Afognak Forest Carbon Project Monitoring Report

Monitoring Period: 2015-2017

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

The Afognak Forest Carbon Project covers 3,326.5 ha (8,219.7 acres) of adjacent or proximal parcels located on the North coast (Perenosa Bay/Delphin Bay area) of Afognak Island, Alaska.

In a series of transactions outlined in Section 1.12.1 in the Project Design Document (PDD), the American Land Conservancy (ALC) and the Rocky Mountain Elk Foundation (RMEF) acquired the Afognak Carbon project properties and related timber rights from the privately owned Alaskan Native Corporations (Afognak Joint Venture, Shuyak, Inc., and Uganik Natives, Inc.) over the period of 2005-2009, with the objective of conserving the land in perpetuity. As part of these transactions, ALC/RMEF specifically retained the carbon legal title rights and right of use for the purpose of a carbon emissions reduction project; attached a permanent federal conservation easement to ensure perpetual conservation management; and transferred the remaining surface title rights to the State of Alaska.

The Afognak Forest Carbon Project achieves net GHG emission reductions and removals through the avoidance of emissions due to logging in the baseline scenario. The Afognak properties were being managed for timber production by the previous managers, with existing or pending logging plans in place across these and adjacent properties owned by the previous owners. The most plausible baseline scenario is a clear-cut, timber-harvesting scenario following minimum State of Alaska forest practice requirements and common practices clearly evident in previous logging on the project lands and adjacent lands across Afognak Island.

The project scenario is conservation management, wherein the State of Alaska manages the properties for the purpose of wilderness and ecosystem protection and enhancement activities under the terms of the title transfer agreement and federal conservation easement. The project scenario retains the current native and naturally regenerating logged forests in perpetuity to retain and sequester carbon on the property. The project is currently being fully implemented as per the project design.

The project will undertake activities on a periodic basis in preparation for verification periods to monitor carbon inventory and stock changes over time. The monitoring period covered by this Monitoring Report includes the years 2015 through 2017. Previous Verified Monitoring Reports covered the initial monitoring period of inception 2006 through 2011, the second monitoring period of 2012-2013, and the third monitoring period 2014 only.

As per the Monitoring Program described in the PDD, the project undertook the following monitoring activities in the summer of 2018:

1. Annual Forest Inventory Change Monitoring

2. Other Monitoring Requirements for the Project (i.e. leakage monitoring)

3. Quality Assurance/Quality Control Measures

The total GHG emission reductions generated by the project in this monitoring period amount to 121,654 tCO_2e in 2015, 93,726 tCO_2e in 2016, and 96,934 tCO_2e in 2017.

1.2 Sectoral Scope and Project Type

Sector 14 - AFOLU

Improved Forest Management (IFM)

Logged Forest to Protected Forest (LtPF)

This is not a grouped project.

1.3 Project Proponent[1]

Organization name	Rocky Mountain Elk Foundation
Contact person	Blake Henning
Title	Chief Conservation Officer
Address	5705 Grant Creek Road, Missoula, Montana 59808
Telephone	406-523-0273
Email	bhenning@rmef.org

1.4 Other Entities Involved in the Project

Organization name	Camco International Group, Inc.[2]
Role in the project	Project Proponent Representative

[1] In 2016, Rocky Mountain Elk Foundation became the sole project proponent for the project. American Land Conservancy who were also originally a project proponent filed a Partial Release Representation with the VCS to remove themselves from the Project.

[2] Camco Global (as referenced in the PDD) changed its name to Camco Clean Energy plc in 2012. Camco International Group, Inc. is a wholly owned subsidiary of Camco Clean Energy.

Contact person	Charles Purshouse
Title	Vice President – Renewables & Environmental Markets
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Email	charles.purshouse@camcocleanenergy.com
Organization name	3GreenTree Ecosystem Services Ltd.
Role in the project	Implementing Partner
Contact person	Mike Vitt
Title	Managing Director
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Telephone	206-307-7096
Email	mike.vitt@3greentree.com

1.5 Project Start Date

The Afognak carbon project and the crediting period start dates are the start of the calendar year closest to the initial acquisitions. The Waterfall parcel and timber rights to Laura Lakes Tract B parcel were acquired Dec. 19, 2005. The Shuyak and Uganik parcels and the remaining timber harvesting rights for Laura Lakes Tract A were acquired July 17, 2009. The project start date is selected as January 1, 2006 for simplicity and annualized tracking.

1.6 Project Crediting Period

Crediting Period: 30 years – Jan 1, 2006 through Dec 31, 2035

The crediting period starts on the project start date; however, note that the baseline scenario has a conservative assumption of harvesting on the properties beginning in 2008 (when the project will first generate VCU's). This partially reflects an assumption of some lead-time in the baseline to implement

harvesting plans, and also recognizes the secondary acquisitions in 2009. This assumption is conservative and leads to less credits being claimed by the project over the project lifespan.

The project crediting and monitoring period is 30 years; however, ALC/RMEF intend to own the carbon title rights in perpetuity, and the federal conservation easement and related transactional agreements commit the State of Alaska to manage the Afognak property for conservation purposes consistent with the carbon project in perpetuity.

1.7 Project Location

The Afognak properties are located in parcels located to the east and west of Perenosa Bay including Delphin Bay on the north coast of Afognak Island in Alaska as shown in Figure 1. The property is located approximately 65 km (40 miles) aerial distance from the main regional town of Kodiak, AK. The Afognak property is bounded by lakes or ocean, and by various State of Alaska and private Alaska Native Corporation lands. The boundaries are surveyed and staked as shown on legally registered plats by parcel (copies of which are available upon request). Further details relating to title and use rights and title and covenant agreements, and the associated timelines can be found in Section 1.12 of the PDD.

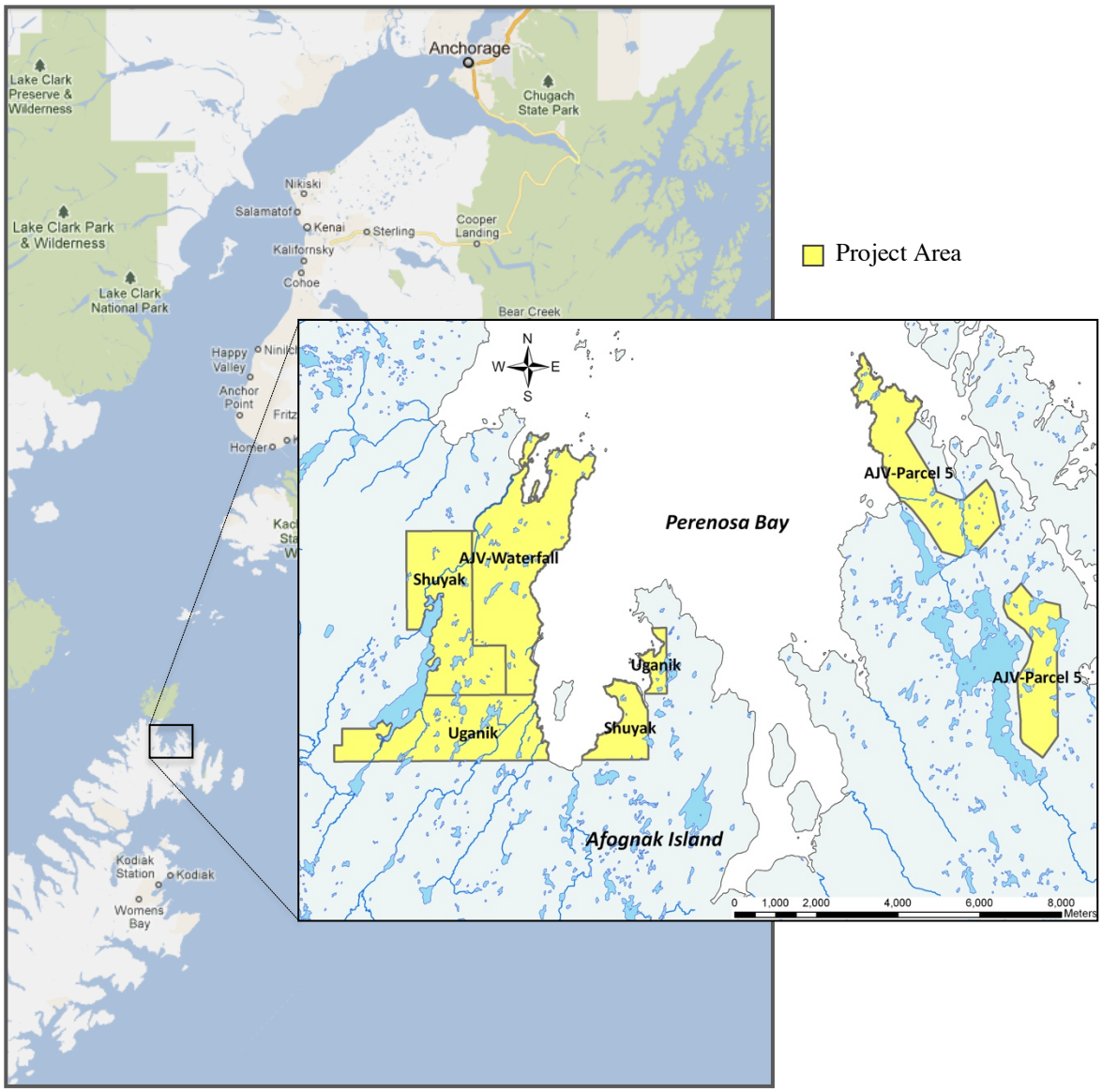

Figure 1. An overview map of the Afognak Island carbon project showing its location relative to Anchorage Alaska and Kodiak Island. The insert shows a magnification of the individual parcels that comprise the project area.

1.8 Title and Reference of Methodology

Methodology: VM0012 Improved Forest Management – Logged to Protected Forest (IFM-LtPF) on Fee Simple Forested Properties – Version 1.1.

1.9 Other Programs

This project is not registered, nor does it participate, in any other environmental or GHG crediting program.

1.10 Sustainable Development

Not Applicable.

2 IMPLEMENTATION STATUS

2.1 Implementation Status of the Project Activity

The primary project activity was the elimination of the baseline logging and other development activities, which has been implemented across the entire project area as of the acquisition date of the various parcels. Other than conservation of the project area, no material planned or unplanned activities were undertaken on any project parcel since the project start date.

This monitoring period represents years 10 through 12 of the ongoing project and includes the calendar years 2015 through 2017. During this monitoring period the project scenario activity of forest conservation has been implemented across the project area. As planned, the project level activities are very low and have primarily included de minimis monitoring activities.
Monitoring activities have been primarily conducted via the analysis of current remote sensing data (satellite imagery) and standard ongoing State of Alaska conservation property oversight of the area. Recent satellite imagery has been acquired and reviewed and it was determined that no material level of forest disturbance has occurred for non-permanence monitoring purposes. The project does not require field leakage monitoring, and instead is an office-based leakage calculations as per the methodology.

The project proponents have changed during the monitoring period, as per the footnote in Section 1.3.

2.2 Deviations

2.2.1 Methodology Deviations

There were three minor deviations from the methodology during this monitoring period (the first two are continuations of previously verified deviations):

- The first deviation is related to the installation of additional monitoring plots within the project area. Specifically, the methodology suggests monitoring plots should be installed in all defined analysis units (See Section 4.1). However, as was the case during the previous project verification periods, monitoring plots were limited to the mature spruce analysis unit (AU101). The other analysis unit defined for the project was for the previously harvested areas (AU201) that are regenerating naturally to sitka spruce, which has been modeled to occur over a period of 8-18 years following harvest based upon observations of existing cutover areas within the project area (Fig. 2). Monitoring plots have not yet been installed within this analysis unit, as there are only small amounts of live tree biomass and deadwood

in these areas following harvest. This deviation is conservative with respect to the calculation of GHG emissions because the deviations between model predictions of net ecosystem carbon would be very small relative to those in the mature spruce plots simply because the amount of biomass and deadwood are so small. Further, this is conservative because the same assumptions of re-growth are made in both the baseline and project scenario for this analysis unit during the project period (and hence net each other out in the calculation of net emissions reductions). Further, the addition of plots in these areas would increase the sample size and reduce estimates of inventory and model error, thereby reducing the uncertainty factor and increasing net VCUs; therefore not installing these monitoring plots is conservative and does not result in additional emission reductions in the project. This deviation is related to the establishment of field plots for the purpose of monitoring ex-post carbon stocks, and therefore by definition is only related monitoring aspects of the project and does not affect any other components of the project. The data that is collected in monitoring plots is only used for ex-post carbon stock calculations during monitoring and is not used or required by any other part of the methodology. This is outlined in VM0012, Section 8.2.2 and 8.2.3 (Determining Actual Onsite Carbon) which references monitoring for each verification; Section 9.2 Data and Parameters to be Monitored, which lists the data collected in the field plots; and then most specifically in Section 9.3 Description of the Monitoring Plan and 9.3.3 Carbon Stock Monitoring Field Plot Sampling Design and Stratification. All of these sections relate to monitoring and verification.

Figure 2. Typical natural regeneration on 10-15 year old clearcut in the Shuyak parcel. Note sparse spruce regen; heavy established shrub and grass.

- The second deviation is related to activity-shifting leakage monitoring. The methodology requests a listing of all properties owned or controlled by the project proponents. The project proponents are not-for-profit land conservation organizations that do not undertake any commercial timber harvesting on properties they own or control and have no history of commercial timber operations on the project area or any other property; and hence are not at risk of activity-shifting leakage across their diverse land holdings (acknowledging that there is the future possibility of unique and rare timber harvesting events related to conservation management that may need to be individually be reported for the purposes of activity shifting leakage assessment). Given the time and effort required to create and update a full list of properties for both project proponents when the historical default condition is no timber harvesting on any property; the project has deviated from the Methodology to only includes a subset listing of only properties on which any commercial harvesting has occurred in the monitoring period (in this case, none). This deviation still meets the objectives and intent of monitoring for activity-shifting leakage by reporting any activity on any property. The project proponents have provided written attestations of the lack of timber harvesting on any other property during this monitoring period. This deviation does not affect the calculation of emission reductions or increase the VCUs claimed by the project. This deviation is only related to the format of reporting data for monitoring for activity shifting leakage and is not used for any other function within the methodology. In VM0012, activity-shifting leakage is referenced in Section 8.3.1, which refers to project starting conditions for activity shifting (and hence is not affected by this deviation), and Section 9.3.7 Leakage Monitoring, to which this deviation applies.

- The third deviation relates to the timing of the re-measurement of the monitoring plots. The methodology requires remeasuring plots every five years. The plots were installed in October 2011, and have been remeasured at nearly seven years versus the required five. There are two reasons for the delay in the timing of re-measurement. 1) The remote location of the project makes the costs of sending a field crew in to measure plots extraordinarily high relative to otherwise similar projects. It made more sense to delay the timing of the plot re-measurement to coincide with next planned verification. 2) The fact that the forest in the project area is quite mature (nearly 200 years old on average) suggests that it is growing and accumulating biomass quite slowly. A comparison of the 2018 measurements to the 2011 measurements confirms that the plots have accumulated 5.5 tC ha-1 on average3 or roughly 0.8 tC ha-1 per year. Since the annual change in biomass C is less than 0.4% of average C stocks, the 2-yr delay in measuring the plots will not have a significant impact on the estimation of GHG emissions for the project. In addition, it will not have negative impact on the conservativeness of the project.

