# PROJECT DESCRIPTION DOCUMENT
VOLUNTARY CARBON STANDARD

## AFOGNAK FOREST CARBON PROJECT
v. 2.6

| | |
|---|---|
| *Afognak Forest Carbon Project* | May 17, 2012 |
| | |
| Version 2.6 | 3GreenTree Ecosystem Services Ltd.<br><br>Camco Global Inc.<br><br>American Land Conservancy<br><br>Rocky Mountain Elk Foundation |

## Table of Contents:

## List of Figures:

## List of Tables:

# 1. Project Details:

## 1.1. Summary Description of 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 7, 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 and monitors 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.

## 1.2. Sectoral Scope and Project Type

Sector 14 - AFOLU

Improved Forest Management (IFM)

Logged Forest to Protected Forest (LtPF)

The Afognak Forest Carbon Project is consistent with the VCS eligibility for an IFM-LtFP project by “protecting unlogged forests that would be logged in the absence of carbon finance”.

## 1.3. Project Proponent

| Organization | Role | Responsibilities | Contact/Address |
|---|---|---|---|
| American Land Conservancy | Project Proponent | Project co-ownership | Kerry O’Toole<br>American Land Conservancy<br>250 Montgomery Street, Suite 210, San |

| | | | |
|---|---|---|---|
| | | | Francisco, CA 94104<br>415-912-3665<br>Kerry@alcnet.org |
| Rocky Mountain Elk Foundation | Project Proponent | Project co-ownership | Blake Henning<br>Rocky Mountain Elk Foundation<br>5705 Grant Creek Road, Missoula, Montana 59808<br>406-523-0273<br>bhenning@rmef.org |
| Camco Global | Project Proponent Representative | 1. Project development support<br><br>2. Ongoing project monitoring and implementation | Charles Purshouse<br>Camco International Group, Inc.<br>390 Interlocken Crescent, Suite 490, Broomfield, Colorado, 80021<br>303-807-6567<br>Charles.purshouse@camcoglobal.com |

## 1.4. Other Project Participants

| Organization | Role | Responsibilities | Contact/Address |
|---|---|---|---|
| 3GreenTree Ecosystem Services Ltd. | Implementing Partner | 1. Project development<br><br>2. Ongoing monitoring and implementation support | Mike Vitt<br>3960 Marine Ave.<br>Belcarra, BC, Canada V3H 4R9<br>Tel: +1 778-998-5478 |

## 1.5. Project Start Date and Project Crediting Period

The Afognak carbon project and the crediting period start dates are the start of the calendar year closest to the initial acquisitions. As detailed in Section 7, 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. Therefore the project start date is selected as January 1, 2006 for simplicity and annualized tracking.

The crediting period starts on the project start date; however note that the baseline scenario has a conservative assumption of harvesting on the initially acquired 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.

**Project Start Date: January 1, 2006**

**Crediting Period Start Date: January 1, 2006 (first credit issuance Dec. 31, 2008).**

**Crediting Period: 30 years –** 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.

## 1.6. Estimated GHG Emission Reductions or Removals:

| | |
|---|---|
| Project | X |
| Mega-Project | |

The Afognak IFM-LtPF carbon project is projected to generate VCU's annually on a variable basis to a total of approximately 1.51 million $tCO_2e$ emissions reductions (1.21 million $tCO_2e$ of saleable VCU's after deductions and buffers) over the 30 year project crediting period.

## 1.7. Description of Project Activity:

In contrast to the baseline scenario, the Afognak Forest Carbon Project will conserve the project area forests for the duration of the project and in perpetuity. This will retain the carbon contained in the current forest biomass, sequester additional carbon in the retained forests, and avoid emissions from logging and transportation in the baseline scenario.

As a conservation-based IFM-LtPF project, there are no specific technologies, products, or services involved in the implementation of the project. Beyond the creation and sale of verified emissions reductions, the Afognak project activities will be primarily focused on property supervision and monitoring, and therefore there are no non-diminis project activities planned on the project area

Further details and specifics of the project scenario ex-ante and ex-post data, assumptions and modeling are found in Section 4.2. Further details on the legal agreements relating to project scenario activities are found in Section 7

