$; t C yr^{-1}) in the project scenario was calculated as:

$$\Delta C_{PRJ,HWP,t} = \Delta C_{PRJ,STORHWP,t} - \Delta C_{PRJ,EMITFOSSIL,t}, \quad (46)$$

$\Delta C_{PRJ,STORHWP,t}$ = the annual change in harvested carbon that remains in storage after conversion to wood products (t C yr^{-1})

$\Delta C_{PRJ,EMITFOSSIL,t}$ = the annual change in fossil fuel emissions from harvesting (logging and log transport) and processing of the various wood products. The project has not included the optional equipment emissions carbon pool and hence this variable = 0.

5.3. Leakage

Activity Shifting Leakage

Rotunda does not own any other properties within the country. There is no risk of activity shifting of commercial timber operations to a different property. The additional parcels owned by Rotunda covered under the same Forest Management Plan but excluded from the carbon project area are not eligible for forest harvesting due to being classified as conservation areas. Therefore, activity shifting leakage to these areas would not be possible.

Market Leakage

The methodology provides three options for market leakage. The Rotunda property has selected to apply the most current VCS Market Leakage Tool (VCS AFOLU Requirements v3.6, Section 4.6.14).

The VCS method involves applying the appropriate market leakage discount factor identified in Table 3 to the net change in carbon stock associated with the activity that reduces timber harvest.

Romania has 6,380,000 ha of forest cover and an annual allowable cut of 14.8 million m^3 (FAO). The Rotunda property is located within the Hunedoara Department, which manages 146,135 ha of public forest, containing 42,670 ha of timber production forests. In 2019, the AAC was 232,655 m^3 within the production forest.

Between 2008-2017 the Rotunda property harvested 18,141 m^3 of wood products (1,814 m^3 annually). Excluding all other harvest on private lands, this is 0.78% of the annual harvest on public lands within this region. Section 4.6.4 of the AFOLU Requirements v3.6 states that "Projects shall account for market leakage where the production of a commodity is significantly affected by the project". In regard to Section 4.6.14, Table 3, there is minimal affect on total timber harvest volumes therefore the Market Leakage Discount Factor is 0%.

Table 6 Historical Harvest Operations Within the Project Area

Year	Thinning (ha)	Regeneration Cuts (ha)	Conservation Cuts (ha)	Hygiene Cuts* (ha)	Accidental** (ha)	Total (ha)
2008-2017	1,197	1,463	8,029	715	6,737	18,141

*Hygiene cuttings are anticipated to continue through the life of the project.
**Accidental cuts are completed after a natural disturbance (drought, pest, snow, wind).

5.4. Net GHG Emission Reductions and Removals

Calculation of the Uncertainty Factor

As per the methodology monitoring section specification, the project has installed at least one field plot in each Analysis Unit (except AU 3 due to the small amount of area dispersed throughout the project area). The project has installed 28 permanent carbon plots in 2020 and 2021.

The project-level uncertainty factor is calculated by a function within the Uncertainty Calculations_20210120 excel spreadsheet, following the formulas below:

Step 1 – the project calculated the average percent model error (E_M) for the project based on the average area-weighted difference between measured values in monitored plot observations and model-predicted values using Equations 60a, b.

$$\mathbf{E_M = 100 \cdot (\sum y_{d,h,i} / \sum(A_{PRJ,h} \cdot y_{m,h,i}))} \quad \mathbf{(60a)}$$

where:

The summation is across all plot observations, i, and across all analysis units, h;

$\mathbf{y_{d,h,i} = A_{PRJ,h} \bullet (y_{p,h,I} - y_{m,h,i})}$ **(60b)**

E_M = Mean model error for the project (%)

$y_{d,h,i}$ = the area-weighted difference between measured and predicted carbon storage in analysis unit, h, plot observation, i (t C)

$y_{m,h,i}$ = carbon storage measured in analysis unit, h, plot observation, i (t C ac^{-1})

$y_{p,h,i}$ = carbon storage predicted by model for analysis unit , h, plot observation, i (t C ac^{-1}) $A_{PRJ,h}$ = area of project analysis unit, h (ac)

Step 2 – The project calculated the inventory error (E_I) at a 90 percent confidence interval expressed as a percentage of the mean area-weighted inventory estimate from the measured plots. Inventory error is estimated based upon the difference between modeled and measured values for monitoring plots established in polygons grouped within analysis units.