2.2.2 Project Description Deviations

[3] This calculation excludes one plot that contains few trees and lost a very large tree to mortality during the seven-year period, causing it to show a large loss in carbon stocks.

There were two project description deviations that occurred during 2015-2017 monitoring period (the first is a continuation of a previously verified deviation).

- The first deviation is an ongoing minor deviation from the project as described in the Project Design document (PDD v2.3). It is related to the application of the LST model as described in Section 4.1.5. Specifically, in the Project Description Document (PDD v2.3), the LST model was run for a period of 100 years using 5-year time steps to project the project and baseline scenarios. However, subsequent runs for use in the previous and current monitoring reports were conducted using a 30-year period with an annual time step. This was done to improve the annual accuracy of model output by removing averaging errors created when estimating annual values from the 5-year periods. This level of accuracy was not required for the PDD. A comparison of the output from the two model applications shows that there were only small differences due to averaging errors in the PDD version. There are no other impacts for the calculation of emission reductions in the project. Moreover, an updated version of the PDD (v3.0), prepared as part of a recent 10-yr baseline re-evaluation effective 2016, includes the output from the annual-timestep modelling.

- The second deviation relates to a change in the method for calculating market leakage. In 2016 it was necessary to update the baseline scenario as 10 years had elapsed since the project start date. In the initial PDD (v2.3) the CAR market leakage formula was selected to determine the market leakage discount. However, since the time of the initial PDD, a new version of the CAR market leakage formula has been developed so we were unable to continue to use the original version. The new version appears to be geared towards implementation in industrial forestry projects where as it penalizes conservation-based projects by forcing them to the highest leakage factor. This is inconsistent with the conservation-based nature of the Afognak project which was clear from its inception. As such, the decision was made to utilize the VCS leakage discount method outlined in the current version of the VCS AFOLU requirements document (v3.6) for all market leakage calculations in the project after 2015. The VCS method clearly fits better with the conservation focus of the Afognak project. Furthermore, both methods are eligible for use in the VM0012 v1.2 methodology. The 20% market leakage factor imposed by the VCS leakage method is more conservative than the original version of the CAR formula which was only applied to the difference harvested biomass and thus resulted in annual leakage discount the ranged from 10-12% of annual gross emission reductions.

2.3 Grouped Project

This is not a grouped project.

2.4 Safeguards

2.4.1 No Net Harm

As a remote conservation-based project that retains fully functional natural ecosystems, there are no material negative environmental impacts from the project. As a private land sale at an appraised market value, there are also no material net socio-economic impacts. There are potentially some lost economic

and employment opportunities for certain regional service providers by eliminating the logging in the baseline scenario, however for the local previous landowners any related impact is mitigated by the extraction of the appraised asset value, which was then shifted into other native corporation businesses and investment of their choosing.

2.4.2 Local Stakeholder Consultation

As outlined in the PDD Section 5.3 (v.3.0), there were extensive local stakeholder consultations prior to and during the acquisitions of the project properties. As the project area is now managed by the State of Alaska under a conservation easement preventing further developments, there are no ongoing or updated stakeholder consultations related to the project or this monitoring period.

3 DATA AND PARAMETERS

3.1 Data and Parameters Available at Validation

Table 1. Data and Parameters Available at Validation.

Data / Parameter	THLB
Data unit	Ha
Description	Timber harvesting land base area
Source of data	GIS
Value applied:	See GIS databases.
Justification of choice of data or description of measurement methods and procedures applied	Best available data from previous timber appraisal
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$A_{BSL,i}$, $A_{PRJ,i}$
Data unit	Ha
Description	Respective areas of baseline and project subregion, *i*
Source of data	Latest Afognak GIS spatial inventory data (see Appendix 1).
Value applied:	See GIS databases.
Justification of choice of data or description of measurement methods and procedures applied	Data are inputted into the Landscape Summary Tool
Purpose of the data	Required for baseline and project calculations

Comments	

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	IPCC default value
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	R_i
Data unit	unitless
Description	Root:shoot ratio in subregion, *i*
Source of data	Based on Li et al. 2003 but modified according to tree age according to Lehtonen et al. 2004
Value applied:	Variable – calculated as a function of age and species based on the references. Conifers range in value from 0.19 to 0.25 depending age. Hardwoods range in value for 0.18 to 0.24. See root biomass worksheet in the sitka spruce example (Appendix 3 of PDD).
Justification of choice of data or description of measurement methods and procedures applied	Root biomass is difficult to measure directly.

Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,NATURAL,i,t}$, $f_{PRJ,NATURAL,i,t}$
Data unit	unitless ($0 \leq f_{BSL,NATURALi}$, $f_{PRJ,NATURAL,i,t} \leq 1$)
Description	The proportion of biomass that dies from natural mortality in subregion, *i*, year, *t*, in the baseline and project cases, respectively.
Source of data	Expert opinion
Value applied:	0.2 % per annum
Justification of choice of data or description of measurement methods and procedures applied	Estimate established over years of FORECAST development comparing model outputs of coarse woody debris and snag accumulation against field data.
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,HARVEST,i,t}$, $f_{PRJ,HARVEST,i,t}$
Data unit	unitless ($0 \leq f_{BSL,HARVEST,i,t}$, $f_{PRJ,HARVEST,i,t} \leq 1$)
Description	The proportion of biomass removed by harvesting from subregion, *i*, in year, *t*, in the baseline and project cases, respectively.
Source of data	Annual harvest schedule produced from the Landscape Summary Tool, by stratum (inventory subregion).
Value applied:	Variable – see Tables 5 & 6 for summarized total annual harvest volume and area. Summarized from individual inventory data produced with the Landscape Summary Tool.
Justification of choice of data or description of	Annual harvest schedule constitutes the most reliable source of information for variable.

measurement methods and procedures applied	
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,DAMAGE,i,t}$, $f_{PRJ,DAMAGE,i,t}$
Data unit	unitless ($0 \leq f_{BSL,DAMAGE,i,t}$, $f_{PRJ,DAMAGE,i,t} \leq 1$)
Description	The proportion of additional biomass removed by for road and landing construction in subregion, *i,* year, *t*, in the baseline and project cases, respectively.
Source of data	Expert opinion initially as a conservative measure. Monitoring data on an ex-post basis.
Value applied:	Zero in ex-ante baseline and project scenarios. From monitoring data for project ex-post calculations.
Justification of choice of data or description of measurement methods and procedures applied	Value is rarely quantified. Precise values are difficult to obtain because they depend on site characteristics, operational equipment available, topography and terrain, etc. Expert opinion is therefore required until site specific information is available through the monitoring program.
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,BLOWDOWN,i,t}$, $f_{PRJ,BLOWDOWN,i,t}$
Data unit	unitless ($0 \leq f_{BSL,BLOWDOWN,i,t}$, $f_{PRJ,BLOWDOWN,i,t} \leq 1$)
Description	The proportion of live aboveground tree biomass subject to blowdown in subregion, *i,* year, *t*, in the baseline and project cases, respectively.

Source of data	Included within the natural mortality factor calculated in $f_{BSL,NATURAL,i,t}$, $f_{PRJ,NATURAL,i,t}$ Also captured by spatial monitoring if >4ha, which would be incorporated as a new subregion on an ex-post.
Value applied:	Zero for the baseline and project ex-ante calculations (part of the natural mortality factor source data).
Justification of choice of data or description of measurement methods and procedures applied	Precise estimates for $f_{BSLBlowdown}$ are very difficult to determine since they require mortality records from individually marked trees located in permanent sample plots and subject to repeated measurements. Hence, an estimate is established by comparing FORECAST model outputs of coarse woody debris and snag accumulation against field data.
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,BRANCH,i,t}$, $f_{PRJ,BRANCH,i,t}$
Data unit	unitless ($0 \leq f_{BSL,BRANCH,i,t}$, $f_{PRJ,BRANCH,i,t} \leq 1$)
Description	The proportion of aboveground tree biomass comprised of branches $\geq$ 5 cm diameter in subregion, *i*, year, *t*, in the baseline and project cases, respectively.
Source of data	Calculated within FORECAST using calibration data from allometric biomass equations by species based upon (Standish, Manning, & Demaerschalk, 1985).
Value applied:	Variable, see source of data.
Justification of choice of data or description of measurement methods and procedures applied	Allometric biomass equations constitute the most reliable source of information for variable.
Purpose of the data	Required for baseline and project calculations

Comments	

Data / Parameter	$f_{BSL,BUCKINGLOSS,i,t}$, $f_{PRJ,BUCKINGLOSS,i,t}$
Data unit	unitless ($0 \leq f_{BSL,BUCKINGLOSS,i,t}$, $f_{PRJ,BUCKINGLOSS,i,t} \leq 1$)
Description	The proportion of the log bole biomass left on site after assessing and/or merchandizing the log bole for quality, in subregion, *i*, year, *t*, in the baseline and project cases, respectively.
Source of data	Based on (Smith, Miles, Vissage, & Pugh, 2004), and expert opinion based on FORECAST modeler previous experience.
Value applied:	0.10 of stemwood and bark is assumed to be left on site.
Justification of choice of data or description of measurement methods and procedures applied	Value is rarely quantified, or data are often considered proprietary. Expert opinion is therefore required.
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,SNAGFALLDOWN,i,t}$, $f_{PRJ,SNAGFALLDOWN,i,t}$
Data unit	unitless ($0 \leq f_{BSL,SNAGFALLDOWN,i,t}$, $f_{PRJ,SNAGFALLDOWN,i,t} \leq 1$)
Description	The proportion of snag biomass in subregion, *i*, year, *t*, that falls over, in the baseline and project cases, respectively.
Source of data	From: (Parish, Antos, Ott, & Di Lucca, 2010)
Value applied:	Variable, depending on species and dbh. Modeled by species and dbh class within FORECAST.
Justification of choice of data or description of measurement methods and procedures applied	Fall rates derived from accelerated failure rate model described in Parish et al. 2009.

Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,lwDECAY,i,t}$, $f_{PRJ,lwDECAY,i,t}$
Data unit	unitless ($0 \leq f_{BSL,lwDECAY,i,t}$, $f_{PRJ,lwDECAY,i,t} \leq 1$)
Description	The annual proportional loss of lying dead biomass due to decay, in subregion *i,* year*, t* (unitless; $0 \leq f_{PRJ,lwDECAY,i,t} \leq 1$), in the baseline and project cases, respectively.
Source of data	Based upon: (Harmon, et al., 1986), (Laiho & and Prescott, 2004).
Value applied:	Variable, modeled within FORECAST, based upon an exponential decay function. Mass loss occurs in proportion to the amount of mass remaining in accordance with an a single exponential model, of the general form: $Y_t = Y_o\, e^{-kt}$ where Y_o is the initial quantity of material, Y_t the amount left at time *t*, and *k* is a decay constant. *k*-values for the species present on the Afognak project area are derived from references provided above.
Justification of choice of data or description of measurement methods and procedures applied	Mass loss occurs in proportion to the amount of mass remaining, and which is a generally accepted method for this variable (see Harmon et al.,1986, Laiho and Prescott, 2004)
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,SWDECAY,i,t}$, $f_{PRJ,SWDECAY,i,t}$
Data unit	unitless ($0 \leq f_{BSL,SWDECAY,i,t}$, $f_{PRJ,SWDECAY,i,t} \leq 1$)
Description	The proportional loss of snag biomass due to decay, in subregion, *i*, year, *t*, in the baseline and project cases, respectively.

Source of data	Based upon: (Vanderwel, Caspersen, & Woods, 2006a); (Vanderwel, Malcolm, & Smith, 2006b); (Kurz & et al, 2009)
Value applied:	Modeled within FORECAST by species based on calibration from the source data references above.
Justification of choice of data or description of measurement methods and procedures applied	As with lying dead wood (see $f_{BSL,lwDECAY,i,t}$), $f_{BSL,SWDECAY,i,t}$ is assumed to occur in proportion to the amount of mass remaining in accordance with a first order exponential model
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,SWDECAY,i,t}$, $f_{PRJ,SWDECAY,i,t}$
Data unit	unitless ($0 \leq f_{BSL,SWDECAY,i,t}$, $f_{PRJ,SWDECAY,i,t} \leq 1$)
Description	The proportional loss of snag biomass due to decay, in subregion, *i*, year, *t*, in the baseline and project cases, respectively.
Source of data	Based upon: (Vanderwel, Caspersen, & Woods, 2006a); (Vanderwel, Malcolm, & Smith, 2006b); (Kurz & et al, 2009)
Value applied:	Modeled within FORECAST by species based on calibration from the source data references above.
Justification of choice of data or description of measurement methods and procedures applied	As with lying dead wood (see $f_{BSL,lwDECAY,i,t}$), $f_{BSL,SWDECAY,i,t}$ is assumed to occur in proportion to the amount of mass remaining in accordance with a first order exponential model
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,dgbDECAY,i,t}$, $f_{PRJ,dgbDECAY,i,t}$
Data unit	unitless ($0 \leq f_{BSL,dgbDECAY,i,t}$, $f_{PRJ,dgbDECAY,i,t} \leq 1$)

Description	The proportional loss of dead belowground biomass due to decay, in subregion *i,* year*, t*, in the baseline and project cases, respectively.
Source of data	Based upon: (Moore, Trofymow, Siltanen, Prescott, & CIDET, 2005); (Melin, Petersson, & Nordfjell, 2009)
Value applied:	Modeled within FORECAST by species based on calibration from the source data references above.
Justification of choice of data or description of measurement methods and procedures applied	As with lying dead wood (see $f_{BSL,lwDECAY,i,t}$), $f_{BSL,SWDECAY,i,t}$ is assumed to occur in proportion to the amount of mass remaining in accordance with a first order exponential model
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,PRODUCTk}$, $f_{BSL,PROCESSk}$, $f_{PRJ,PRODUCTk}$, and $f_{PRJ,PROCESSk}$
Data unit	unitless; $0 \leq f_{BSL,PRODUCTk}$, $f_{BSL,PROCESSk}$, $f_{PRJ,PRODUCTk}$, and $f_{PRJ,PROCESSk} < 1$
Description	The respective fractions of harvested biomass allocated to a given forest product type, *k*, and its associated processing efficiency for the baseline (BSL) and project (PRJ) cases.
Source of data	(Miner, 2006).
Value applied:	Afognak Carbon Model 3.3 (Appendix 1)
Justification of choice of data or description of measurement methods and procedures applied	Best available data from the literature.
Purpose of the data	Required for baseline and project calculations
Comments	