## 1.8. 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 can be found in Section 7.

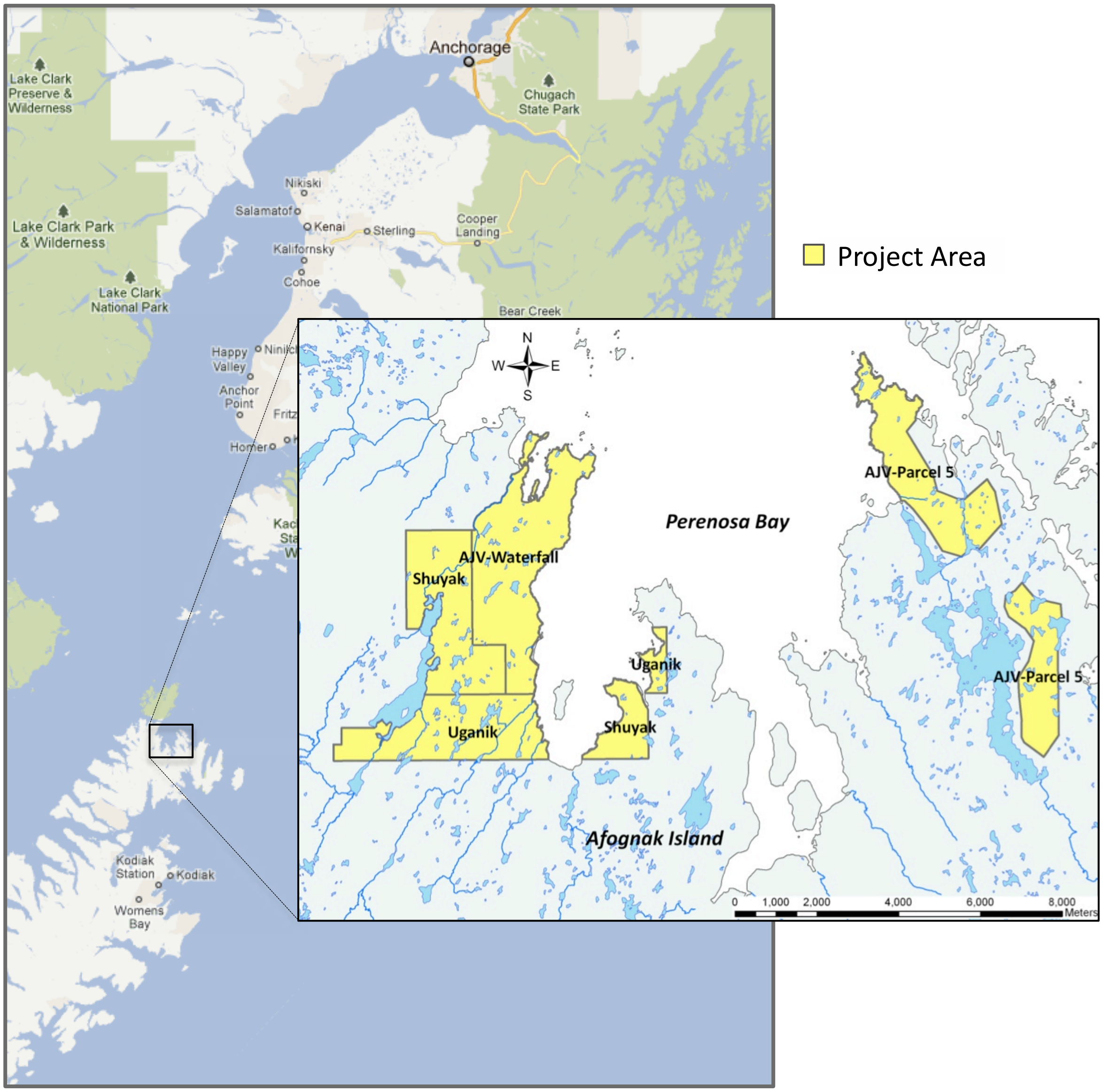



**Figure 1. An overview map of the Afognak Island carbon project showing its location relative to Anchorage Alaska and Kodiak Island. The insert shows a magnification of the individual parcels that comprise the project area.**

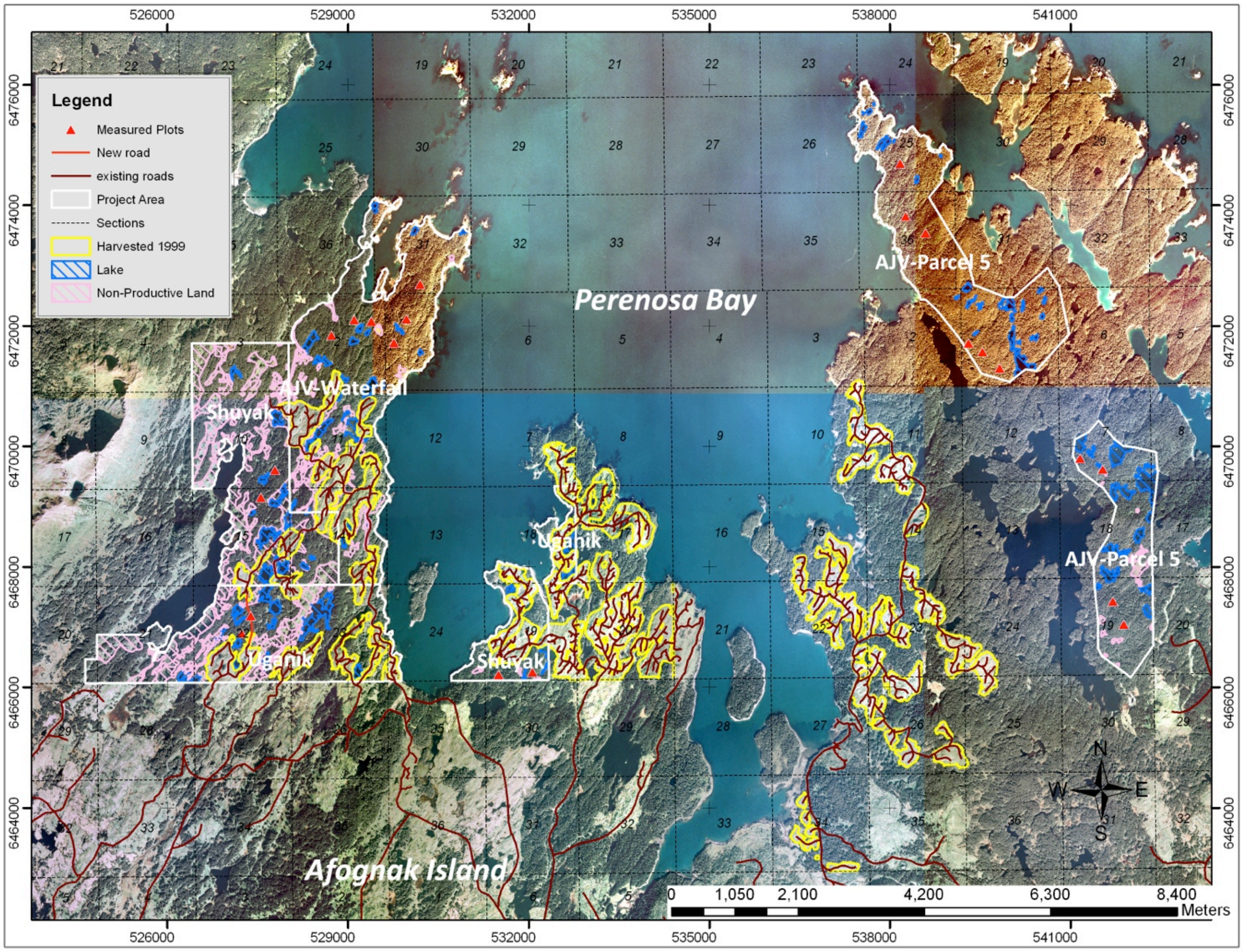



Figure 2- An overview map showing the Afognak project boundary overlaid on orthophotos taken in 2006. Existing road networks, areas harvested in 1999, and non-productive land are shown. The red triangles indicate the location of monitoring plots established in 2011.

## 1.9. Conditions Prior to Project Initiation:

In 1971 Congress passed the Alaska Native Claims Settlement Act, which created Alaska Native Corporations and transferred a portion of the land settlement from National Forest to fee simple title owned by the newly created Alaska Native Corporations. In 1980 Congress passed the Alaska National Interest Lands Conservation Act and conveyed the remaining settlement lands (in this region) to private ownership under the regional Alaska Native Corporations.