Inventory error, E_I, is estimated by first calculating the standard error of the area-weighted differences between the plot observation measurement and the associated model-predicted carbon storage (both on a per acre basis) for analysis units. The standard error is then multiplied by the *t*- value for the 90 percent confidence interval. Finally, E_I is expressed in relative terms (in Equation 60c) by dividing the 90% confidence interval of the area-weighted differences between predicted and measured values in all plots by the area-weighted average of the measured values in all monitoring plots.

$E_I = 100 \bullet [SE * 1.654 / ((1/N) \bullet \sum(A_{PRJ,h} \bullet y_{m,h,i}))]$ (60c)

where:

E_I = Inventory error for the project (%)

SE = the project level standard error of the area weighted differences between measured plot observation and predicted values of carbon storage.

N = total number of plot observations in all analysis units 1.654 = the 90% confidence interval t-value

All other terms as defined in equation 60a.

$SE = S/ \sqrt{N}$ (60d)

where:

N = total number of plot observations in all analysis units

S = the standard deviation of the area weighted differences between measured and predicted values of carbon storage across all analysis units.

$S = \sqrt{[(1/ N- 1) \bullet \sum(y_{d,h,i} - \bar{y}bar_d)^2]}$ (60e)

where:

$ybar_d$ = the project-level mean of the area weighted differences between measured plot observation and predicted values of carbon storage. See equation 60b for the calculation of $y_{d,h,i}$

All other terms as defined in equation 60b and 60c.

Step 3 - The total error for the project (E_P; %) is calculated by adding the model and inventory error terms, as calculated in Steps 1 and 2.

$$E_P = E_M + E_I \qquad (60f)$$

Step 4 – Compare the result of Step 3 against Table 7to determine the uncertainty factor.

Table 7: Uncertainty Factor calculation.

Estimated Project Error, E_P (%)	Uncertainty Factor (= $ER_{Y,ERR}$)
0 – 10%	= 1.5%
>10%	= 1.5% + E_P – 10%

Initial Estimate of Uncertainty

Carbon plot volumes were compiled using CBM-CFS3. The inventory error term (E_I) was calculated to be 1.97% while the model error term (E_M) was 0.77%. As shown in Equation 60f, the project error term (E_P) was calculated as the sum of E_M and E_I (2.75%). Thus, the uncertainty factor ($ER_{Y,ERR}$) was calculated (based upon Table 7) to be 1.5%.

This uncertainty factor will be re-assessed at verification and adjusted annually to reflect improved field data from the project monitoring plot network.

Calculation of Gross Emissions Reductions

Gross carbon emissions reductions ($ER_{y,GROSS}$; t CO_2e yr^{-1}) created by the Rotunda Carbon Project were calculated annually as the difference between the baseline and project scenario emission reductions/emissions:

$$ER_{y,GROSS} = (\Delta C_{BSL,t} - \Delta C_{PRJ,t}) \bullet 44/12 \qquad (57)$$

Where,

$\Delta C_{BSL,t}$ = total baseline scenario emissions calculated from equation 1 (t C yr^{-1}).

$\Delta C_{PRJ,t}$ = total project scenario emissions calculated from equation 29 (t C yr^{-1}).

44/12 = factor to convert C to CO_2e

The gross emissions reductions calculated for the Rotunda project within the monitoring period are shown in

Table 8.

Table 8: Ex-Post Estimate of Emission Reductions and Leakage Related to Project Activities for current monitoring period.

Year	Estimated baseline emissions or removals (tC)	Estimated project emissions or removals (tC)	Estimated leakage emissions (tCO2e)	Estimated net GHG emission reductions or removals (tCO2e)
2018	-155	635	0	2,898
2019	149	244	0	346
2020	7	1,211	0	4,414
Total	**2**	**2,090**	**-**	**7658**

Table 9: Ex-Post Estimate of Verified Carbon Units (VCUs) Produced From Project Activities during the monitoring period.