Data / Parameter	$f_{BSL,PERMHWPk}$, $f_{PRJ,PERMHWPk}$
Data unit	unitless ($0 \leq f_{BSL,PERMHWPk}$, $f_{PRJ,PERMHWPk} \leq 1$)
Description	The fraction of biomass allocated to permanent storage, for each product type, *k*, in the baseline and project cases, respectively.
Source of data	Permanent carbon storage was calculated here using the 100-year method developed by (Miner, 2006).
Value applied:	Values are product-specific, as derived below.
Justification of choice of data or description of measurement methods and procedures applied	$f_{BSLPERMHWPk} = (1/(1 + (Ln(2)/HL_k)))^Y$ where: HL_k is the half-life of a given product type, *k* (years), and *Y* is the elapsed time (i.e, 100 years). Product halflife (HL_k) values were as follows: Sawnwood = 35y, Veneer, plywood and structural panels = 30y, Non-structural panels = 20y, and paper = 2y (Miner 2006).
Purpose of the data	Required for baseline calculations of permanent carbon storage from primary processing.
Comments	

Data / Parameter	$f_{BSL,BARK}$, $f_{BSL,COARSE}$, and $f_{BSL,FINE}$ $f_{PRJ,BARK}$, $f_{PRJ,COARSE}$, and $f_{PRJ,FINE}$
Data unit	unitless; $0 \leq f_{BSL,BARK}$, $f_{BSL,COARSE}$, $f_{BSL,FINE}$, $f_{PRJ,BARK}$, $f_{PRJ,COARSE}$, and $f_{PRJ,FINE} < 1$
Description	The proportions of bark, coarse, and fine residual biomass, respectively, (unitless; $0 \leq f_{BSL,BARK}$, $f_{BSL,COARSE}$, $f_{BSL,FINE}$, < 1) that comprise $B_{BSL,RESIDUAl,t}$ and $B_{PRJ,RESIDUAl,t}$ for the baseline (BSL) and project (PRJ) cases.
Source of data	(Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)
Value applied:	26.5%, for $f_{BSL,BARK}$ and $f_{PRJ,BARK}$

	42.9%, for $f_{BSL,COARSE}$ and $f_{PRJ,COARSE}$ 30.6%, for $f_{BSL,FINE}$ and $f_{PRJ,FINE}$
Justification of choice of data or description of measurement methods and procedures applied	Best available values.
Purpose of the data	Required for baseline calculations of permanent carbon storage from secondary processing.
Comments	

Data / Parameter	$f_{BSL,BARKUSE}$, $f_{BSL,COARSEUSE}$, and $f_{BSL,FINEUSE}$ $f_{PRJ,BARKUSE}$, $f_{PRJ,COARSEUSE}$, and $f_{PRJ,FINEUSE}$
Data unit	unitless; $0 \leq f_{BSL,BARKUSE}$, $f_{COARSEUSE}$, $f_{FINEUSE} < 1$
Description	The proportions of bark, coarse, and fine residual biomass, respectively, allocated to secondary manufacturing, for the baseline (BSL) and project (PRJ) cases.
Source of data	(Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)
Value applied:	100%, for $f_{BSL,BARKUSE}$ and $f_{PRJ,BARKUSE}$ 85%, for $f_{BSL,COARSEUSE}$ and $f_{PRJ,COARSEUSE}$ 42%, for $f_{BSL,FINEUSE}$ and $f_{PRJ,FINEUSE}$
Justification of choice of data or description of measurement methods and procedures applied	Evidence indicates that on average 80% of bark is combusted for energy, with the remainder used principally as mulch (Perlack et al. 2005). Decay rates for mulch are difficult to estimate. Hence, as a default, all bark ($f_{BSL,BARKUSE}$)is assumed to be 100% combusted, a conservative assumption.
Purpose of the data	Required for baseline calculations of permanent carbon storage from secondary processing.
Comments	

Data / Parameter	$f_{BSL,PROCESSc}$ and $f_{BSL,PROCESSf}$ $f_{PRJ,PROCESSc}$ and $f_{PRJ,PROCESSf}$
Data unit	unitless; $0 \leq f_{PRJ,PROCESSc}, f_{PRJ,PROCESSf} < 1$
Description	Processing efficiencies of coarse and fine residuals, respectively, in secondary manufacturing, for the baseline (BSL) and project (PRJ) cases.
Source of data	(Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)
Value applied:	85 % to all processing efficiencies
Justification of choice of data or description of measurement methods and procedures applied	Processing efficiencies of coarse and fine residuals in secondary manufacturing are typically much higher than primary manufacturing.
Purpose of the data	Required for baseline calculations of permanent carbon storage from primary processing.
Comments	

Data / Parameter	$f_{BSL,PROCESSc}$ and $f_{BSL,PROCESSf}$ $f_{PRJ,PROCESSc}$ and $f_{PRJ,PROCESSf}$
Data unit	unitless; $0 \leq f_{PRJ,PROCESSc}, f_{PRJ,PROCESSf} < 1$
Description	Processing efficiencies of coarse and fine residuals, respectively, in secondary manufacturing, for the baseline (BSL) and project (PRJ) cases.
Source of data	(Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)
Value applied:	85 % to all processing efficiencies
Justification of choice of data or description of	Processing efficiencies of coarse and fine residuals in secondary manufacturing are typically much higher than primary manufacturing.

measurement methods and procedures applied	
Purpose of the data	Required for baseline calculations of permanent carbon storage from primary processing.
Comments	

Data / Parameter	BEF
Data unit	Unitless
Description	Biomass expansion factors
Source of data	Not applicable
Value applied:	No specific BEF are used other than the root:shoot variable (R_i) described above.
Justification of choice of data or description of measurement methods and procedures applied	Not applicable
Purpose of the data	Not applicable
Comments	

Data / Parameter	Allometric equation parameters
Data unit	Unitless
Description	Convert height and DBH into biomass of component pools.
Source of data	Allometric equations from (Standish, Manning, & Demaerschalk, 1985) are used to calibrate biomass modeling within FORECAST. See Appendix 3.
Value applied:	Variable by species, see source of data.

Justification of choice of data or description of measurement methods and procedures applied	Used to derive biomass estimates for pools that are difficult to measure.
Purpose of the data	Are used in conjunction with permanent sample plot data to estimate biomass.
Comments	

3.2 Data and Parameters Monitored

Table 2. Data and Parameters Monitored

Data / Parameter	$A_{PRJ,i,}$
Data unit	Ha
Description	Area of forest land in subregion, *i*
Source of data	Latest Afognak GIS spatial inventory data (see Appendix 1).
Description of measurement methods and procedures to be applied	GIS inventory data updated from GPS coordinates and Remote Sensing data.
Frequency of monitoring/recording	Annual
Value monitored:	3326.5
Monitoring equipment	Visual, satellite, orthophotos
QA/QC procedures to be applied	Standard GIS QA/QC procedures. Latest Afognak Standard Operating Procedures (SOP)
Purpose of the data	Calculation of baseline & project emissions
Calculation method	

Comments	

Data / Parameter	$A_{PSP,i}$
Data unit	m^2
Description	Area of permanent sample plot in subregion, *i*
Source of data	Field measurement
Description of measurement methods and procedures to be applied	Standard plot layout design
Frequency of monitoring/recording	Plot measurements are repeated on 5-year intervals
Value monitored:	TBD – Fixed area
Monitoring equipment	GPS, measuring tape
QA/QC procedures to be applied	GPS of plot center. Latest Afognak Standard Operating Procedures (SOP) followed, including check cruising processes.
Purpose of the data	Calculation of baseline & project emissions
Calculation method	GPS positioning of plot center. Tape measurements to calculate area. Measurements were taken in feet using Imperial-based equipment. Feet were converted to meters by multiplying by 0.3048; 1 ft = 0.3048 m.
Comments	

Data / Parameter	$DBH_{i,t}$
Data unit	cm

Description	Diameter at breast 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 DBH tape for trees > 5 cm DBH.
Frequency of monitoring/recording	Individual plot tree re-measurements are repeated on 5-year intervals
Value monitored:	As measured
Monitoring equipment	DBH tape, data logger
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Measured. Measurements were taken in inches using Imperial-based equipment. Inches were converted to centimeters by multiplying by 2.54; 1 ft = 0.3048 m.
Comments	Used in allometric biomass equations

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	Permanent sample plots
Description of measurement methods and procedures to be applied	All trees > 1.3 m tall within a permanent sample plot

Frequency of monitoring/recording	Individual tree measurements are repeated on 5-year intervals
Value monitored:	As measured
Monitoring equipment	Hypsometer, a transit, a clinometer, a relascope, a laser or other instrument designed for the measuring height.
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Measured. Measurements were taken in feet using Imperial-based equipment. Feet were converted to meters by multiplying by 0.3048; 1 ft = 0.3048 m.
Comments	Used in allometric biomass equations

Data / Parameter	$B_{AGi,t}$
Data unit	t d.m. ha^{-1}
Description	Aboveground live tree biomass in subregion, *i*, year, *t*, in the project case.
Source of data	Permanent sample plots.
Description of measurement methods and procedures to be applied	Calculated from $Height_{i,t}$, $DBH_{i,t}$, and $A_{p,i,t}$
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored:	Variable
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).

Purpose of the data	Calculation of baseline & project emissions
Calculation method	Above ground biomass for each tree within a permanent sample plot will be estimated from allometric equations using height and dbh (Standish, Manning, & Demaerschalk, 1985). Area-based estimates of biomass will then be derived.
Comments	Data used to validate ex-ante values from inventory + model output

Data / Parameter	$B_{BGi,t}$
Data unit	t d.m. ha^{-1}
Description	Belowground live tree biomass in subregion, *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 from $B_{AGi,t}$ and R_i
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored:	Variable
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Calculated as the product of $B_{AGi,t}$ and R_i

Comments	Data used to validate ex-ante values from inventory + model output

Data / Parameter	$B_{TOTALi,t}$
Data unit	t d.m. ha^{-1}
Description	Total live tree biomass in subregion, *i*, year, *t*, in the project case.
Source of data	Permanent sample plots.
Description of measurement methods and procedures to be applied	Calculated from $B_{AGi,t}$ and $B_{BGi,t}$
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored:	Variable
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Calculated as the sum of $B_{AGi,t}$ and $B_{BGi,t}$
Comments	Data used to validate ex-ante values from inventory + model output

Data / Parameter	$C_{LB,i,t}$
Data unit	t C ha^{-1}
Description	Total carbon storage in live tree biomass in subregion, *i*, year, *t*, in the project case.

Source of data	Permanent sample plots.
Description of measurement methods and procedures to be applied	Calculated from $B_{AGi,t}$ and $B_{BGi,t}$ and CF
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored:	Variable
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Calculated from $B_{AGi,t}$ and $B_{BGi,t}$ and CF
Comments	Data used to validate ex-ante values from inventory + model output

Data / Parameter	$C_{DOM,i,t}$
Data unit	t C ha^{-1}
Description	Total carbon storage in dead organic matter in subregion, *i*, year, *t*, in the project case.
Source of data	Permanent sample plots.
Description of measurement methods and procedures to be applied	Calculated from $DOM_{SNAGi,t}$ and $DOM_{LDWi,t}$ and CF
Frequency of monitoring/recording	Upon establishment of PSP. Every 5 years, thereafter.
Value monitored:	Variable
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).

Purpose of the data	Calculation of baseline & project emissions
Calculation method	Calculated from $DOM_{SNAGi,t}$ and $DOM_{LDWi,t}$ and CF
Comments	Data used to validate ex-ante values from inventory + model output

Data / Parameter	Mean tree age
Data unit	years
Description	Mean tree age with a given permanent sampling plot in subregion, *i*, for the project case.
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Age will be recorded from a sample of dominant trees within a PSP
Frequency of monitoring/recording	Upon establishment of permanent a sample plot.
Value monitored:	Variable
Monitoring equipment	Tree coring bit.
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Cores will be analyzed by counting rings following Afognak SOP's. .
Comments	Data will be used to validate and update inventory (see Section 3.4)

Data / Parameter	$f_{PRJ,NATURAL,i,t}$

Data unit	unitless ($0 \leq f_{PRJ,NATURAL,i,t} \leq 1$)
Description	The proportion of biomass that dies from natural mortality in subregion, *i*, year, *t*, in the project case.
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Height and dbh of dead trees in permanent sample plots will be recorded.
Frequency of monitoring/recording	Every 5 years
Value monitored:	Proportion
Monitoring equipment	Observation
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Tree mass components calculated from allometric equations (Standish, Manning, & Demaerschalk, 1985) and biomass expansion factors (Li, Kurz, Apps, & Beukema, 2003); (Lehtonen et al. 2004). Mass is converted to its carbon equivalent by multiplying by the carbon fraction (0.5). Proportion derived by comparison with calculated estimates of total carbon in subregion, *i*.
Comments	

Data / Parameter	$f_{PRJ,HARVEST,i,t}$
Data unit	unitless ($0 \leq f_{PRJ,HARVEST,i,t} \leq 1$)
Description	The proportion of biomass removed by harvesting from subregion, *i*, in year, *t*, in the project case.
Source of data	Afognak harvesting records

Description of measurement methods and procedures to be applied	Volume derived from harvesting records. Wood density (see below) used to derive biomass estimates. Modeled estimates of total biomass in subregion, *i*, used to derive parameter.
Frequency of monitoring/recording	Every 5 years
Value monitored:	Proportion
Monitoring equipment	
QA/QC procedures to be applied	Data will be verified by ground-truthing and comparison with remote sensing information.
Purpose of the data	Calculation of leakage up until 2016 when a different method was employed.
Calculation method	Data will be verified by ground-truthing and comparison with remote sensing information.
Comments	Harvested volume is converted to mass by multiplying by average wood density (0.4; (Gonzalez, 1990)). Proportion derived by comparison with modeled estimates of total biomass in subregion, *i*.

Data / Parameter	$f_{PRJ,DAMAGE,i,t}$
Data unit	unitless ($0 \leq f_{PRJ,DAMAGE,i,t} \leq 1$)
Description	The proportion of additional biomass removed by for road and landing construction in subregion, *i,* year, *t*, in the project case.
Source of data	Remote sensing
Description of measurement methods and procedures to be applied	Areal estimate of removals derived from remote sensing data.