The relevant Native Corporations (Afognak Joint Venture, Shuyak, Inc. and the Uganik Native Corp, etc.) have managed their lands on Afognak almost solely for timber production. Typical practice across Afognak and Kodiak Island properties is clear-cutting to State Best Management Practices (i.e. legal minimum) with natural regeneration and no additional silvicultural activities. Roads were constructed to minimum standards, using excellent native rock material to create a low grade, but all weather road system throughout the currently logged areas. Extensive areas of recent logging activities are located across Afognak Island, including significant prior harvesting on the south end of the Uganik and Shuyak project parcels. Further logging was halted by the ALC/RMEF acquisition, and comparative evidence of ongoing clear-cutting operations continues on directly adjacent and regional properties.

### *Project Site Background Information*

**Physical description:** The project area is located surrounding east and west of Perenosa Bay including Delphin Bay on north Afognak Island, approximately 64km (40mi) straight-line distance northwest from the City of Kodiak, on Kodiak Island, Alaska. Private logging roads access the properties from the south; connecting to private log sorts in Kazakof Bay some 35km to the southeast. Access to Afognak Island and/or the project area directly is by floatplane or boat.

The unlogged areas are native old growth Sitka Spruce forests that have naturally established over the past 200-250 years on previously unforested sites (i.e. the initial Russian explorers in the 1760's apparently reported limited forest cover on Afognak Island (which is now primarily covered with forest)).

The project land is moderately rolling, with multiple lakes (Little Waterfall Lake, Paul's and Laura Lake being the largest) and small wetland areas scattered throughout. The forest contains primarily small perennial or ephemeral streams with a limited number of larger anadromous fish streams (note there are two major streams, one draining Paul's Lake and the Waterfall drainage).

Afognak Island is with a sub-arctic marine climatic zone, with persistent temperate and wet conditions. Annual precipitation averages 53 inches (1346 mm) on Afognak Island, with very little seasonal precipitation variation. Mean annual temperature is 41°F (5°C) at Kodiak. Extreme temperatures noted were 86°F (30°C) in June (1953) and -16°F (-26.7°C) in January (1989).

**Biological description:** The Afognak project area is a low elevation coastal temperate rainforest that has a remarkably uniform forest cover made up entirely of Sitka Spruce (*Picea Sitchensis*), interspersed with lakes, ponds, and various wetlands and small streams. The forest is either undisturbed 180-250 year old native old growth, and cutover areas are in various stages of natural regeneration <20 years old. Understory species are very uniform and include Sitka Alder, Devil's Club, Salmonberry, blueberry and a variety of grasses in openings and wet areas. A consistent mix of feather mosses and extensive arboreal moss across all surfaces is found across the property.

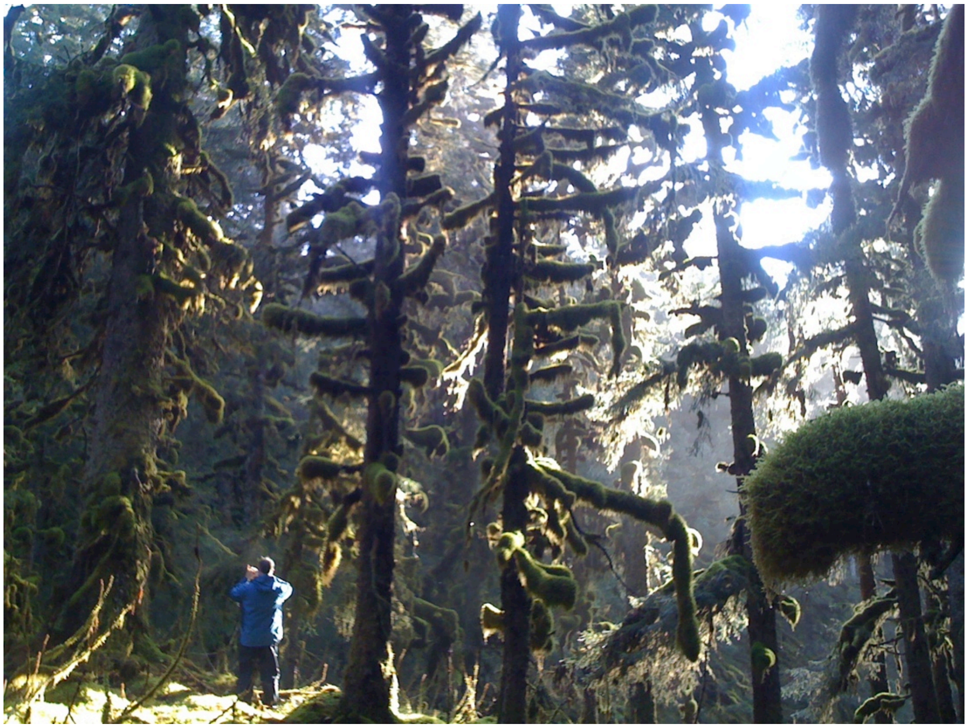


Figure 3 - Typical mature Sitka spruce (photo from within the Waterfall parcel).

Figure 4 - Typical natural openings, as found predominantly in the Uganik parcel.

Afognak is home to five species of Pacific salmon (Chinook, chum, coho, pink, sockeye) and steelhead, rainbow trout, Arctic char and Dolly Varden along with salmon-feeding wildlife, such as Kodiak brown bear, red fox, river otter, weasels and bald eagle. Because of its isolation and distance from the Alaskan mainland, only six species of land mammals (Kodiak brown bear, red fox, river otter, ermine (weasel), little brown bat, tundra vole) colonized the island. Non-native Roosevelt elk, Sitka-black tailed deer, mountain goat, snowshoe hare, and beaver were introduced to the archipelago between the 1920's and 1950's; they now commonly occur in self-sustained populations on the island.

### *Current State of the Properties*

Approximately 15% of the productive landbase within the project area has been clear-cut logged since the mid- to late- 1980's. As typical of the area, generally all harvests were full clear-cuts with little or no tree retention; and buffers and reserves limited to anadromous streams and small inaccessible areas. Harvested areas were left for natural regeneration, and no further silvicultural treatments were undertaken or planned. The regenerating areas have been observed during site visits to be undergoing severe grass and shrub competition, with regeneration success seen to be variable, but generally very poor. In many observed locations spruce regeneration is visible in a low proportion of the cut over areas, and the remaining areas heavily colonized by 1-2 meter dense Salmonberry, Devil's Club, and grasses; to the point where it is clearly evident that a severe regeneration lag will occur prior to full stand restocking to Sitka spruce.