Year	Estimated Gross Emissions reductions (tCO_2e)	Estimated leakage emissions (tCO_2e)	Non-Permanence Buffer Contribution (tCO_2e)	Buffer release (tCO_2e)	Annual Saleable VCU's (tCO2e)
2018	2,898	0	348		2,506
2019	346	0	42		299
2020	4,414	0	530		3,818
Total	**7,658**	**-**	**919**	**0**	**6,624**

Calculation of Net Emissions Reductions

The annual net GHG emissions reductions are calculated each year using Equation 58.

$ER_y = ER_{y,GROSS} - LE_y$ (58)

where:

ER_y = the net GHG emissions reductions and/or removals in year y (the overall annual carbon change between the baseline and project scenarios, net all discount factors except the permanence buffer) (t $CO_2e\ yr^{-1}$).

$ER_{y,GROSS}$ =the difference in the overall annual carbon change between the baseline and project scenarios (t $CO_2e\ yr^{-1}$).

LE_y = Leakage in year y (t $CO_2e\ yr^{-1}$), as calculated in equation 56.

Calculation of Voluntary Credit Units (VCUs)

The number of VCU's the Rotunda carbon project generates as available for issuance and sale in year, *y* (VCU_y; t $CO_2e\ yr^{-1}$), is calculated as:

$VCU_y = ER_y \bullet (1 - ER_{y,ERR}) - BR_y$ (59)

where:

ER_y = the net GHG emissions reductions and/or removals in year (t $CO_2e\ yr^{-1}$), as calculated in equation 58.

$ER_{y,ERR}$ = the uncertainty factor for year, y, (calculated in Section 3.4), expressed as a proportion.

BR_y = estimated VCU-equivalent tCO_2e issued to the VCS Buffer Pool in year, *y*, calculated using the latest version of the VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer (Voluntary Carbon Standard, 2008).

BRy is calculated by multiplying the most current verified permanence risk Buffer Withholding Percentage for the project by the change in carbon stocks (difference between baseline and project scenario) for the project area.

The project VCS Buffer Discount Factor (BR_Y) was calculated as 12%, as per the non-permanence risk assessment. The BR factor will be re-assessed at each verification, as necessary.

The uncertainty factor was determined to be 1.5%, as calculated above. The uncertainty factor will be re-calculated from field plot data at each verification.

The annual VCUs projected for the Rotunda Project are shown in

Table 9.

6. References

Muller-Using, S., Bartsch, N. 2009. Decay dynamics of coarse and fine woody debris of a beech (Fagus sylvatica L.) forest in Central Germany. European Journal of Forest Research.

Petrillo, M., Cherubini, P., Fravoluni, G., Marchetti, M., Ascher-Jenull, J., Sharer, M., Synal, H.A., Bertoldi, D., Camin, F., Larcher, R., Egli, M. 2016. Time since death and decay rate constants of Norway spruce and European larch deadwood in subalpine forests determined using dendrochronology and radiocarbon dating. Biogeosciences.

APPENDIX A – SPATIAL NDVI ANALYSIS

Monitoring – Project Area

The spatial monitoring program was implemented to identify natural disturbance events, planned project activities such as harvests, road construction and reforestation, and unplanned anthropogenic ("human-caused") disturbances such as illegal or unplanned harvests which are >4ha.

Changes in vegetation cover were monitored by comparing temporally different satellite images and their respective derived normalized difference vegetation indices (NDVI). The resulting analysis rendered increases and decreases in vegetation cover which have been classified and symbolized according to the magnitude of change. Changes are measured at the pixel scale of the imagery (10 m x 10 m for Sentinel-2 Imagery).

Losses of at least 0.5 ha in area (50 continuous pixels) are examined and contribute to the 4-ha minimum disturbance size.

Data Acquisition

To account for seasonality of vegetation cover, imagery from different years within a close seasonal range were selected for analysis. Cloud cover was limited to between 0 and 6% and any localized cloud cover was checked to not overlap the project area. The objective of this monitoring program included the assessment of a portion of a planned road that was constructed in late 2017/early 2018. Imagery from August 20, 2017 and August 4, 2020 were selected based on data availability and the above criteria.

Data Classification

Representative ranges were established for the change in NDVI over the designated time period.