Frequency of monitoring/recording	Annual.
Value monitored:	Proportion
Monitoring equipment	
QA/QC procedures to be applied	Data will be verified by ground-truthing or remote sensing information.
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Areal estimate of removals is multiplied by average carbon density within a subregion.
Comments	

Data / Parameter	$DOM_{SNAG,i,t}$
Data unit	t d.m. ha^{-1} (d.m. = dry matter)
Description	Total mass of dead organic matter contained in standing dead wood in subregion, *i,* year, *t* in the project case.
Source of data	Permanent sample plots
Description of measurement methods and procedures to be applied	Calculated from $Height_{i,t}$, $DBH_{i,t}$, and $A_{p,i,t}$ of dead trees measured in permanent sample plots described in Section 3
Frequency of monitoring/recording	Every 5 years
Value monitored:	Variable
Monitoring equipment	Observation
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Standing biomass for all snags within a permanent sample plot will be estimated from allometric equations

	using height and dbh (Standish, Manning, & Demaerschalk, 1985).
Comments	

Data / Parameter	$DOM_{LDW,i,t}$
Data unit	t d.m. ha^{-1} (d.m. = dry matter)
Description	Total mass of dead organic matter contained in lying dead wood in subregion, *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 described in Section 3
Frequency of monitoring/recording	Every 5 years
Value monitored:	Variable
Monitoring equipment	Observation
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Calculated using the following field-measured parameters $L_{,i,t}$, $d_{n,i,t}$, $D_{LDW,c,i,t}$, and $N_{i,t}$
Comments	

Data / Parameter	$V_{LDW,c}$
Data unit	m^{-3} ha^{-1}
Description	Total volume of dead organic matter contained in lying dead wood in subregion, *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 transect method described in Section 3
Frequency of monitoring/recording	Every 5 years
Value monitored:	Variable
Monitoring equipment	Observation
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Calculated using the following field-measured parameters $L_{,i,t}$, $D_{LDW,c,i,t}$, and $N_{i,t}$
Comments	

Data / Parameter	$L_{,i,t}$
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	Tape
Description of measurement methods and procedures to be applied	Field measurements
Frequency of monitoring/recording	Plot measurements are repeated on 5-year intervals
Value monitored:	Default 100m
Monitoring equipment	Tape
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions

Calculation method	Line intersect method
Comments	Used to calculate mass of lying dead wood DOM_{LDW}

Data / Parameter	$d_{n,i,t}$
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	Field measurement
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 (> 10 cm diameter) intersecting the lines are measured. Minimum measurement diameter must not be less than 10cm.
Frequency of monitoring/recording	Plot measurements are repeated on 5-year intervals
Value monitored:	As measured
Monitoring equipment	Caliper, diameter tape
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Line intersect method
Comments	Used to calculate mass of lying dead wood DOM_{LDW}

Data / Parameter	$N_{i,t}$

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	Plot measurements are repeated on 5-year intervals
Value monitored:	As measured
Monitoring equipment	Visual observation
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Line intersect method
Comments	Used to calculate mass of lying dead wood DOM_{LDW}

Data / Parameter	$D_{LDW,c,i,t}$
Data unit	t d.m. m^3
Description	Basic wood density of dead wood in the density class, *c* along the transect in subregion, *i*, at time, *t* .
Source of data	Two 50-m lines are established bisecting each plot and wood pieces > 10 cm diameter intersecting transect are sampled.
Description of measurement methods and procedures to be applied	Pieces of know volume are take to lab, dried and weighed to calculate density
Frequency of monitoring/recording	Transects are re-sampled every 5 years

Value monitored:	As determined from estimated density class- (1) sound (0.32 t m^{-3}), (2) intermediate (0.26 t m^{-3}) and (3) rotten (0.15 t m^{-3}). From Heath and Chojnacky 1995
Monitoring equipment	Determined from literature sources for similar species
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	Line intersect method
Comments	Used to calculate mass of lying dead wood DOM_{LDW}

Data / Parameter	E_M
Data unit	%
Description	An estimate of model error based on the relative area-weighted difference between of model-predicted values of carbon storage and those values measured in field plots
Source of data	Model output and field data
Description of measurement methods and procedures to be applied	
Frequency of monitoring/recording	At each verification
Value monitored:	-3.8%
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	See Section 4.4.1

Comments	Used in the calculation of uncertainty factor (Section 4.4.1)

Data / Parameter	E_I
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
Description of measurement methods and procedures to be applied	
Frequency of monitoring/recording	At each verification
Value monitored:	11.3%
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	See Section 4.4.1
Comments	Used in the calculation of uncertainty factor See Section 4.4.1

Data / Parameter	E_P
Data unit	%
Description	An estimate of total project error based 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	
Frequency of monitoring/recording	At each verification
Value monitored:	7.5%
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of baseline & project emissions
Calculation method	See Section 4.4.1
Comments	Used in the calculation of uncertainty factor See Section 4.4.1

Data / Parameter	$ER_{y,ERR,}$
Data unit	%
Description	The uncertainty factor calculated for year 'y' in See Section 4.4.1
Source of data	Model output and field data
Description of measurement methods and procedures to be applied	
Frequency of monitoring/recording	At each verification
Value monitored:	1.5%
Monitoring equipment	
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).

Purpose of the data	Calculation of baseline & project emissions
Calculation method	See Section 4.4.1
Comments	Used in the calculation of VCUs (Section 4.4.2)

Data / Parameter	MLFy
Data unit	unitless
Description	The market leakage factor determined for year 'y'
Source of data	FORECAST model output for the project case (see Spruce C Curve tab of 'Afgonak LST Jan, 2019.xslx') and data from the Forest Inventory and Analysis (FIA) program of the U.S. Forest Service in the case of the leakage area (State of Alaska, Hemlock and Sitka Spruce forest type group; see FIA tab of 'Afgonak LST Jan, 2019.xslx'). Note that the wood density used to convert merchantable volume projected by FORECAST to biomass was assumed to be (0.4 t / m^3) based on the range reported for sitka spruce grown in Alaska (340 to 440 kg / m^3) provided in Gonzalez (1990), pp 33.
Description of measurement methods and procedures to be applied	Comparison of the ratio of merchantable biomass to total tree biomass in the project area to that in the likely leakage area.
Frequency of monitoring/recording	At each verification
Value monitored:	0.2
Monitoring equipment	N/A
QA/QC procedures to be applied	Latest Afognak Standard Operating Procedures (SOP).
Purpose of the data	Calculation of market leakage discount

Calculation method	Biomass Ratio Difference (%) = ((Project Biomass Ratio – Leakage Area Biomass Ratio) / Project Biomass Ratio) * 100) Where: Project Biomass Ratio = 0.54 Leakage area Biomass Ratio = 0.66 Biomass Ratio Difference (%) = -22% Since Leakage-Area ratio > 15% greater than Project ratio MLF_Y = 0.2 (see Table 3 of the VCS AFOLU Requirements V3.6 document).
Comments	Used in the calculation of the market leakage discount (Section 3.3.2)

3.3 Monitoring Plan

The objective of the project monitoring plan is to reliably monitor changes in carbon stocks related to the calculation of VCU's in during each monitoring period. 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.

The project has followed the Monitoring Plan as per Section 4.3 of the Afognak PDD during this monitoring period, portions of which are presented or paraphrased in this section for purposes or reporting monitoring activities and results for this period. This monitoring report focuses on reporting on the 4 primary activities within this Afognak Forest Carbon Project monitoring plan during the monitoring period:

1. **Inventory Change Monitoring** (PDD Section 4.3.1)

The project will undertake and document updates to the forest inventory data for the property using aerial observation, individual ground observations, and/or remote sensing methods, including at minimum (at a minimum scale of 4 ha):

a) Natural disturbance events (>4 ha),

b) Project activities,

c) Unplanned man-made disturbance.

These spatial inventory changes were monitored during this monitoring period as detailed in Section 3.3.1 be monitored prior to each verification using a combination of remote sensing, aerial and/or ground-based surveys across the project area.

2. **Other Monitoring Requirements of the Project** (PDD Section 4.3.2)

The project will monitor annualized changes in:

d) activity shifting leakage

e) and market leakage

These requirements were monitored during this monitoring period by updating the calculations following the methods outlined in the PDD (v3.0) Section 4.3. These monitoring results are detailed in Section 3.3.2.

3. **Field Plot Monitoring** (PDD Section 4.3.3)

At minimum, the Afognak project will update the inventory, uncertainty calculations, and carbon calculations from field plot measurement data as outlined in (PDD) Sections 3.4 and 4.5.

During this monitoring period, the project has not made any changes to the monitoring plan elements described in the PDD Section 4.3.3 in terms of:

- Stratification of Land Area
- Post-stratification
- Type and Number of Sampling Plots
- Plot type
- Number of Plots, Precision, and Sampling Size
- Sampling Design
- Measurement and Data Analysis Techniques

The details of these elements of the project monitoring plan are further detailed in the PDD Section 4.3.3 and as there have not been any changes to these elements, the full descriptions are not included in detail here for brevity.

The results of project monitoring during this period for Field Plot Monitoring are detailed in Section 3.3.3.

4. Quality Assurance/Quality Control Measures (QA.QC) (PDD Section 4.3.4)

Afognak 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 who had previous experience installing similar permanent carbon plots. The Afognak plot installation SOP requires blind check-cruises of a minimum of 10% of the plots. In the 2011 installation field season, 3 of the 22 plots were

check-cruised using blind checks (crews swapping plots), with 100% re-measurement of all variables. The plot check cruises 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.

Note PDD Section 4.3.4 for this element describes the monitoring process undertaken during the initial plot installation only. No changes or additions to this monitoring plan description has been made during this monitoring period. During this monitoring period these field plots have been re-measured in a manner consistent with the original plot installations described in this part of PDD Section 4.3.4. As the PDD Section 4.3.4 outlines

Further details related to activities and QA/QC for Field Measurement results in this monitoring period are in Sections 3.3.3 and 3.3.5.

QA/QC for Laboratory Measurements

As per the PDD, no laboratory measurements were taken for the Afognak sampling, and this section is not applicable. No changes to this element were made during this monitoring period.

QA/QC for Data Entry

Afognak data is field entered into electronic data recorders, and all data transferred electronically, which resolves many data entry error points. Standard procedures and ongoing QA/QC programs for data will be followed to ensure proper entry of data from paper to electronic format. If there are anomalies that cannot be resolved, the plot will be re-measured or omitted from the analysis.

The results of QA/QC for Data Entry during this monitoring period are described in Section 3.3.4.

Frequency of Monitoring (PDD Section 4.3.4)

Given the dynamics of forest processes, the permanent plots will be re-measured at intervals of not longer than 5 years (beginning at their date of first measurement). As noted, permanent plots may be established over multiple years, and such re-measurement schedules will be tracked on for each plot based on its establishment date.

Inventory data will be updated annually or at each verification/monitoring reporting period, including the results of project activities, natural disturbances, and other changes to the inventory.

This monitoring report describes the remeasurement of the permanent plots (see also the deviation on plot re-measurement timing) and reports on the annual inventory data monitoring.

Use of monitoring data to update carbon stock estimations (PDD Section 4.3.4)

Data gathered through the monitoring process will be used to:

1. Update the project inventory data and related modeling and monitoring stratification as per (PDD) Section 3.4;

2. update the leakage calculations in (PDD) Section 4.3;

3. update error estimates used in the calculation of the uncertainty factor as per (PDD) Section 4.5; and,

4. Update and improve calculations of carbon stocks in (PDD) Section 4.2 and possibly (PDD) Section 3.1 as described in (PDD) Sections 3.4 and 4.2.

The use of monitoring data to update carbon stock estimations has been followed during this monitoring period as described throughout this report.

Updating of Inventory (PDD Section 4.3.4)

The ex-post stratification and polygon assignment to specific analysis units shall be updated at minimum prior to each verification, for any of the following reasons:

1. Errors in the inventory from field sampling or other monitoring. If the criteria used to allocate a polygon are not in accordance with field evidence, that polygon should be updated and re-assigned accordingly if necessary. Any non-de minimis updates due to errors in the inventory will require recalculation of both the annual project emissions and the annual baseline emissions for the current monitoring period prior to the next verification;

2. Changes to spatial inventory from monitoring for natural disturbance and planned/unplanned project activities. Updates will be made for any monitored event (at minimum >4 ha) that affects the criteria used to define a given polygon or analysis unit in the project inventory. Note that disturbance or activity events may result in creation of a new polygon, or an age reclassification for the stand, and/or a re-assignment of the polygon. These updates only affect the calculation of carbon emissions from the project scenario.

3. Established polygons may be merged if the original justification for their separate creation no longer applies. These updates only affect the calculation of carbon emissions from the project scenario.

These monitoring steps have been followed during this monitoring period as described throughout this monitoring report.

Ex-Post Calculations of Carbon Stocks (PDD Section 4.3.4)

Ex-post carbon stocks will be determined (at a maximum interval of 5 years) by updating the project's forest carbon inventory from monitoring data.

This will be done by:

1. Incorporating any new forest inventory data (including data from new or re-measured sampling plots, and other monitored data as outlined in Section 3.3) obtained during the previous year into the inventory estimate.

2. Updating the forest inventory for spatial monitoring results, including annual project activities and/or disturbances that have occurred during the monitoring period.

3. Using the selected model(s) to project prior-year data from the forest inventory to the current reporting year (as described in Section 4.2).

4. Comparing estimates of live biomass and dead organic matter in polygons and calculated from monitoring activities against current-year modeled values in the project scenario.

5. Making calibration adjustments to models and/or parameters such that the fit between the equivalent modeled and measured variables meets targets (see description of stratification in Section 3).

6. If any changes are made to the model assumptions or parameters used in Section 4.2, the calculation of baseline emissions (from the current date forward, Section 3.1) will be redone using the updated model(s) and parameter sets.

7. Calculating the error terms for use in calculating the uncertainty factor (Section 4.5).

After each monitoring event, actual (ex-post) annual net carbon stocks will be calculated using the following equations from the VCS methodology document. For transparency, the equation numbers used here are the same as those used in the methodology document.

$$\mathbf{C_{ACTUAL,i,t} = C_{LB,i,t} + C_{DOM,i,t}} \qquad \textbf{(28a)}$$

where:

$C_{ACTUAL,i,t}$ = carbon stocks in all selected carbon pools in subregion, i, year, t; t C

$C_{LB,i,t}$ = carbon stocks in living tree biomass in subregion, i, year, t; t C

$C_{DOM,i,t}$ = carbon stocks in dead organic matter in year, t; t C

Live biomass

Average aboveground biomass for measured stratum, i, in year, t ($B_{AG,i,t}$) will be determined by converting the aboveground, tree-level measurements (kg biomass per tree) described in Section 3.3 to area-based, stand-level measurements (t ha^{-1}). This is achieved by summing the aboveground biomass of all the trees within a sample plot, converting kg to t, and then dividing the sum by the plot area in ha. All plots within a particular stratum will be averaged to get an average estimate of stand-level aboveground biomass (t ha^{-1}). Once the average aboveground biomass has been determined for each measured stratum, belowground biomass is estimated by multiplying the aboveground biomass by the root:shoot ratio, R_i (Equation 28d) and the two are summed to determine total stand-level live biomass for measured stratum i, time t, ($B_{TOTAL,i,t}$). R_i is described in Section 3.1. Finally, the average measured carbon stock in living tree biomass for measured stratum i, time t, ($C_{LB,i,t}$) is calculated as shown in Equation 28c. This value of $B_{BG,i,t}$ will be compared to the equivalent calculation of live biomass ($LB_{PRJ,i,t}$) calculated in the project scenario (Section 4.2) (see the section on updating the modeled project carbon balance below).

$$B_{TOTAL,i,t} = (B_{AG,i,t} + B_{BG,i,t}) \qquad (28b)$$

$$C_{LB,i,t} = (B_{TOTAL,i,t}) \bullet CF \qquad (28c)$$

where:

$B_{AG,i,t}$ = aboveground tree biomass (t d.m. ha^{-1}) measured in stratum, i, year, t

$B_{BG,i,t}$ = belowground tree biomass (t d.m. ha^{-1}) measured in stratum, i, year, t.