**Figure 5 - typical natural regeneration on 10-15 year old clearcut in the Shuyak parcel. Note sparse spruce regen; heavy established shrub and grass**

There is private logging road access to or near all of the project properties, and all but the Paul's and Laura Lakes parcels have significant all weather logging road access throughout most of each property following the pre-existing logging areas. The U.S. Fish and Wildlife Service and Wildlife Forever (an NGO) are currently undertaking a road deactivation and access management planning program which may alter future ground access routes, and has resulted in the recent addition of a narrow right of way connector road to simplify access management (this road section has been identified and is accounted for in the forest inventory data).

**Figure 6 - Typical forest road on Afognak. Phote from within the Shuyak parcel.**

## 1.10. Compliance with Laws, Statutes and Other Regulatory Frameworks:

This forest carbon project is designed to be compliant with applicable U.S. and State of Alaska laws in both the baseline and forest carbon project scenarios.

The Afognak carbon project is focused on conserving forest ecosystems and habitat, and is generally inherently compliant with state, federal, and international laws and regulations simply because of the limited level of land use activity. In addition, the property is managed by the State of Alaska Department of Natural Resources with an accompanying a U.S. Federal Conservation Easement, which further demonstrates compliance with legal requirements of these authorities.

The project has projected the baseline scenario to be fully compliant with State of Alaska private forestland laws and regulations (Alaska Forest Resources & Practices Act). In general, the two regulations impacting the baseline scenario modeling are required buffers on anadromous streams and bald eagle nests.

An overview of the most relevant laws and regulations that might apply in certain circumstances to the Afognak property under the baseline or project scenario:

### *State Legislation and Regulation:*

**Statute:** *Alaska Forest Resources & Practices Act* (FRPA, AS41.17).
**Comments:** The Alaska FRPA governs how timber harvesting, reforestation, and timber access occur on state, private, and municipal land. The AK Department of Natural Resources, Division of Forestry publishes three field management guidebooks related to the FRPA: Forest Resources & Practices Act - YELLOW BOOK April 2009; Forest Resources & Practices Regulations - GREEN BOOK April 2009; Implementing Best Management Practices for Timber Harvest Operations - PURPLE BOOK 2005.pdf".

### *Federal Legislation:*

**Statute/Regulation:** *Fishery (General) Regulations*, SOR/93-53
**Comments:** The FRPA regulations are the approved management measures for implementation of the Fishery Regulations.

**Statute/Regulation:** *Clean Water Act (Sec. 319)*
**Comments:** The FRPA regulations are the standards for non-point source pollution control under the Clean Water Act (Sec. 319). FRPA Best Management Practices are the sole enforcement mechanism for violations of water quality standards.

**Statute/Regulation:** *Coastal Clear Water Act (Sec. 6217)*
**Comments:** The FRPA regulations are also the approved management measures for control of non- point source pollution under the Coastal Clean Water Act (Sec. 6217).

**Statute/Regulation:** *Alaska Coastal Management Program (ACMP)*
**Comments:** On private land, the FRPA and its regulations are the ACMP standards, policies, and review processes for forest operations. On state and other public land, the FRPA and its regulations are the standards for compliance with the timber harvest and processing and habitat standards under the ACMP.

## 1.11. Participation in Other GHG Programs:

The Afognak project does not participate in any other GHG program.

## 1.12. Other Forms of Environmental Credit:

The Afognak project does not participate in any other environmental credit program.

## 1.13. Additional Information Relevant to the Project:

### *Eligibility Criteria:*

The Afognak project meets both of the criteria for VCS Improved Forest Management – Logged to Protected Forest (IFM-LtPF) eligible projects as defined in the VCS AFOLU Guidelines v.3.0 (VCS, 2011):

a. Protecting currently logged or degraded forests from further logging.
b. Protecting unlogged forests that would be logged in the absence of carbon finance.

***Leakage Management:***
The Afognak project does not employ plans specifically designed for leakage management.

***Commercially Sensitive Information:***
None of the contents of this PDD are considered confidential. However, the project proponents may identify reference and supplemental evidence materials as commercially sensitive and confidential at the time of validation and/or verification.

***Further Information:***
This section intentional left blank.

# 2. Application of Methodology:

## 2.1. Title and Reference of Methodology:

VCS methodology:

*VM0012 Improved Forest Management in Temperate and Boreal Forests (LtPF) v1.1.*

## 2.2. Applicability of Methodology

**Table 1 - Compliance with Methodology Applicability Criteria**

| Summarized Applicability Criteria | Afognak Fit |
|---|---|
| Meets either current VCS IFM-LtPF criteria | Afognak meets both criteria |
| Projects located in FAO Temperate and Boreal Ecological Zones; and have Tier III inventory data available. | Afognak is located in the Temperate Ecological Zone.<br><br>Afognak utilizes detailed site level inventory meeting Tier III criteria. |
| Projects that meet the most current approved VCS Standard requirements for ownership | See Section 7. The Afognak project can demonstrate Proof of Right and Right of Use for all criteria required by VCS Version 3.1. |
| Projects with starting avg. annual illegal, unplanned, and fuelwood removals are <5% of annual harvest ($tCO_2e$); | Afognak has no illegal or unplanned harvesting, and *de minimis* fuelwood removals. |
| Projects without managed peatland forests | Afognak does not contain managed peatland forests. |
| Projects where % wetlands are not expected to change as part of project activities | Afognak will not materially alter the % of wetlands on the project area. |
| Projects that can demonstrate that no activity shifting leakage occurs to other proponent lands at the start of the project. | The ALC/RMEF does not undertake commercial timber harvesting on lands owned or managed by them, and can demonstrate baseline activities are not being shifted to other conservation land holdings. |

| | |
|---|---|
| Projects that do not include non-de *minimis* application of organic or inorganic fertilizer in the project scenario. | Afognak does not include any application of fertilizer either the baseline nor project scenario. |

Therefore, **the Afognak Forest Carbon Project is fully compliant with all of the listed applicability measures in the selected methodology.**

## 2.3. GHG Sources, Sinks and Reservoirs:

The Afognak Forest Carbon Project is bounded by the entire legal land description included in Section 7, within which the project considers the following GHG sources, sinks and reservoirs:

**Table 2 - Selection of Carbon Pools**

| Carbon Pool | Selected ? | Justification/Explanation | Scenario Carbon Flows: |
|---|---|---|---|
| **Above Ground Tree Biomass (Live)** | Yes | Live Above Ground Biomass. Required by VCS. Major carbon pool subject to changes from the baseline to the project scenario. | Reservoir – biomass in un-harvested forest biomass<br><br>Sink – Biomass re-growth after harvest disturbance<br><br>Sink – Biomass accumulation in growing retained forest<br><br>Source – Carbon flows resulting from timber harvest removals and adjacent biomass impacts during operations (shifted to other carbon pools)<br><br>Source – emissions from mortality and decay in remaining forests |
| **Above-Ground Non-Tree Biomass (Live)** | No | Live Above Ground Biomass. Excluded by VCS. Minor carbon pool subject to changes from the baseline to the project scenario | Sources and sinks are *de minimis* |
| **Below Ground Biomass Pool (Live and Dead)** | Yes | Live and Dead Below Ground Biomass. Required by VCS. Major carbon pool subject to changes from the baseline to the project scenario. | Reservoir – biomass in retained forest.<br><br>Sink – Biomass accumulation in avoided harvest stands<br><br>Sink – Biomass accumulation in growing stands<br><br>Sink – Biomass re-growth after forest management activities |

| | | | |
|---|---|---|---|
| | | | Source – Carbon flows resulting from forest management harvesting removals (shifted to other carbon pools)<br><br>Source – emissions from mortality and decay in remaining forests (shifted to other carbon pools) |
| **Dead Wood Pool** | Yes | Dead Above Ground Biomass. Required by VCS. Minor carbon pool subject to changes from the baseline to the project scenario. | Sink – dead snags, coarse branches, and stems before and after forest management activities<br><br>Source – decay of deadwood pool |
| **Litter Pool** | No | Dead Above Ground Biomass. Excluded by VCS for AFOLU projects. Minor carbon pool subject to changes from the baseline to the project scenario – generally considered as a transitional pool only. | Litter is a short-lived transition pool, and differences between the project and baseline are *de minimis* over time |
| **Soil Carbon Pool** | No | Dead Below Ground Carbon. Optional in VCS AFOLU IFM projects, but excluded in this methodology. As a conservative approach, changes to soil carbon from harvesting are assumed to be *de minimis*. Monitoring is difficult. | Soil carbon is a reservoir of long-lived carbon storage which is likely unaffected by timber harvesting. |
| **Wood Products Pool** | Yes | Required by VCS. All baseline scenarios involve logging. | Sink – carbon in permanent storage in harvested wood products<br><br>Source – emissions from decaying wood products |

**Table 3 - Emissions Sources Included/Excluded from the Project Boundary**

| Emissions Sources | Gas | Selected? | Justification/Explanation |
|---|---|---|---|
| **Use of Fertilizers** | $CO_2$<br><br>$CH_4$<br><br>$N_20$ | No<br><br>No<br><br>No | Neither the project nor the baseline scenario includes the use of fertilizer, and hence these emission sources are excluded.<br><br>These exclusion assumptions do not increase the emission reductions in the project. |

| | | | |
|---|---|---|---|
| **Combustion of Fossil Fuels by Vehicles / Equipment** | $CO_2$<br><br>$CH_4$<br><br>$N_2O$ | Yes<br><br>No<br><br>No | Carbon emissions from harvesting equipment, log transport, and primary forest product manufacturing are included.<br><br>$CH_4$ and $N_2O$ emissions from equipment are assumed to be *de minimis*.<br><br>The exclusion of these combustion gases does not increase the emissions reductions in the project |
| **Burning of Biomass (on site slash burning)** | $CO_2$<br><br>$CH_4$<br><br>$N_2O$ | No<br><br>No<br><br>No | Emissions from burning of biomass are not included specifically in either scenario; however, carbon stock decreases due to burning are accounted as a carbon stock change.<br><br>These exclusion assumptions do not increase the emission reductions in the project. |

## 2.4. Baseline Scenario

***STEP 1 – Identify Plausible Alternative Baseline Scenarios to the VCS Project Activity***

The Afognak Forest Carbon Project has identified four (5) potential baseline scenarios that were evaluated in this baseline selection process. Italicized text indicates direct quotes from methodology or VCS requirements in baseline scenario selection.

**1. Historical Practice**

The VCS standard and VM0012 require the consideration of historical practice as a baseline scenario in Step 2a. As this project involves a distinct change in ownership at the project start date, there is no historical management data (and specifically less than 5 years management history for the project proponent, as per the methodology Step 2a) related to ALC/RMEF (or the State of Alaska as the surface estate holder – see Section 7 for additional ownership and transactional history), and therefore the historical management practices data for the project proponent/current surface owners does not exist for the project area. Therefore, this scenario will be eliminated in Step 2a.

**2. Continuation of the previous owners practices**

The second potential baseline scenario was the continuation of the previous owner's historical operating practices as a representation of common practice (as per Step 2b). Direct harvest and planning data related to previous or planned operations by the previous owners were not available to the carbon project. However, there is a projected harvesting plan within the timber appraisals for the Uganik and Shuyak properties, evidence from previous harvesting on the Uganik, Shuyak and Waterfall properties, previous timber harvesting rights agreements for the Paul's Lake and Laura Lake parcels, and other visual evidence of common practice from orthophotos, photographs, field visits and other documentation which can collectively be used to project a conservative and reasonable projection of the continuation of the previous owners practices across the project area. See Appendix 4 for additional details and background on Afognak common practices, previous and comparable operations, and other assumptions related to the extent of logging, logging practices, and the rate of harvest projected for this baseline scenario.

**3. Acquisition by a market driven acquirer baseline logging scenario**

The third baseline scenario identified was the sale of the properties and/or timber rights from the previous owners to a market-driven acquirer (i.e. a logging company or other). It is assumed that as the previous owners *might* have been willing to sell the land or timber rights to another party in lieu of continuing to harvest themselves (although we have no direct evidence of other acquisition transaction discussions had occured), and/or in lieu of completing the transactions with ALC/RMEF. It can be assumed that a market driven land or timber rights buyer would be strongly motivated to reduce costs by achieving maximum economies of scale and remote operation efficiencies. Any acquirer of fee simple or timber harvesting rights using private capital would be motivate to maximize return on investment, and would be strongly motivated to reduce the impact of remote operations cost. It is logical that these buyers would harvest (at minimum) in a similar fashion to the previous owners (under the assumption the previous owners were efficient), or more likely at a faster timber harvesting rate to repay their acquisition capital and maximize the profit opportunity. There is evidence of operators such as Trans-Pac and others acquiring timber rights for extensive logging on Afognak and Kodiak Islands[1]. The scenario is essentially another variation of a common practice scenario that is comparable to Baseline Scenario 2, but potentially more aggressive in harvesting.