Table A10: Classification Ranges for Changes in NDVI

NDVI change	Qualitative Classification
> 0.2	Significant vegetation gain
0.1 to 0.2	Vegetation gain
0.05 to 0.1	Minor vegetation gain
0 to 0.05	Minimal positive vegetation change
0 to -0.05	Minimal negative vegetation change
-0.05 to -0.1	Minor vegetation loss
-0.1 to -0.2	Vegetation loss
< -0.2	Significant vegetation loss

Results

Two contiguous areas of greater than 0.5 ha (50 contiguous pixels) were identified as showing significant vegetation loss in the Clopotiva area. There were no areas of significant loss > 0.5 ha in the Pui area.

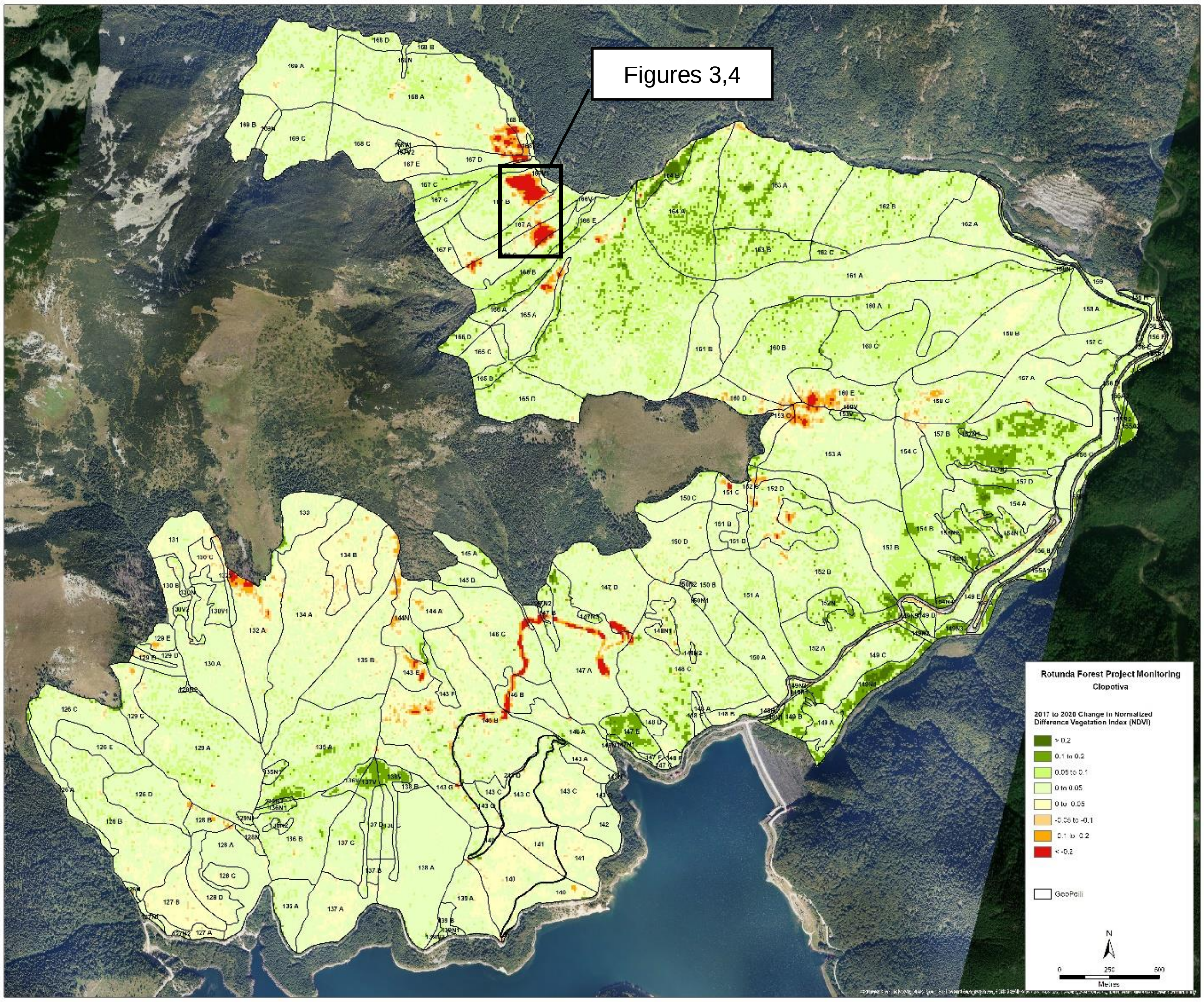

Figure A5: Calculated change in NDVI over the Clopotiva area from August 2017 to August 2020