$B_{TOTAL,i,t}$ = total tree biomass (t d.m. ha^{-1}) measured in stratum, i, year, t

$$B_{BG,i,t} = B_{AG,i,t} \bullet R_i \qquad (28d)$$

CF = carbon fraction of dry matter (IPCC default value = 0.5)

Dead organic matter

Carbon stored in dead organic matter pools in measured stratum, i, year t, ($C_{DOM,i,t}$) is calculated as the sum of that stored in lying dead wood and standing snags.

$$C_{DOM,i,t} = (DOM_{LDW,i,t} + DOM_{SNAG,i,t}) \bullet CF \qquad (28e)$$

where:

$DOM_{LDW,i,t}$ = average mass of dead organic matter contained in lying dead wood (t d.m. ha^{-1}) in measured in subregion, i, year, t

$DOM_{SNAG,i,t}$ = average mass of dead organic matter contained in standing snags (t d.m. ha^{-1}) in measured in subregion, i, year, t

The average quantity of dead organic matter contained in lying dead wood for measured stratum, i, in year, t ($DOM_{LDW,i,t}$) is calculated according to Equations 61a-c in Section 3.3. The value of $DOM_{LDW,i,t}$ will be compared to the equivalent calculation of lying dead wood mass ($LDW_{PRJ,i,t}$) in the project scenario (Section 4.2) (see comparison method and steps below).

The average quantity of dead organic matter contained in standing snags for measured stratum, i, in year, t ($DOM_{SNAG,i,t}$ is calculated by summing the mass (aboveground only) of all the measured standing dead trees within a sample plot (converting kg to t) and dividing the sum by the plot area in ha (See Section 3.3). The belowground component of snags is treated as dead below ground biomass (See Section 4.2) and is not directly measured. All plots within a particular stratum should be averaged to get an average estimate of $DOM_{SNAG,i,t}$. The value of $DOM_{SNAG,i,t}$ will be compared to the equivalent calculation of standing dead tree mass ($SNAG_{PRJ,i,t}$) in the project scenario (Section 4.2) (see the section on updating the modeled project carbon balance below).

These ex-post calculations have been undertaken during this monitoring period as described throughout this monitoring report document.

Updating the Modeled Project Carbon Balance (PDD Section 4.3.4)

The precision of the modeled carbon stocks will be evaluated for each analysis unit using the method described for determining mean model error in (PDD) Section 4.5 (Equations 60a,b). If the model error term is > 10% the proponents will attempt to improve the model fit by re-evaluating and adjusting model parameters until model error term is < 10%. Model error terms greater than 10% (after model adjustments) will be penalized according the calculation of the uncertainty factor described in (PDD) Section 4.5. If changes in model assumptions or parameters are made, the baseline scenario (from the next year forward) must be recalculated using the revised model ((PDD) Section 3.1).

The project has updated the modeled project carbon balance as per this element of the PDD project monitoring plan, as described throughout this monitoring report document.

Specific Monitoring Results During this Monitoring Period:

All elements of the Afognak Monitoring Plan for the previous monitoring periods (2006-2011, 2012-2013, and 2014) and the current monitoring period (2015-2017) were developed and implemented by Camco and 3GreenTree.

During the first monitoring period field crews were sent to Afognak Island (in October, 2011) to install the initial plot network (22 plots located across the project properties) and to complete monitoring for spatial inventory changes since the latest orthophotos being used at that time (from 2006). This included extensive coverage across the project area by foot (generally on route to field plot locations, but also multiple routes taken across areas with previous activities), and aerial flights in fixed wing aircraft, with a particular focus on areas along the southern border (where adjacent harvesting has occurred during the monitoring period) and within existing harvested areas (to look for unplanned harvesting, extensive blowdown, or other disturbances). In the subsequent second verification, extensive helicopter-based overflights were undertaken to review site conditions in transacts across the majority of the project area. The results of previous monitoring activities were fully outlined in the previous monitoring reports.

Due to the lack of management activity on the properties and the relative stability of the old growth forests on the project area, the primary monitoring activities have shifted primarily to remote sensing using updated satellite, orthophoto, and/or other data to monitor for material forest disturbances or other non-de minimis forest change. State of Alaska personnel are active in managing access and use permitting, along with implementing conservation on the properties, which includes active oversight of these properties along with their other regional and adjacent assets.

3.3.1 Annual Inventory Change Monitoring

The GIS inventory for the Afognak project area has been updated to the end of 2013 as follows:

- The spatial inventory data was initially prepared as part of the forestland appraisal process (Forest and Land Management, Inc., 2008) and updated in 2011 using the high resolution (0.6m) orthophotos of the project area taken in 2006. The orthophotos were acquired as part of the USDA-NRCS-1-06 Alaska Digital Orthoimagery program (http://browse.alaskamapped.org/#browse/available_data). These geo-referenced images were used to identify and digitize non-productive land that had not been spatially identified during the appraisal process (see Figure 3). The following images were downloaded and overlaid in compilation to cover the project area:

ID	Photo Date
n_5815217_ne_05_06_20060912.tif	09-Aug-06
n_5815217_nw_05_06_20060912.tif	09-Aug-06
n_5815217_se_05_06_20060912.tif	09-Aug-06
n_5815217_sw_05_06_20060912.tif	09-Aug-06
n_5815218_nw_05_06_20060912.tif	09-Aug-06
n_5815218_sw_05_06_20060912.tif	09-Aug-06

- The non-productive area associated with roads was accounted for by applying a 5m buffer on either side of all road lines and labeling that area as non-productive. Streams were buffered by 20m on either side and land classification within these buffers was not changed (e.g. if the area were classified as mature spruce, it was left as such). However, stream buffer areas were excluded from the potential harvest area within the baseline scenario.
- No new areas of timber blowdown (>4ha)[4], incidents of fire, or visible areas of pests or disease were noted on the property by State of Alaska staff, nor are evident from detailed spatial analysis of satellite imagery from April 2013 (See also Appendix 3).
    - For this monitoring period, no new areas of timber blowdown > 4 ha were visually evident in 2016-17 high-resolution satellite imagery (see Appendix 3). In fact, no areas of new blowdown or other disturbances was noted at any size that is visually apparent in this review of new satellite imagery. See also Footnote 4.
- No areas of illegal or unintentional incursion of adjacent management activities have been noted by State of Alaska staff, and none are evident along the property lines of the property, as per visual analysis of 2016-2017 satellite imagery (See also Appendix 3).
- The permitting activity log compiled by the State of Alaska indicates there have been no other activities that afffect carbon stocks in the project area during the monitoring period. Reported permitted activities would relate to hunting or other recreational uses in the general project area.

[4] Individual tree blowdown was rarely or occasionally observed along exposed cutblock edges during field work on the site, including during the 2018 monitoring work. However, no specific areas of blowdown (i.e. >0.5ha or more), unstable timber faces, or ongoing/extending blowdown were observed, which is consistent with the visual satellite imagery reviews. As these old harvest areas are now 10-20 years old, the risk of extensive future blowdown is low, but will be monitored in future. Field observations of within-stand individual tree blowdown appears normal or lower than experienced foresters expected for normal endemic stand dynamics for coastal forests.

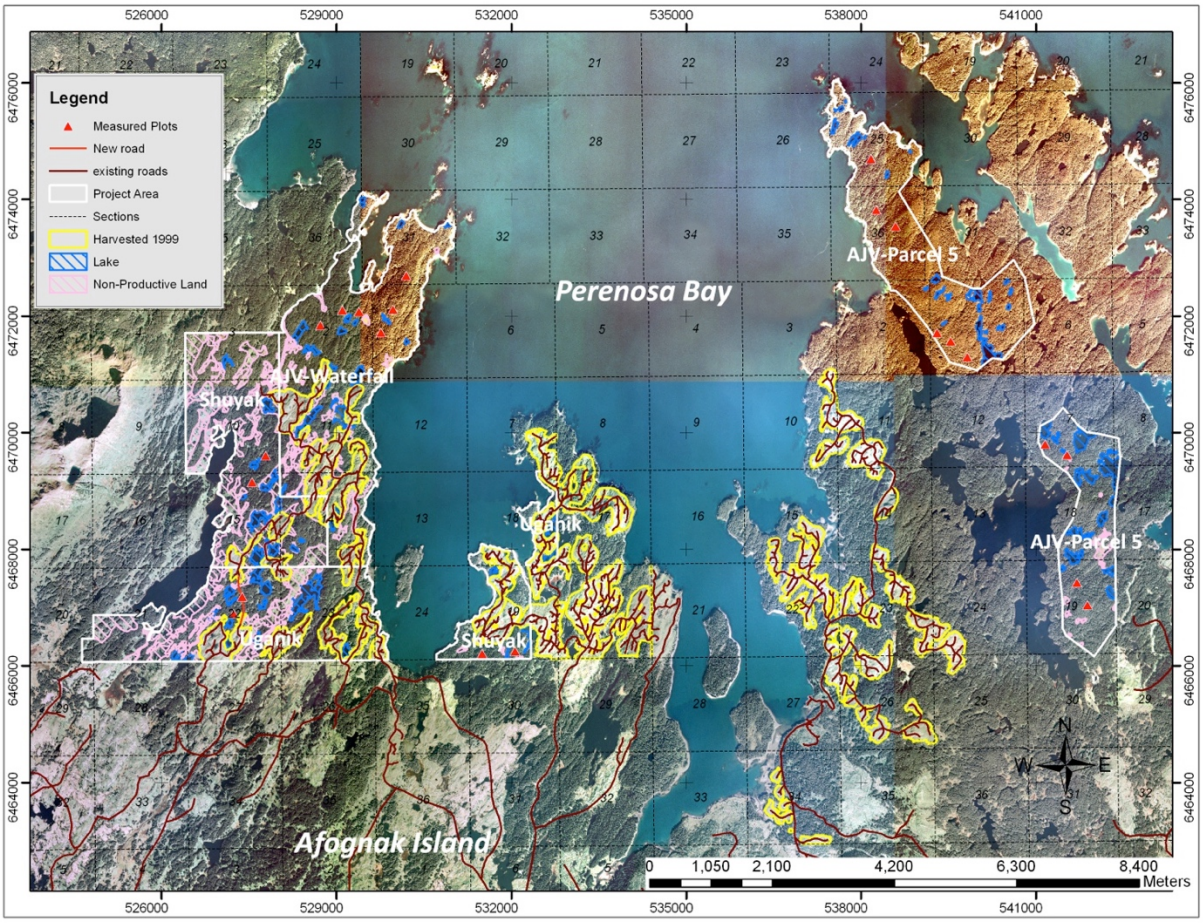

Figure 3. An overview map showing the Afognak project boundary overlaid on orthophotos taken in 2006. Existing road networks, areas harvested in 1999, and non-productive land are shown. The red triangles indicate the location of monitoring plots established in 2011.

3.3.2 Leakage monitoring

Activity shifting leakage:

The activity shifting leakage monitoring involves updating relevant project proponent logging activities on other properties owned or managed by ALC, RMEF, and/or Camco by monitoring period. Table 3 lists the level of harvesting activities on other properties owned or managed by the proponents that might have potential for activity shifting. As none of the project proponents undertake commercial harvesting on other properties, there is no evidence of activity shifting leakage during this monitoring period.

Table 3. Ex-post Activity Shifting Monitoring – 2015-2017.[5]

Property	Year	Logging Volume (m^3)	Activity shifting evidence/comment
All properties outside Afognak	2015	0.0	n/a – no harvest
All properties outside Afognak	2016	0.0	n/a – no harvest
All properties outside Afognak	2017	0.0	n/a – no harvest

Annual market leakage calculations (annually)

Calculations for market leakage are updated each monitoring period to reflect the level of timber harvesting volume in the baseline and any changes in harvest activities in the project scenario. As planned, there have been no harvesting activities in the project during the monitoring period of 2015-2017. The harvest levels in the baseline scenario remain the same as those indicated in the PDD. However, as a result of the required baseline update in 2016, the method employed to estimate market leakage changed from the CAR market leakage formula (used from 2006-2015) to the VCS leakage discount method outlined in the current version of the VCS AFOLU requirements document (v3.6). Both methods are eligible for use in the VM0012 v1.2 methodology. Since, the CAR method was selected in the PDD, the change to the VCS method represents a project description deviation (see Section 2.2.2). The calculated market leakage for each year is shown in Table 9.

The VCS leakage discount method is based upon a comparison of the ratio of merchantable biomass to total tree biomass (aboveground + belowground) in the project area to the same ratio in the assumed leakage area. In the case of the Afognak project located in northwestern Alaska, the logical leakage area was determined to be the state of Alaska. The ratio of merchantable to total biomass in the project area was calculated using detailed output from the FORECAST growth model that was used to generate the stand biomass and volume curves for the project (see Appendix 1). The merchantable biomass to total biomass ratio for the leakage area was determined using data from the Forest Inventory and Analysis (FIA) program of the U.S. Forest Service parameterized for the state of Alaska with a focus on the Hemlock and Sitka Spruce forest type group; see Appendix 1). A detailed description of the data and calculations used to determine the market leakage factor (MLF_y), as shown in Equation 56b of the VM0012 v1.2 methodology, are provided in Table 2 in Section 3.2.

[5] Data reported via email August 2018 by Blake Henning for RMEF and on behalf of ALC.

3.3.3 Field plot monitoring

The necessary number of permanent field plots for biomass and carbon measurements were established across the project area in October 2011 and no additional plots have been installed during this monitoring period. All field plots have been remeasured in August 2018.

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

Afognak 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 field plots were remeasured during this monitoring period. The plot remeasurements were undertaken by trained crews highly experienced in forest mensuration and field plot installation and measurement. The Afognak plot installation SOP requires blind check-cruises of a minimum of 10% of the plots. In the 2018 plot remeasurement field season, 2 of the 22 plots were check-cruised using blind checks (crews swapping plots), with 100% re-measurement of all variables. The plot check cruises 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.

QA/QC for Laboratory Measurements

As expected, no laboratory measurements were taken for the Afognak during this monitoring period, and this section is not applicable.

QA/QC for Data Entry

During this monitoring period the Afognak data was field entered into electronic data recorders, and all data transferred electronically. Blind check plots were used to test data collection and entry simultaneously, and no material errors were noted, and no unresolvable data anomalies were found.

QA/QC for Data Archiving

Afognak has document control procedures to cover the carbon monitoring data, including retaining the following for 2 years past the duration of the project. Camco retains electronic records within corporate cloud-based server storage methods that are consistent with the project monitoring plan requirements.

1. The electronically collected field data was output into MS Excel format, and copies of the original data related to the original plot field measurement, check plots, and related data summaries are maintained by Camco.

2. Copies of all 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 are

maintained by Camco on cloud-based servers (Dropbox), and will be maintained for at least 2 years past the end of the project.

3. Records of the version and relevant change history of software or data storage media changed between monitoring periods are maintain by 3GreenTree and/or Camco as necessary.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

The baseline scenario has been reviewed as part of the VCS-required 10-year baseline re-validation. From this review, no changes to the baseline scenario and calculations were deemed necessary, as outlined in Section 3.1 of the new PDD (v3.0). As part of this review process, the PDD was converted into the latest template format (VCS PDD Template v3.3), and was updated to the requirements of the latest methodology (update from v1.1 to v1.2 in this period). The update of VM0012 to v1.2 involved a change to the method for calculating the annual change in storage in harvested wood products (HWP). This change in HWP calculations affected the ex-post calculations starting in 2016 for this monitoring report. See Section 4.1.5 for more detail.