**4. Acquisition for conversion to real estate development lands**

For the fourth scenario, the acquisition appraisals for the Afognak properties considered comparable higher and better use development into remote residential for select areas of the property along shorelines and lakes (Forest and Land Management, Inc. , 2008). A potential baseline scenario is therefore that an entity would acquire the lands from the previous owners (or the previous owners would implement this directly), with the intent of financial return on investment from the development and sale of remote residential and vacation properties. Based on the appraisal assessments, it is clear that extensive real estate development across all of the project parcels is unlikely, so this scenario would likely include a focus on maximizing real estate opportunities within the highest and best use areas (i.e. shoreliens, lakes, streams, etc.), supplemented with timber harvesting in some cases.

**5. Acquisition for conversion to conservation lands**

The fifth potential baseline scenario is the acquisition of the forest for conservation purposes. This scenario is representative of, or comparable to, the project scenario without carbon. There is no credible market-based business model for this baseline scenario to provide financial returns for private investment capital, as there are no material revenue returns from conservation activities similar to the project scenario. There is, however, regional evidence of other grant funded conservation acquisitions (in particular acqusitions made with Exxon Valdez Oil Spill restoration funds). These comparable conservation acquisitions were not repeatable without grant funding, which is generally available only for a specific period (i.e. for example the Exxon Valdez Oil Spill funding), or otherwise is difficult to raise, intermittendly available, or at much small scale than this project. The inclusion of this scenario also meets element 2.1.1 a), item ii) in the VCS Additionality Tool VT0001.

The areas in italics in the following are the baseline selection criteria outlined in the methodology.

Each prospective baseline scenario meets the following baseline selection scenario eligibility criteria, except where noted and excluded:

[1] i.e. see: http://www.transpacfibre.com/web/transpac_alaska_lp/index.htm for an example reference on TransPac acquiring timber rights on Afognak

1. *Including activities and areas where forests remaining forests* - this criterion eliminated the potential Baseline Scenario 3 "Acquisition for conversion to real estate development lands".

2. *Comply with legal requirements for forest management and land use in* the area – all of the baseline scenarios could be operated in compliance with Alaska forestry best management practices and related laws and regulations. Logging and remote residential develop would be permitted under the KIB land zoning for these properties without further public review.

3. *Demonstrate that the "projected baseline scenario environmental practices equal or exceed those commonly considered a minimum standard among landowners in the area"* (VCS, 2011) - all prospective baseline scenarios could have complied with minimum environmental performance of landowners in the area, most of whom follow the minimal requirements in Alaska.

This project identified 5 baseline scenarios, including the required historical practice and common practice scenarios, and meets the methodology requirement.

***STEP 2 – Selection of a Single Plausible Baseline Scenario for the Project***

*Project proponents shall select a single plausible baseline scenario for the project using the following steps:*

***STEP 2a - The Historical Baseline Scenario - based on actual property harvest history must be selected if:***

*2a.1 The current property owner retains ownership of the property and has at least 5 years historical harvest level data history, and*

The Afognak property was sold to ALC/RMEF, and transferred to state ownership, and there is no history of management by ALC/RMEF prior to the project start date. Therefore, the Baseline Scenario 1, Historical Baseline Scenario is eliminated as not applicable in Step 2a, and the four remaining baseline selection will continue to Step 2b.

*All other cases will utilize the Common Practice Baseline Scenario Selection steps below:*

***STEP 2b - The Common Practice Baseline Scenario – based on previous owner activities:***

a. *If the current owner has owned the property for less than five years then the project proponent may:*
   i. *Choose to use the previous owners historical activities or management plan as representative of common practice, in which case the baseline scenario is selected based on the process and criteria in Step 2a; or,*
   ii. *Choose to select the baseline scenario based on common practice and investment analysis of scenarios as outlined in Step 2c below*

As per Step 2b, the project has selected a projection of the previous owners operations as representative of the most likely baseline scenario, and although no forward looking harvesting or management plans from the previous owners are available, there is substantial current and historical evidence of common practices on the project area and on adjacent forest areas (see Appendix 4). Therefore, the project will select **Baseline Scenario 2 - Continuation of the previous owners practices** the most likely baseline based on Step 2b, and utilize a representation of the previous owners practices to create a projected baseline scenario.

For reference and comparison, the following assessments were made on the remaining alternative baseline scenarios to support the choice of Baseline Scenario 2:

Baseline Scenario 1 – Continuation of Historical Practice: As noted, the current project owners ALC/RMEF have not owned or managed the properties prior to the project start date, and therefore this scenario is not applicable and is eliminated under Step 2a.

Baseline Scenario 2 – Continuation of Previous Owners Practices: This is the selected baseline from Step 2b, and based on the assessments of the remaining scenario selections, is a reasonable and conservative representation of the most likely baseline scenario.

Baseline Scenario 3 – Acquisition by a market driven acquirer: This scenario is similar to Baseline Scenario 2 (except likely less conservative) and is an alternative version of a common practice baseline. As noted in the scenario description, the remote location of this project site would very likely require a market-based acquirer with invested acquisition capital to be intensely focused on maximizing logging efficiency – primarily by maximizing logging volume to offset the high costs of remote equipment transport and mobilization, remote crew costs, ocean based log transport (to Asia on high volume container vessels, etc. Unlike the previous Native Corp. owners (who were deeded the land under a land claims settlement, and therefore had no capital investment, nor capital costs), a private market acquirer under this scenario would have deployed equity and debt capital into the acquisition, and would require a market-based return on investment. The result would be at minimum represented by the selected Baseline Scenario 2, but would more likely result in additional logging on a much quicker timeframe, and hence be less conservative. This scenario is eliminated by the selection in Step 2b, in addition to being better represented by the more conservative Baseline Scenario 2.