Table A11: Areas with a significant loss of vegetation cover encompassing > 0.5ha

Pixel Count	Area (ha)
143	1.43
66	0.66

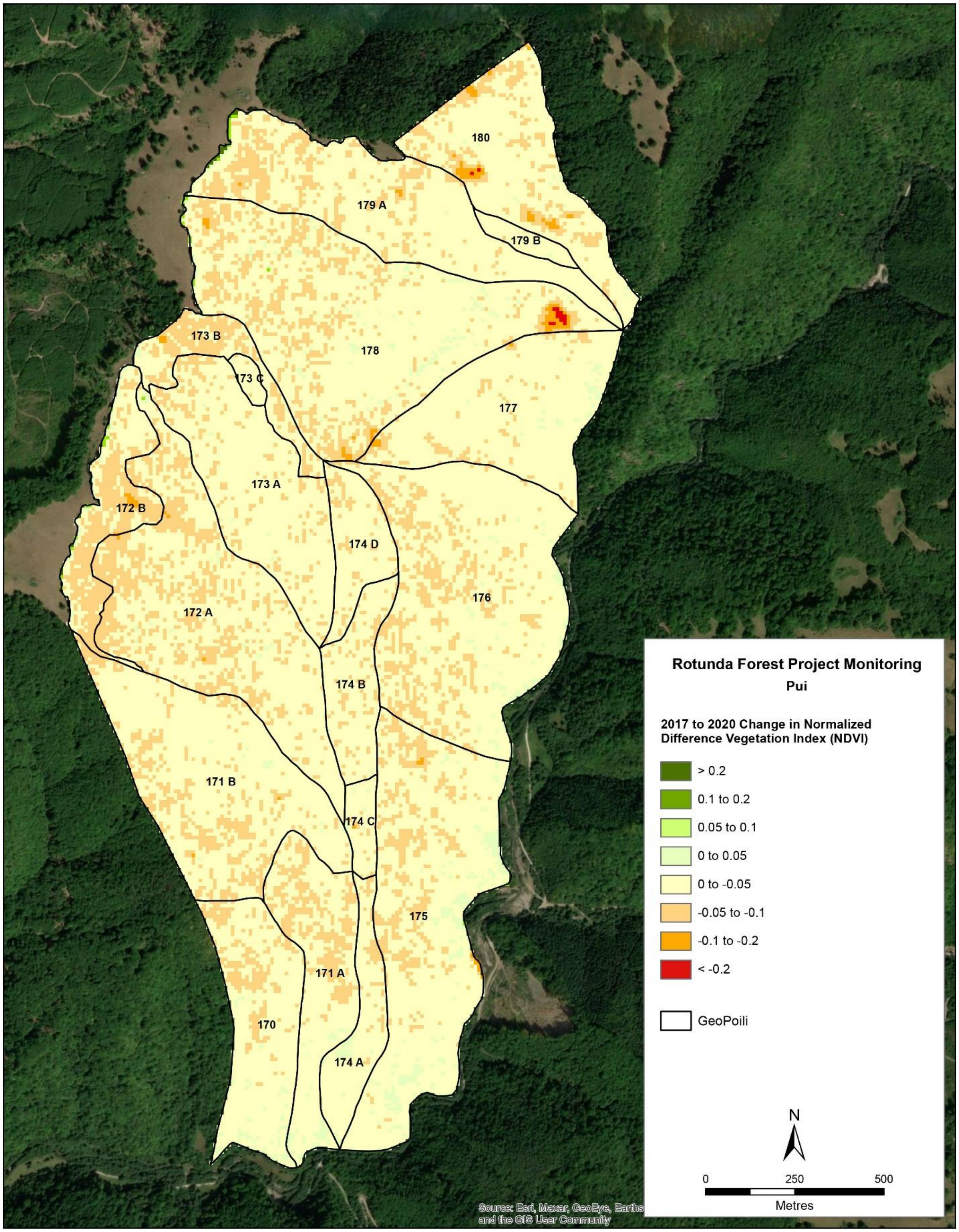

Figure A6: Calculated change in NDVI over the Pui area from August 2017 to August 2020