4.1.1 Stratification of Land Area and Updates to Spatial Inventory

There have been no updates made to the spatial inventory that was established in the Afognak PDD (v.2.3). The following section describes the development of the inventory for use in the carbon calculations.

STEP 1 – Stratify to create homogeneous units

The Afognak forest inventory is contained within a robust Geographic Information System dataset. The polygons are homogeneous, based upon forest cover and stand age class. The forested area has been stratified into two age-classes: mature spruce, and regenerating stands (areas harvested in 1999). No additional forest age data are available. Further, there is no evidence of significant variability with respect to forest productivity within the area. Calculations within the Landscape Summary Tool are made by summing the areas of groups of polygons that have the same starting age, analysis unit classification, and management/disturbance trajectory (see below). These groups are referred to through this report as subregions.

Development of Analysis Units

The relative homogeneity of the Afognak forest inventory allowed for stratification of the forest area into only two analysis units. The first, AU 101, represents the existing naturally originated, mature spruce stands. The second, AU 201, represents naturally regenerating spruce stands following clearcut harvesting. All of the polygons containing mature spruce within the Afognak forest inventory were assigned to AU 101 with a 2011 starting age of 190 (based upon the tree age data collected during the field sampling in 2011). Likewise, stands that were harvested in 1999 were assigned to AU 201 and

given a starting age of 13 in 2011. A map of the spatial distribution of the analysis units at project initiation is shown in Figure 4.

The FORECAST model (see below) was used to create a series of stand attribute curves for each analysis unit including merchantable volume and carbon storage by ecosystem pool. The specific regeneration assumptions for each of the analysis units are shown in Table 4. The assumptions in Table 4 are based upon: 1) a previous study conducted on Afognak Island in which spruce regeneration was evaluated 25 years after a clearcut harvesting and 2) assessments of regeneration within cutover areas examined during the site visit in October of 2011. The spruce stands represented in analysis units 101 and 201 were simulated using two separate age cohorts in FORECAST. This was done to represent the uneven-aged nature of the stands that are anticipated to develop as a consequence of regeneration delay. In the case of the spruce stand simulated as developing after clearcut harvesting, the regeneration delay is assumed to be due to competition from shrub vegetation (primarily). The regeneration delay for AU 201 (8-18 years after harvest) was based both on observations (during the field work conducted in 2011) of the regrowth in areas harvested in 1999. In addition, a previous study on Afognak in a spruce stand 25 years after harvest showed that spruce regeneration had been delayed and was poor due to shrub and grass competition (US Forest Service, 1972). The assumption of delayed regeneration after harvesting is conservative from a carbon perspective.

The stand attribute curves, as described above, were consolidated within a spreadsheet for use in an Excel spreadsheet-based Landscape Summary Tool developed for this project (see Appendix 1).

Table 4. FORECAST regeneration assumptions for each of the analysis units (AU).

AU	Description	SI[1]	Cohort 1[2] stems/ha	Cohort 2 stems/ha	Cohort 1 Regen year	Cohort 2 Regen year	Initial shrub cover (%)	Shrub Regen Year
101	F / L_med	14	550	1000	1	14	5	1
201	F / L_good	14	350	1200	8	18	5	1

1. The reference site index at breast-height age 50 (SI) was set at 14m in FORECAST.

2. Two age cohorts were used to represent the extended period of natural regeneration

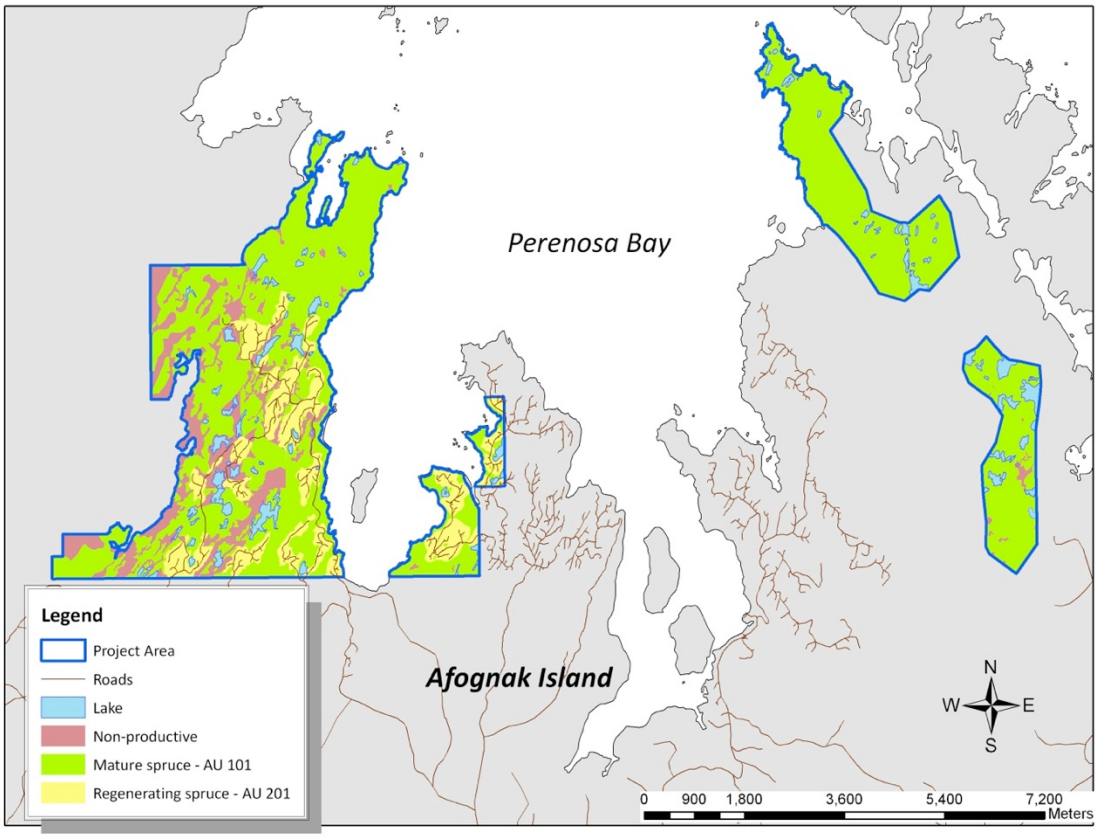

Figure 4. A map of the Afognak property showing the spatial distribution of analysis units at project initiation.

STEP 2 – Identify areas eligible for specific management activities

The portion of the Afognak property area included within the baseline (and project) analysis was defined based upon an existing harvest plan developed during an appraisal of the Afognak properties conducted prior to the acquisition of the property (Forest and Land Management, Inc. , 2008). There were several stages in this process.

1.) The first stage in the process was to review the appraisal harvest plan and associated inventory. In the appraisal some of the forested area (buffers adjacent to large lakes and some ocean front areas (~320.3 ha) was identified as higher and better use and assumed to be left for some sort of recreational land use or conversion rather than harvesting. However, it was clear from examining areas adjacent to the project that similar areas had been harvested in the past, so this area was included in the baseline potential harvest area but with some restrictions (see below). In addition, there were some access and harvesting

issues related to terrain and riparian areas in the west Shuyak and Uganik parcels that caused the appraisers to identify specific areas of mature spruce to be left out of the harvest plan (~155.1 ha). These areas were excluded from the potential baseline harvest area. The remainder of the productive mature spruce area within the Afognak project area was identified as available for potential harvest within the baseline scenario.

2.) The second stage in the process was to identify non-productive or legally protected land to be excluded from the productive forest landbase. The first step in this process was to use the high-resolution orthophotos to spatially identify non-productive land within the project area that had previously been identified as forested. The second step in this stage was to remove buffers adjacent to streams and roads. These entities had previously been defined in the GIS data only as lines. Road areas were buffered by 5m on either side, and stream areas were buffered by 20m on either side. These buffered areas were removed from the potential harvest area in the baseline scenario and from the productive forest area (in the case of road buffers) in both the project and baseline scenarios. The total non-productive land area within the project area (including road buffers but excluding lakes) is approximately 423 ha.

3) The final stage in the process was to estimate the amount of retention that would be left behind from the spatially identified potential baseline harvest area. This was done through a review of adjacent harvesting areas observed in the orthophotos and from recent harvesting observed during the fieldwork in 2011. It was assumed that 5% of the mature forest area would be left behind in the potential harvest area that was outside of the higher and better use buffer areas described in Stage 1 above, and that 15% of the area within these buffers would be left behind. The total mature area left behind in the potential harvest area is 137.3 ha or 6.5% of the total. These retention areas were not spatially defined but were taken into account in the total area numbers used in the Excel Landscape Summary tool.

A summary of the different areas identified in these three stages are shown in Table 5 and Figure 5. Taking into account the whole area of mature spruce on the productive landbase (2293.8ha), the total retention of mature spruce in the baseline scenario is 325.4 ha (14.2% of the total).

Table 5. A breakdown of the total project area into productive and non-productive classes. The area of retention of mature spruce is also shown.

Description	Area (ha)
Total Non-productive area	641.9
Total non-productive land	423.0
Total lake area	176.2
Road buffers	42.7
Total Productive area	2684.6
Total Mature forest	2293.8
Total formerly harvested	390.8
Potential baseline harvest area	2105.7
Baseline outside of HBU[1] buffer	1785.4
Baseline inside HBU buffer	320.3
Actual baseline harvest area	1968.4
Total Project area mature retention	325.4
Within harvest area retention[2]	137.3
Outside baseline harvest area retention	155.1
Stream buffer mature retention	33.1
Total Project Area[3]	3326.5

1. HBU = Higher and better use buffers specified during the appraisal process.

2. Area not spatially identified in maps.

3. The total project area as determined from the spatial data is greater than that determined by summing the official survey data (3315.3 ha) by 11.2 ha (0.32%). It is difficult to determine the source of this difference, but it is likely largely associated with non-productive areas (lakes etc.) and is *de minimis* with respect to the carbon the calculations.

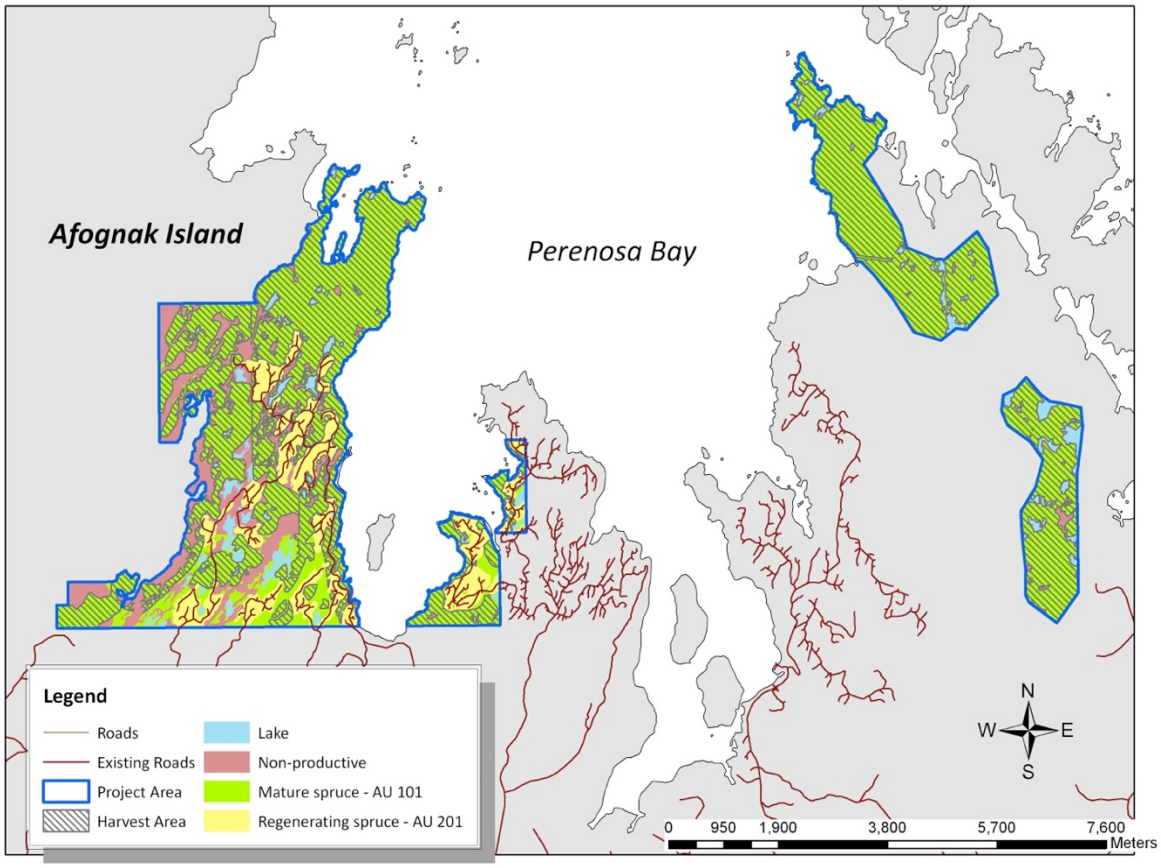

Figure 5. The Afognak project area showing the potential harvest area for the baseline scenario.

4.1.2 Model Selection and Use

The FORECAST model (v8.5) and the Excel summary spreadsheet tool were used in conjunction with a Microsoft Excel spreadsheet model (Landscape Summary Tool, as referenced in Appendix 1).

The combination of FORECAST and the Landscape Summary Tool meet all six criteria for model selection in the methodology document. In addition, FORECAST also meets the preferred criteria #7 and #8. Further details about these models and their application in the Afognak Forest Carbon Project are provided in the sections below.

4.1.3 Calculating the Baseline Carbon Balance

The carbon accounting approach employed for the Afognak carbon project utilized the management interface and biomass output from a locally calibrated stand-level model, FORECAST, in conjunction with an Excel-based Landscape Summary Tool for calculating landscape-level carbon totals.

FORECAST was used to simulate the temporal changes in carbon storage of different ecosystem pools for each of the analysis units. The stand-level output from FORECAST was linked to the Landscape Summary Tool using a shared database approach. This allowed the summary tool to extrapolate the stand-level output on the carbon pools associated with all of the inventory polygons and associated subregions that comprise the Afognak GIS database. While not spatially explicit, the Landscape Summary tool calculates to the total areas of each treatment area within the project and baseline scenarios on 1-year time steps.

4.1.4 Description of the Baseline Scenario Modelling

The selected baseline scenario applied in the Landscape Summary Tool assumes logging would have occurred over a ten-year time period beginning in 2008. A total of 984.2 hectares of mature spruce forest would be harvested during the first 5 years and the same area harvested again during the next five years. It was assumed for the baseline scenario that the annual area harvested would be constant during those ten-years of harvesting at ~196.8 ha/yr. Given, the long-rotation length of these forest types 100 to 140 years, it was assumed that there would be no further harvesting conducted during the 100-year simulation period.