Baseline Scenario 4 – Acquisition for conversion to real estate development lands: The potential remote residential real estate development value for the lands was considered in the acquisition appraisal documents (Forest and Land Management, Inc. , 2008). It was concluded that the highest and best use for the majority of the land was logging. Certain higher amenity areas were considered to have potential value for cabins, remote housing and other related development. In particular the areas along shorelines and close to anadromous streams were considered the highest potential. However, as a baseline scenario it appears clear that real estate development would not be economically viable on the majority of the property (which would be replaced by timber as the best use), and it is not clear that there is a substantive enough real estate opportunity (and absorption rate) in this remote an area to significantly improve the returns over timber with a real estate focus. Therefore, the credibility of a real estate focused baseline is uncertain at best, and in our opinion a much less credible and likely scenario to a timber focused baseline. Therefore, this scenario has been rejected as very uncertain and not the most likely baseline scenario, primarily based on the evidence presented in the appraisal documents. Note that to be conservative in recognizing any small real estate potential that does it, the selected baseline scenario conservatively includes an assumed reduction in the logging scenario in key HBU areas to account for the potential of limited remote residential development on the highest amenity sites within the project area. Therefore, Baseline Scenario 4 was considered potentially non-viable and reasonably representable within the selected baseline scenario, and such was eliminated.

Baseline Scenario 5 – Acquisition for conversion to conservation lands: there is no economic rationale for investing market capital to acquire the project properties or the biomass/timber rights thereon for the purpose of conservation. Without carbon finance, there are no feasible material revenue sources from the land, and no means to generate any rate of return on private capital. Logically, this scenario was eliminated as there are more financially attractive baseline scenarios. Further support for this is found in Section 2.5, where this scenario is found to be additional when considered as the project scenario.

To summarize, the most likely baseline scenario was selected as Baseline Scenario 2 – Continuation of Previous Owners Practices based on a selection in Step 2b. The alternative baseline scenarios were all considered non-viable, less conservative, less likely, or otherwise reasonably represented within the selected baseline scenario.

The details of ex-ante modeling and assumptions related to the selected most plausible baseline scenario are located in section 4.1.

#### *STEP 2c - The Common Practice Baseline Scenario*

Based on the selection made in Step 2a, Step 2c is not applicable. However, note for comparison purposes that the selected Baseline Scenario 2 would also meet the common practice tests from Step 2c.

#### *STEP 3 – Additionality Test*

The project is additional as per Section 2.5 in a manner consistent with this baseline selection method.

### a. Demonstration and Assessment of Additionality:

The project uses the VT0001 Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities v1.0 (Voluntary Carbon Standard, 2010b):

This PDD meets the eligibility requirements of this tool by:

1. The project activities are not in violation of any applicable law;
2. The project employs a step-wise method to determine the most baseline scenario, which is consistent with the application of this tool.

#### *Step 1a – Identification of plausible baseline scenarios*

1. Historical practice (Step 1a.i - Continuation of pre-project land use)
2. Continuation of the previous owners practices (selected baseline scenario) (Step 1a.iii – Extrapolation of legal and observed regional common practice)
3. Acquisition by a market driven acquirer baseline logging scenario (Step 1a.iii – Extrapolation of legal and observed regional common practice)
4. Acquisition for conversion to real estate development lands (Step 1a.iii – Extrapolation of legal and observed regional common practice)
5. Acquisition for conversion to conservation lands (project scenario) (Step 1a.ii – Project activity without carbon project)

#### *Step 1b – Legal tests*

All plausible baseline scenarios could be undertaken within the legal requirements of private forestland and remote residential land zone. All timber operations within the discussed scenarios could easily meet the minimal private forest legal requirements in Alaska (also see Appendix 4 for a brief summary and references), the most significant of which are minimal tree retention on fish streams and buffers on eagle nests (both of which have very little spatial impact on timber stocks and could easily be met by all scnearios withoug material impact). There are very few land zoning restrictions for remote rural residential development affecting potential Baseline Scenario 3 within Kodiak Island Borough, Conservation District Zoning, as reviewed in (Forest and Land Management, Inc. , 2008).

#### *Step 1c – Selection of Most Plausible Baseline Scenario*

See Section 2.4 for description of the baseline selection process as per the methodology.

The outcome of the selection process was to select “Baseline Scenario 2:  Continuation of the previous owners practices”.

### *Step 2 - Investment Analysis*

The project scenario is less financially attractive then *all* of the alternative baseline scenarios.  As a Logged to Protected Forest conservation project, the project scenario for the Afognak Carbon project generates no material financial or economic benefits other than carbon related income, and therefore is suitable for Option I – Simple Cost Analysis.

Given the fact that the project scenario without carbon generates no return (or substantially negative return after capital costs and expenses), it is logical to conclude that all of the other 3 potential baseline scenarios (1 being eliminated due to inapplicability) have the ability to generate revenue from the sale of timber in potential scenarios 2 and 3, and real estate (likely combined with some degree of timber). Therefore, any simple cost analysis will result in Step 2a demonstrating the project is additional.

### *Step 2a – Investment Analysis – Option I Simple Cost Analysis*

The operating costs of the Afognak carbon project specific to the carbon project itself are projected to average USD$70,000/year (including verification, issuance and registration, project management, monitoring, and sales costs; not including capital costs, management overhead costs, road costs, or taxes).  In addition, it is estimated that $100,000/year would be necessary at minimum to manage the property without the direct carbon project expenses themselves (see the Simple Cost Analysis and Financial Viability tabs in the Afognak Carbon Model referenced in Appendix 3) [2].

With the exception of carbon, there are no material revenue sources available from the project properties under the project scenario and related covenants and title agreements.

The Simple Cost Analysis tab in the Afognak Carbon Model as listed in Appendix 3 compares the potential financial returns in Baseline Scenario 2 and the Project Scenario.  To summarize, it can be seen that as expected the project has a strongly negative return with zero revenue and even minimal land management costs. The sampled baseline scenario (based on the PD modeled baseline scenario volumes and timber valuation data from the land appraisal documentation (Forest and Land Management, Inc. , 2008) has the potential to generate competitive market returns from logging (particularly under this scenario where there is no capital costs).  Therefore, at least one baseline scenario generates substantially higher financial benefits than the project scenario without carbon revenue, which is a clear indication of project additionality under an investment analysis test.

As per the additionality tool Section 2.2.2, the project clearly produces no financial benefits other than VCS related income, and therefore the tool continues to Step 4 (Common Practice Analysis).

### *Step 3. Barrier Analysis*

As an extension of the Investment Analysis above, there is a clearly related applicable barrier:

### *Step 3a:*

There are barriers for AFOLU project activities undertaken and operated by private entities:

- Similar conservation activities have only been implemented with grants or other non-commercial finance terms. In this context similar activities are defined as activities of a similar scale that take place in a comparable environment with respect to regulatory framework and are undertaken in the relevant geographical area.  See the fund ing summary in (Alaska Department of Natural Resources, 1999).

[2] Additional details of cost modeling assumptions available upon request.