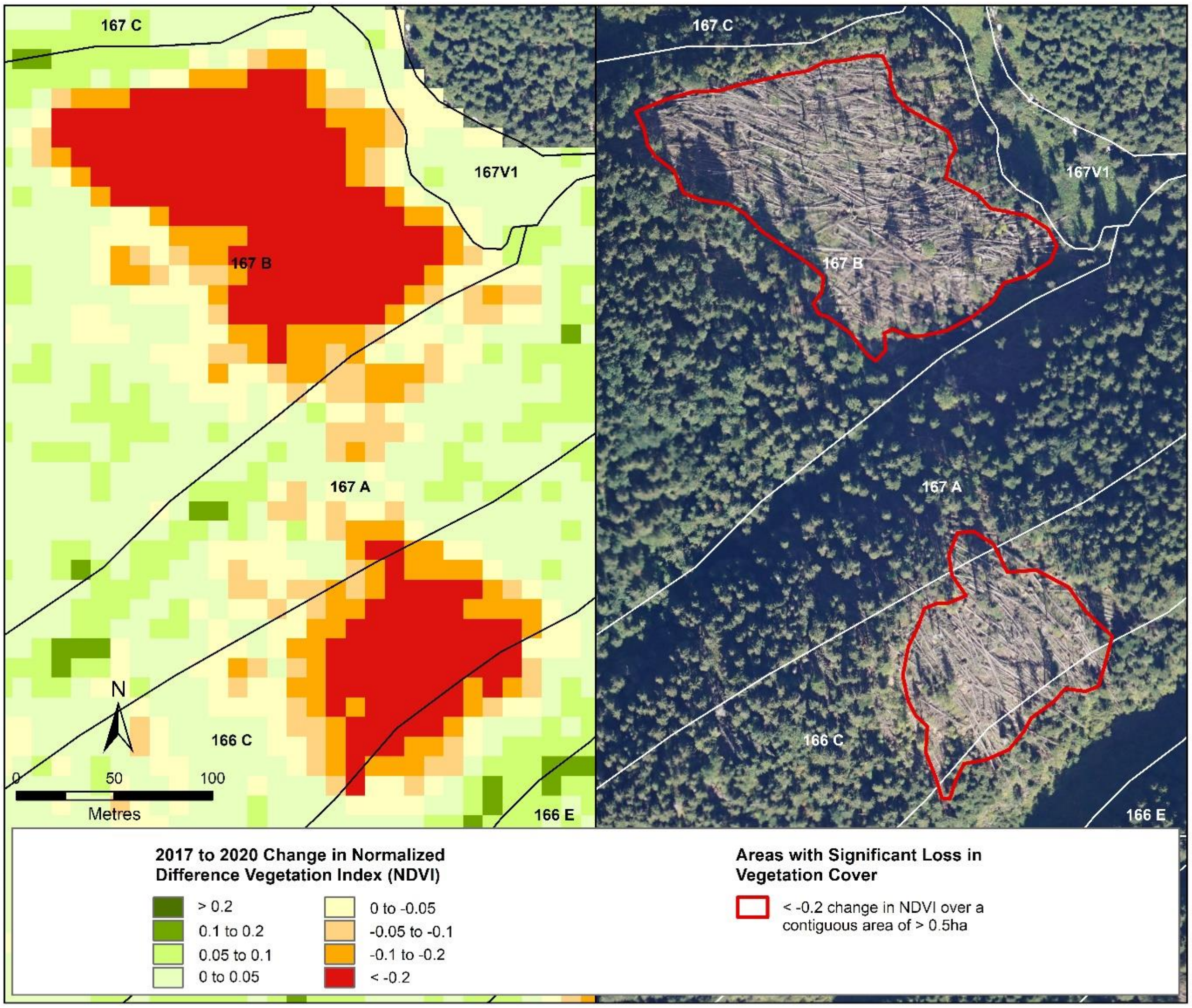

Figure A7: Areas with significant loss in vegetation cover >0.5 ha in Clopotiva.