The harvest method employed in the baseline scenario is clearcutting (the complete removal of all standing trees), a method with the lowest harvesting cost and maximum timber asset retrieval. Stands are assumed to regenerate naturally (i.e., no reforestation investment) in the baseline scenario since this is common practice across Afognak Island. As indicated earlier in this section, stands were simulated to represent a regen delay following harvesting with two recruitment periods. Harvesting activities that occurred in 2008 were limited to the Waterfall and Laura Lakes Tract B parcels; in the remaining years harvesting activities were distributed throughout all parcels. An overview of the baseline scenario assumptions is presented in Table 6. Both the baseline and project scenarios in the Landscape Summary Tool were calculated with 1-year time steps for a total of 30 years. The annual rate of harvest (by area) was assumed to be constant during that period.

Table 6. Overview of the Landscape Summary Tool assumptions for the Baseline and Project scenarios.

Scenario	Harvest Period	Harvest Area (ha yr^{-1})	Regeneration Method
Baseline	10 yrs. beginning in 2008	196.8	Natural
Project	None	0	n/a

4.1.5 Calculation of Annual Emissions/Reductions

As described in Section 4.1, there have been some changes to the calculation of emission reductions with respect to C storage in HWP. These changes start at year 10 of the project (2016) as required by the baseline review process. Thus, reported emission/reduction values will reflect these changes in calendar years after 2015. References to the calculation changes have been described in brief on the covering page of the newly updated PDD (v3.0).

Annual emissions/reductions for the baseline scenario for the years 2015-2017 were calculated using the output from the Afognak Landscape Summary Tool (see reference to file in Appendix 1). Harvesting activities were distributed throughout all parcels. The FORECAST model output, analysis units, baseline assumptions and spatial inventory data used in the carbon emissions calculations made in the project and baseline scenarios are the same as those described within the Afognak PDD v2.3. The only difference was that the LST model was run for 30 years using an annual time step instead of 100 years using a 5-year time step. The annual time-step approach led to some small differences in the carbon emissions output relative to the values reported in the PDD (v2.3). These differences are derived from averaging errors in the 5-yr time step model.

Output with respect to volume harvested and annual emissions/reductions (including key components) are shown in Table 7. The full LST output file is referenced in Appendix 1.

Table 7. Baseline Scenario Emissions/Reductions for the Monitoring Periods 2006-2017. Only years 2015-2017 are included in this monitoring period (grayed rows are previously verified project years).

Year	Project Year	Baseline (Emissions) Reductions (tCO2e)	Baseline Scenario Volume Harvested (m^3)	Baseline Net Change in Ecosystem C (tC)	Baseline Storage HWP (tC)	Baseline Storage Waste Products (tC)	Baseline Emissions Production & Waste (tC)
2006	1	0	0	0	0	0	0
2007	2	0	0	0	0	0	0
2008	3	(101,111)	91,326	(27,344)	1,165	375	(1,747)
2009	4	(105,980)	91,962	(28,669)	1,173	378	(1,759)
2010	5	(110,414)	92,595	(29,876)	1,181	380	(1,771)
2011	6	(114,477)	93,230	(30,982)	1,189	383	(1,783)
2012	7	(117,941)	94,184	(31,960)	1,201	316	(1,694)
2013	8	(121,566)	94,645	(32,947)	1,207	317	(1,702)
2014	9	(124,329)	95,278	(33,699)	1,215	319	(1,713)
2015	10	(126,869)	95,738	(34,420)	1,221	321	(1,722)
2016	11	(108,067)	96,712	(35,087)	7,354	0	(1,740)
2017	12	(111,816)	97,171	(35,721)	6,974	0	(1,748)

4.2 Project Emissions

4.2.1 Stratification of Land Area and Updates to Spatial Inventory

The project landbase has been stratified using the analysis unit approach as described in Section 4.1. There have been no updates made to the spatial inventory that was established in the Afognak PDD (version 2.3).

4.2.2 Calculation of Annual Emissions/Reductions

Annual emissions/reductions for the project scenario for the years 2015-2017 were calculated using the output from the Afognak Landscape Summary Tool (see reference to file in Appendix 1). The FORECAST model output, analysis units, baseline assumptions and spatial inventory data used in the carbon emissions calculations made in the project and baseline scenarios are the same as those described within the Afognak PDD v2.3. The only difference was that the LST model was run for 30 years using an annual time step instead of 100 years using a 5-year time step. The annual time-step approach led to some small differences in the carbon emissions output relative to the values reported in the PDD. These differences are derived from averaging errors in the 5-yr time step model.

Output with respect to volume harvested and annual emissions/reductions (including key components) are shown in Table 8. A link to the detailed LST output file is provided in Appendix 1.

Table 8. Project Scenario Emissions/Reductions for the Monitoring Periods 2006-2017. Only years 2015-2107 are included in this monitoring period (grayed areas related to previously verified periods).

Year	Project Year	Project (Emissions) Reductions (tCO2e)	Project Scenario Volume Harvested (m^3)	Project Net Change in Ecosystem C (tC)	Project Storage HWP (tC)	Project Storage Waste Products (tC)	Project Emissions Production & Waste (tC)
2006	1	0	0	0	0	0	0
2007	2	0	0	0	0	0	0
2008	3	8,911	0	2,428	0	0	0
2009	4	8,863	0	2,415	0	0	0
2010	5	8,815	0	2,402	0	0	0
2011	6	8,732	0	2,379	0	0	0
2012	7	8,844	0	2,410	0	0	0
2013	8	8,275	0	2,255	0	0	0
2014	9	8,740	0	2,381	0	0	0
2015	10	8,827	0	2,407	0	0	0
2016	11	9,090	0	2,479	0	0	0
2017	12	9,351	0	2,550	0	0	0

4.3 Leakage

There was no risk of activity shifting leakage found in the monitoring period, as the project proponents are not for profit land trusts that do not undertake commercial timber harvesting on any other property as a normal course of business.

The market leakage calculations have been updated to reflect the ex-post annual time-step projections for the baseline, which resulted in some annualized variation from the ex-ante projected leakage levels in the PDD and there is no material change to the market leakage assessment or calculations up until 2016 when the required baseline update occurred. A description of the changes in the method used to

calculate market leakage after 2015 are provided in Section 3.3.2. The calculated market leakage discounts factors and related calculation factors are shown in Table 9.

Table 9. Market Leakage Discount Factors – Monitoring Period 2006-2017. Only 2015 through 2017 is included in this monitoring period (grayed areas related to previously verified periods). Note that the method used to calculate market leakage changed in 2016 (see text).

Year	Project Year	Change in Harvest Volume (tCO2e)	Market Leakage -- 20% of Harvested (tCO2e)	Market Leakage Discount (% of total VCU's)
2006	1	0	0	0.0%
2007	2	0	0	0.0%
2008	3	67,034	(13,407)	12.2%
2009	4	67,500	(13,500)	11.8%
2010	5	67,965	(13,593)	11.4%
2011	6	68,430	(13,686)	11.1%
2012	7	69,131	(13,826)	10.9%
2013	8	69,470	(13,894)	10.7%
2014	9	69,934	(13,987)	10.5%
2015	70,208	(14,042)	10.3%	70,208
2016	70,922	(23,431)	20.0%	70,922
2017	71,259	(24,233)	20.0%	71,259

4.4 Net GHG Emission Reductions and Removals

4.4.1 Calculation of the Uncertainty Factor

As described in the PDD, an Uncertainty Factor ($ER_{y,ERR}$) including inventory and model error terms was calculated for year y based upon the comparison of the stand-level measures of net aboveground ecosystem C within the field plots and the associated model-projected values. The value of the Uncertainty Factor was determined to be 1.8% based upon a calculated Inventory error (EI) term of 11.9% and a model error (EM) term of -1.5%. Thus, the project error (EP) term was determined to be 10.3%.

In summary, the Uncertainty Factor is determined from the inventory and model error terms as follows:

Uncertainty Factor =

If EP < 10% then 1.5%;

If EP > 10% then 1.5% + EP – 10%

where:

EP = EI + EM

EP = Total project error (%)

EI = Inventory error at the 90% confidence interval (%, expressed as the absolute value of the ± error term).

EM = Model error (%). May be positive (model > measured value) or negative (model < measured value).

The spreadsheet used in the calculation of the Uncertainty Factor is referenced in Appendix 1. The outcome of the deduction taken by the project to account for the uncertainty factor calculation is shown in Table 11.

4.4.2 Summary of GHG Emission Reductions and Removals

A summary of emission reductions and removals for the baseline and project scenarios is shown in Table 10.

The determination of net GHG Emissions and the associated calculation of total saleable VCUs were made following the approach specified in the Methodology. The results for the 2015-2017 verification period are shown in Table 11. The Afognak Carbon Model v.3.5 spreadsheet used to calculate the values shown in Table 11 is referenced in Appendix 1. The variations from the ex-ante projections made in the PDD are related solely to the shift to annual modeling time steps.

Table 10. A summary of emission reductions and removals for the baseline and project scenarios during the 2015-2017 verification period.

Year	Baseline emissions or removals (tCO_2e)	Project emissions or removals (tCO_2e)	Gross GHG emission reductions or removals (tCO_2e)	Adjusted emission reductions (tCO_2e)[1]	Leakage Risk Discount (tCO_2e)	Net GHG emission reductions or removals (tCO_2e)
2015	(126,869)	8,827	135,696	129,381	(14,042)	121,654
2016	(108,067)	9,090	117,157	110,778	(23,431)	93,726
2017	(111,816)	9,351	121,167	114,758	(24,233)	96,934
Total	(346,752)	27,268	374,020	354,918	(61,706)	312,313

[1.] Used in the calculation of non-permanent buffer set-aside shown in Table 11.

Table 11. Total Ex-Post VCU's for Issuance for the 2015-2017 Monitoring Period Verification, (and Terms Used in Their Calculation). Additional calculation details found in the Afognak Carbon Model referenced in Appendix 1.

Year	Gross Emissions Reductions (tCO_2e)	Leakage Risk Discount (tCO_2e)	Uncertainty Risk Discount (tCO_2e)	Non-Perm. Buffer Set-Aside (tCO_2e)	Cumulative Buffer Account (tCO_2e)	Release From Buffer (tCO_2e)	Saleable VCU's (tCO_2e)
2015	135,696	(14,042)	(2,190)	(12,938)	94,172		106,526
2016	117,157	(23,431)	(1,687)	(11,077)	105,249		80,961
2017	121,167	(24,233)	(1,745)	(11,475)	99,215	17,509	101,222
Total	374,020	(61,706)	(5,622)	(35,490)		17,509	288,709

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6 APPENDICES

6.1 Appendix 1: Supporting Files and Documents

A list of supporting files used in the calculation of carbon offsets for the 2015-17 period is provided in Table 12.

Table 12. Supporting files used in the calculation of carbon offsets for the 2015-2017 period. The names of worksheets in which specific data and/or calculations are located are also shown.

Description	File Name	Worksheet
Tree measurement data from monitoring plots	Afognak plot data & UF Sep 2018.xlsx	Tree data
Tree-level biomass calculations	Afognak plot data & UF Sep 2018.xlsx	Tree data
Downed wood debris data and mass calculations	Afognak plot data & UF Sep 2018.xlsx	CWD Data
Stand-level biomass & carbon calculations	Afognak plot data & UF Sep 2018.xlsx	Summary
Uncertainty Factor calculations	Afognak plot data & UF Sep 2018.xlsx	Uncertainty Factor Calculation
QA Check Plot Data	Afognak plot data & UF Sep 2018.xlsx	QAQC
Landscape Summary Tool: Carbon calculations	Afognak LST Jan, 2019.xlsx	Annual curve based calculations
Landscape Summary Tool: Carbon calculations	Afognak LST Jan, 2019.xlsx	Annual curve based calculations
Calculation of C storage and emissions associated with the production of HWP	Afognak Carbon Model v3.7 – Monitoring 2018.xlsx	Annualized HWP Carbon Model
Calculation of Market Leakage	Afognak Carbon Model v3.7 – Monitoring 2018.xlsx; Afognak LST Jan, 2019.xlsx	VCS Market Leakage; FIA Data & Spruce C Curve

Calculation of Saleable VCUs	Afognak Carbon Model v3.7 – Monitoring 2018.xlsx	Ann. Summary Tables & Figs
Afognak Inventory Data	Afognak Nov. 29.mdb	NA
VCS Non-Permanence Risk Report Template Short	Afognak – VCS Permanence Risk Report Calculation Tool, v3.1 2015-2017 MR v1.1.doc	NA
VCS Risk Report Calculation Tool	Afognak – VCS Risk Report 2015-2017 MR v1.1.doc	NA

6.2 Appendix 2: Non-Permanence Risk Assessment

This assessment uses the latest approved VCS non-permanence tool as per the methodology requirement: VCS AFOLU Non-Permanence Risk Tool, v.3.3, and using the VCS Risk Report Calculation Tool v.3.3 and the VCS Non-Permanence Risk Report Template Short, v3.0.doc.

These files are attached as per the filenames listed in Appendix 1.

The results of these risk assessment tools is the application of a 10% non-permanence risk rating for this monitoring period.