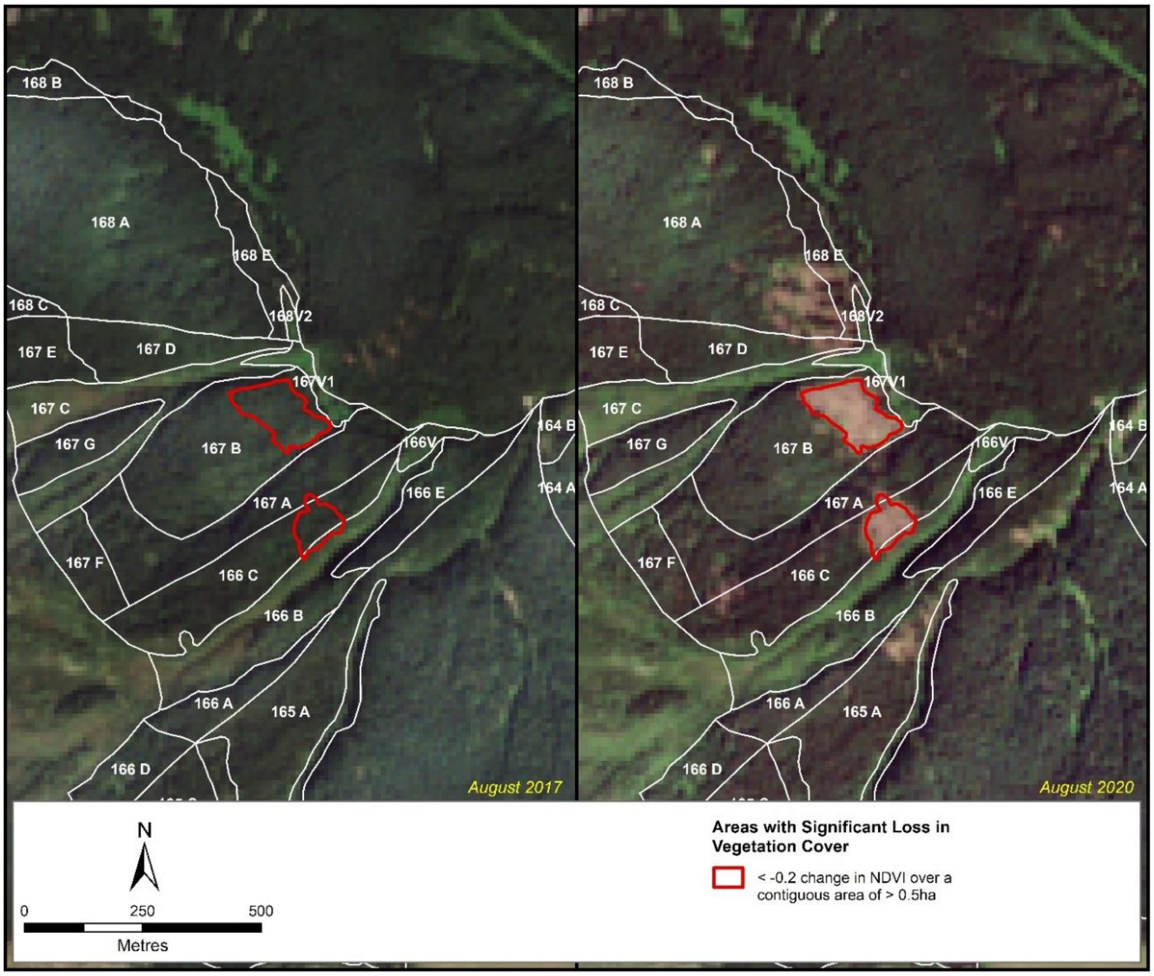

Figure A8: Comparison of August 2017 and 2020 imagery used for NDVI analysis in the region of identified significant vegetation cover loss.

Discussion

Two areas of significant disturbance met the continuous 50-pixel threshold within the Clopotiva project area. These areas measured 2.09ha of disturbance. Following discussions with Rotunda forest managers, it was verified that these disturbances are a result of significant windthrow events. Both polygons identified experienced significant stand mortality.

In addition to the windthrow areas, a road can be seen travelling through the central Clopotiva region. This road was planned and developed within the project scenario, accounting for the changes in greenhouse gas emissions. No other unplanned disturbances were identified within the project area which met the minimum thresholds for spatial change reporting.

Conclusion

The completion of the NDVI spatial assessment indicates that no additional changes are required for the analysis units. Reassignments to the analysis unit are not required, due to unplanned spatial changes totalling 2.09 ha, short of the 4 ha minimum threshold.