6.3 Appendix 3 – Visual Analysis of 2016-2017 Satellite Imagery

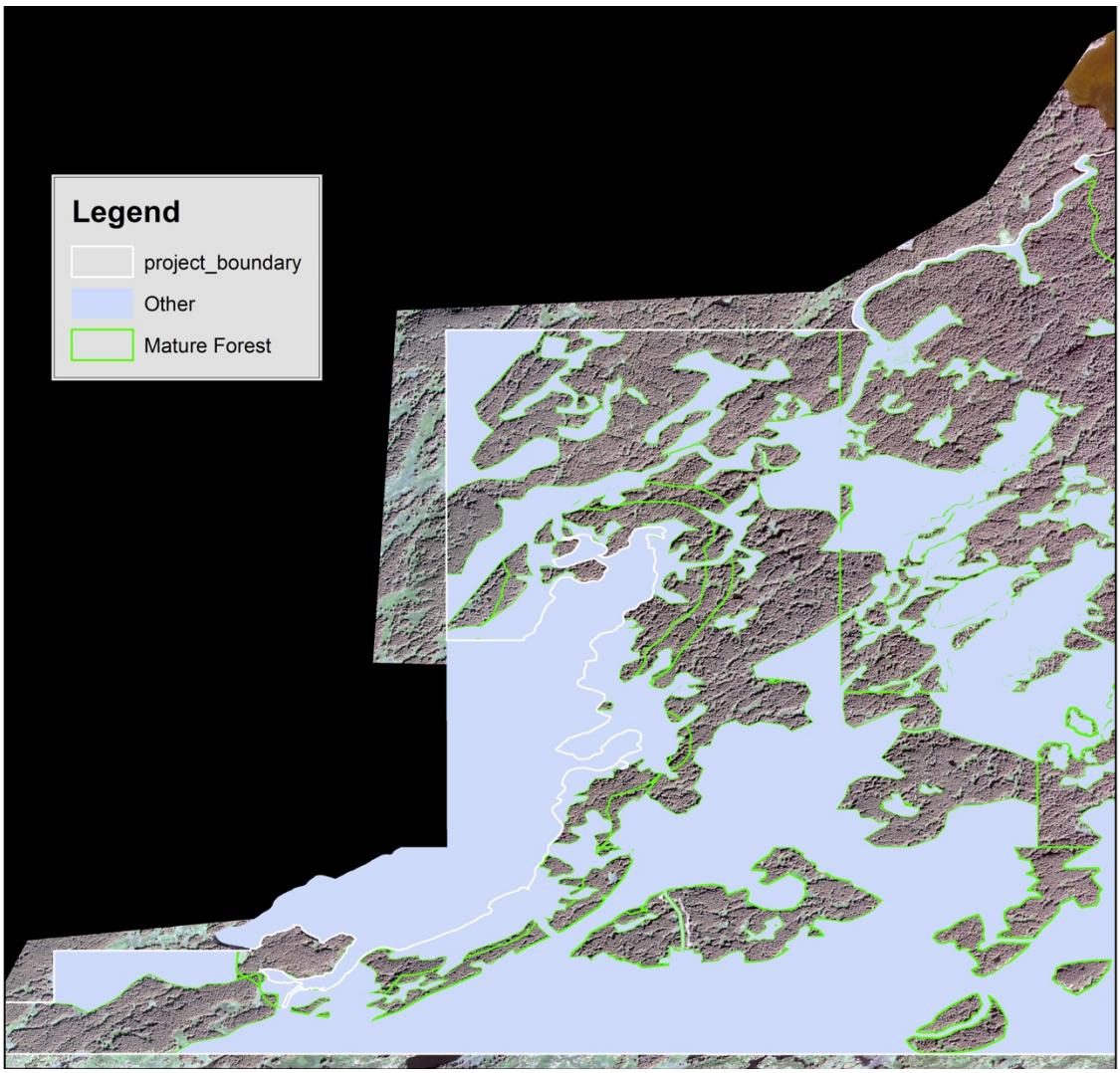
A visual assessment of the Afognak project area was conducted by overlaying the project area on the most recent satellite imagery available for the project area (Oct. and Nov. 2017). The Satellite imagery was purchased from Land Info Worldwide Mapping LLC with the following specifications: (Worldview 2&3 archive satellite imagery at 50cm resolution, 4-band PS, 8-bit; taken Oct 22, 2017 and Nov 22, 2017). The project spatial data were overlaid on top of the geo-corrected imagery TIFF files to facilitate the inspection. The project area was divided into four sections (west part 1, west part 2, east part 1, and east part 2) for more magnified inspection. The inspection focused on areas of mature spruce (AU 101) which would have been harvested in the baseline scenario (as per Figure 5)[6]. Other areas including lakes, stream buffers, road buffers, non-productive forest, and regenerating areas (AU201) were lumped into a category labelled as "other" and masked to facilitate a clearer evaluation.

A visual inspection of the forest cover within the baseline harvest area polygons shows that there has been no visible or significant disturbance within the mature forest areas (AU 101) through the fall of 2017 for the project landbase. While there are some small patches with the lighter green indicating less forest cover, these represent small patches of non-productive land that could not be mapped and they have not changed from the last monitoring period and are also present in the 2006 orthophotos (Figure 3)[7] .

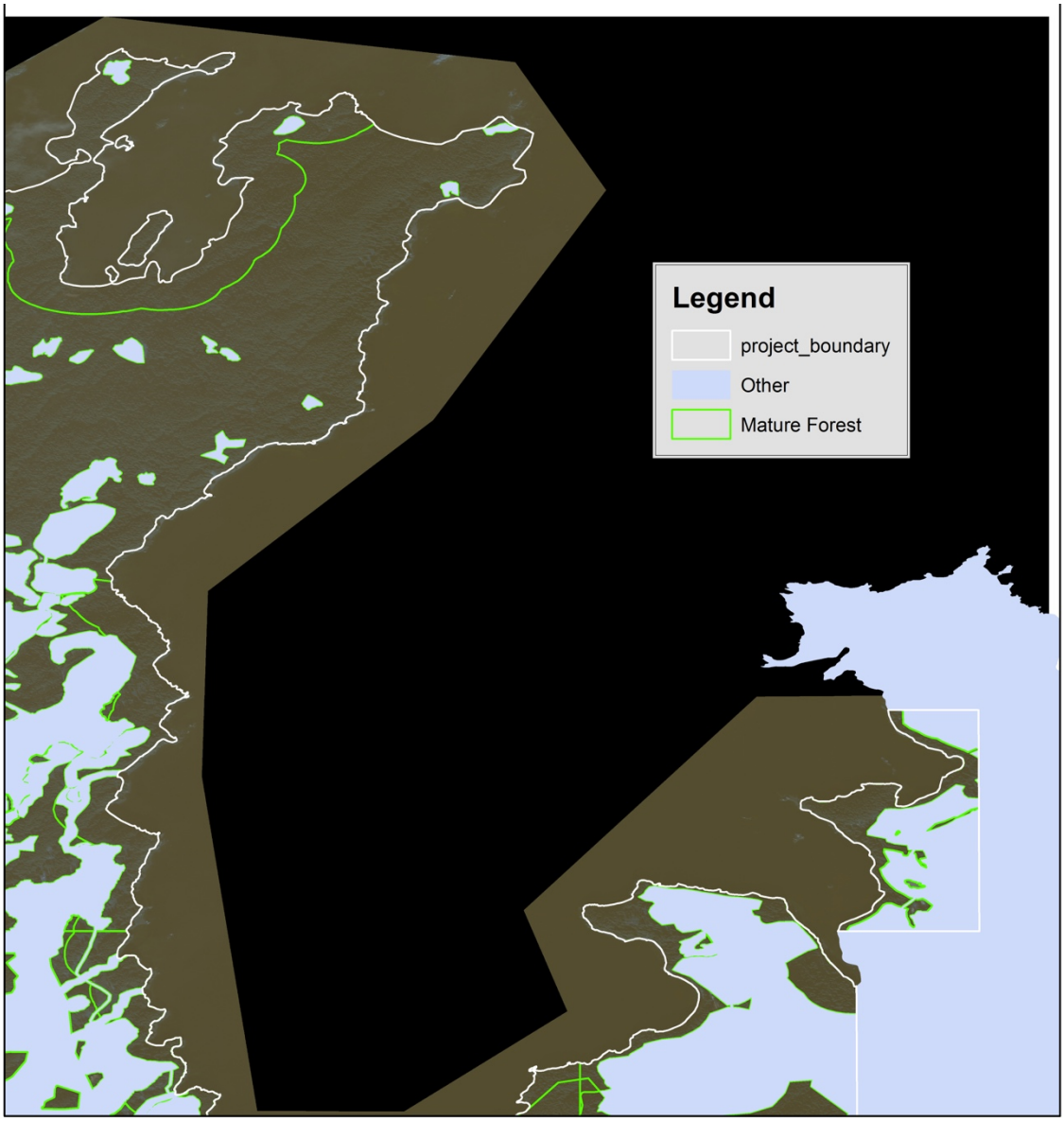
[6] Note there are small areas of cloud cover within these satellite images (<20% of the image area) that limit visual inspection, however these are fully random occurrences in terms of visually sampling the project area, and these areas have been assessed against earlier (2016) Google Earth imagery.

[7] Note that these small areas were accounted for in the original carbon analysis by assuming that 4% of the mature spruce area was non-productive on average and adjusting the area-based carbon contents accordingly

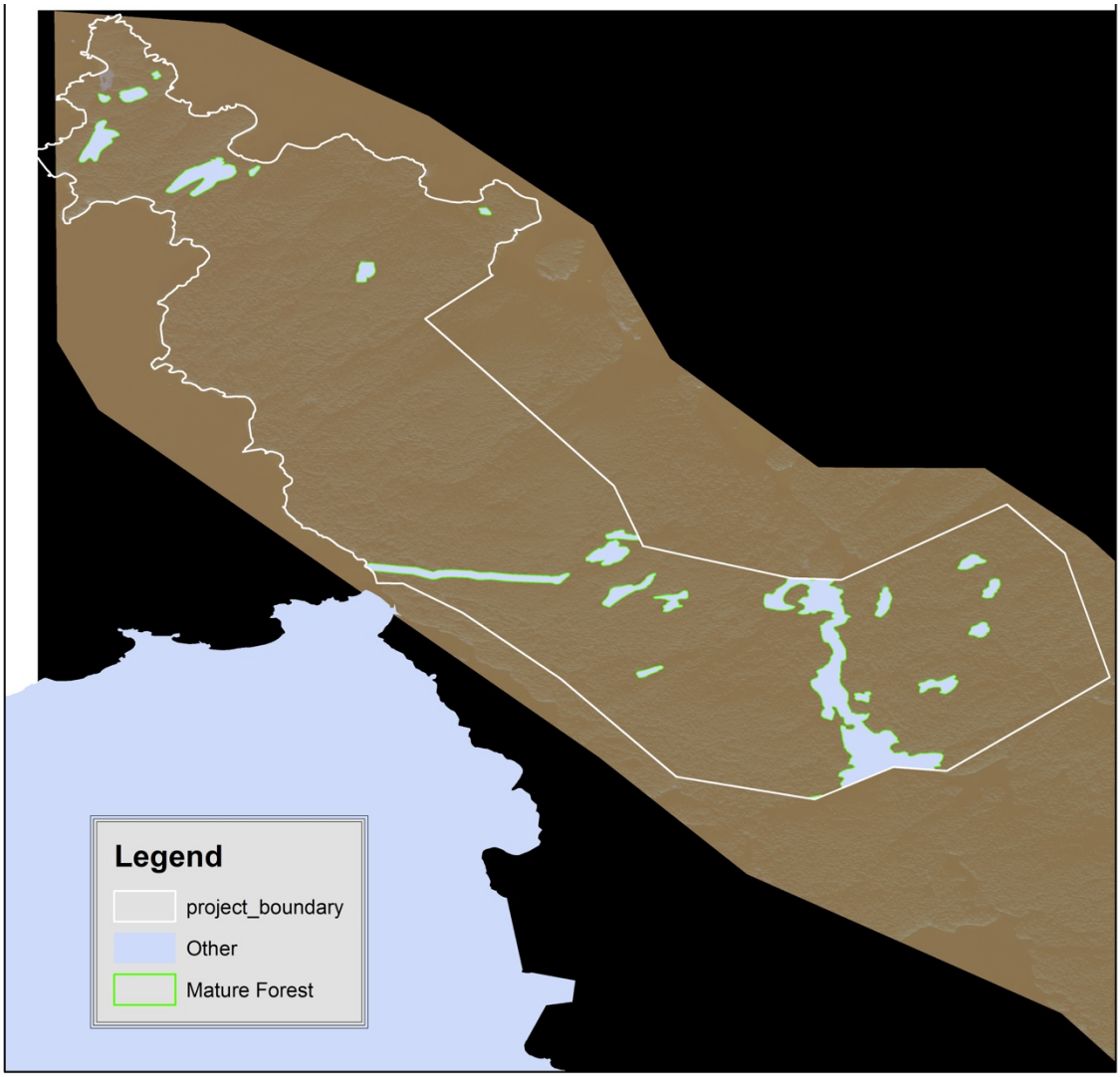
West area part 1



West area part 2



East area part 1



East area part 2

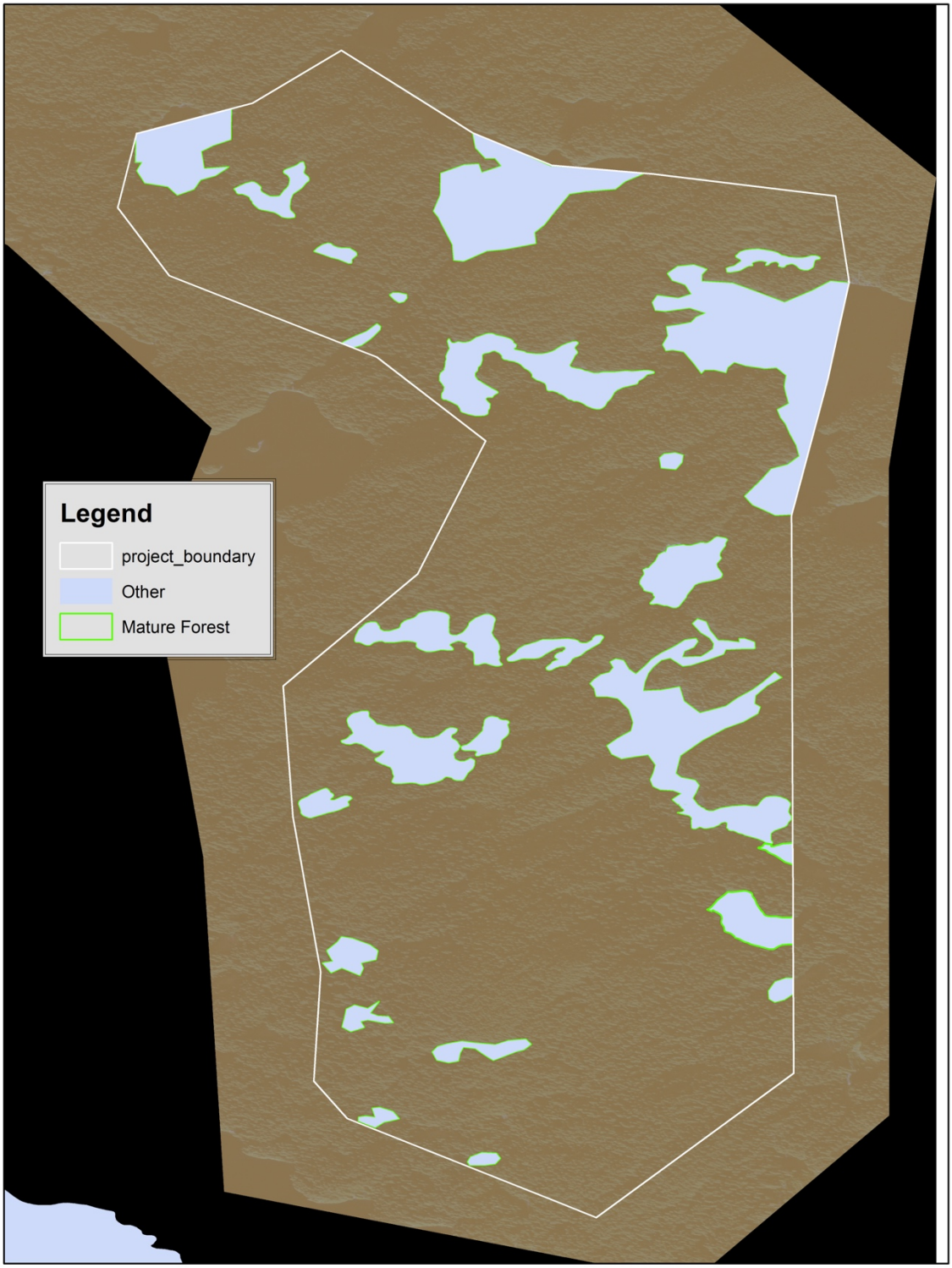


Figure 6. Overlay of mature forest areas (AU101) onto geo-rectified satellite imagery from the fall of 2017. The project area is split into 4 discrete areas.