### *Step 4. Common Practice Analysis*

The Common Practice Analysis is a credibility check on the project's conclusions in the Investment and/or Barrier Analysis. The project undertook to identify comparable conservation acquisitions or projects that might contradict the conclusions of the Investment Analysis (for example, are there conservation acquisitions which generate attractive (or any) financial returns that might be comparable to the other baseline scenarios?), or the supplementary Barrier Analysis (for example, are there conservation acquisitions funded with private market capital, or non-grant capital?).

The project's Common Practice Analysis included 3 steps:

1. Interviewing a leading expert in the Afognak/Kodiak region on conservation acquisitions;
2. Reviewing the key conservation acquisition portfolio of the Exxon Valdez Oil Spill Trustee Council (the major source of regional conservation acquisitions in the past 20 years);
3. Providing supplementary information related to the differences between the Afognak project grant-financing sources versus other conservation acquisitions.

Through these steps, the project is able to conclude there is no indication of comparable conservation acquisitions in the region surrounding the project that provide material revenues from conservation without carbon finance, and no indication of the use of non-grant market capital being used in conservation acquisitions. In addition, even within the context of grant-financed conservation acquisitions, the Afognak project was unique. Therefore, the project concludes there is no evidence of common practice activities that would contradict or alter the findings of additionality from the Investment Analysis and supplementary Barrier Analysis.

Additional Common Practice Analysis Details:

The project first interviewed Tim Richardson of the American Land Conservancy (with over 23 years of conservation work in the Afognak region, including previous work with two local Native Corporations and the Kodiak Brown Bear Trust), to review his professional knowledge of comparable conservation activities in the region surrounding Afognak Island and Kodiak Island, and coastal Alaska generally. Mr. Richardson confirmed that he was not aware of any conservation related to *for-profit* financing anywhere in the region. He noted that the non-government conservation acquisitions on Afognak Island and Kodiak Island were very limited prior to the Exxon Valdez Oil Spill (EVOS) funding , with no acquisitions >160 acres (and those being generally small refuge in-holding acquisitions made by the Land and Water Conservation Fund in the early to mid-1990's). Starting in 1993, EVOS funding became the major source of conservation acquisition funding in the region that resulted in the acquisition of $350 million of regional lands for conservation purposes (see below). He also noted that he was unaware of any conservation activities that generated material levels of revenue to the managers – in Alaska the most common practice for conservation activities are based on no resource extraction, the retention of free public access, and the limitation of development (Tim Richardson, Personal Communication, May 11, 2012; email May 14, 2012). Based on this information, it is apparent that there are no material sources of revenue from conservation acquisitions, and no evidence of non-grant sources of financing in the project area.

Second, the project reviewed the published summary of funding acquisitions from the predominant source of grant-based conservation acquisition funding in the region over the period of 1993-2009 - the

EVOS Large Parcel Acquisition program managed by the EVOS Trustee Council ((http://dnr.alaska.gov/commis/evos2/EVOS_atlas_web.pdf (Alaska Department of Natural Resources, 1999)). This program was funded from the one-time Exxon Valdex spill settlement, and allocated $350M to provide the basis for the acquisition of protective bundles of rights on over 635,000 acres of land in the Kodiak, Kenai Peninsula, and Prince William Sound regions, including 88,000 acres on Afognak Island. Activities not permitted under the EVOS acquisitions were: *"Changing the topography, dumping trash, using biocides, removing or destroying plants except for subsistence or medicinal use, altering watercourses, using motorized vehicles with the exception of floatplanes, removing or harvesting timber, introducing nonindigenous plants, and building facilities. Limited facilities such as public use cabins, weir sites, trails and campsites may be constructed for research or management purposes".* Based on these usage restrictions, and a review of the individual projects within the atlas, it is apparent that there are no material sources of revenue from these comparable acquisitions, and therefore no evidence of other projects that are able to provide any form of investment return that would challenge the conclusions of the Investment Analyis for the Afognak Carbon Project. There also were no listed sources of for-profit financing within the acquisitions. The EVOS acquisition funding was a unique source of conservation financing which had deployed the acquisition funds by 2009-10 and is no longer available for similar scale acquisitions.

Third, although the common practice analysis conclusions can be made on the first two steps, for supplemental information purposes it is important to note that even within the context of other grant-financed conservation acquisitions in the area, the Afognak project properties were unique transactions. For example, originally the EVOS Habitat Protection Progam (HPP) had allocated $10.45 million towards the protection of an additional 18,000 acres of land in Perenosa Bay on Afognak Island, which included the timber rights in the Paul's and Laura Lakes, Tracts A and B, and the Waterfall parcels including Shuyak and Uganik within the project area. For the first time with EVOS funding, this transaction required matching funds to be raised and contributed (by Rocky Mountain Elk Foundation and the American Land Conservancy). However, the purchase was vetoed by the then Governor of Alaska Frank Murkowski because of the Governor's stance on the use of federal money to purchase lands owned by Native Corporations[3]. Following the veto, the EVOS HPP funds were no longer available to protect further lands on Afognak Island so RMEF and ALC were forced to raise additional not for profit grant funding. In 2005, RMEF and ALC were able to purchase the timber rights for the Laura Lake Tract B and Waterfall Parcels, and although smaller than the 18,000 acres initially envisaged, the protection of Laura Lake Tract B and Waterfall marked the first time that private sector grant funds had been used for conservation purposes on Afognak Island. In 2009, after nine years of work, RMEF and ALC protected the remaining parcels of forest in the project lands (Paul's Lake Tract A, Uganik and Shuyak) with a combination of funds, including some support from the EVOS Habitat Protection Program.

In summary, the common practice analysis found that not only were other conservation acquisitions not evidence of common practice (or different or contrasting investment or barrier analysis results) for similar project areas, but even further that the Afognak project properties transactions were unique in comparison to other conservation acquisitions which had occurred in the region from the short term

[3] http://peninsulaclarion.com/stories/061303/ala_061303akpm004001.shtml

source of conservation acquisition grant financing available after the Exxon Valdez oil spill. Therefore, the project concludes there is no indication of Common Practice for the project scenario.

**Based on the application of this VCS tool, the Afognak Forest Carbon Project is additional based on Investment Analysis.**

### 2.5. Methodology Deviations:

No material deviations from the methodology were made.

## 3. Monitoring:

Monitoring relates to the ongoing measurement of carbon pools and for compliance of the project's activities. In the case of the Afognak project, the monitoring plan has the purposes of:

a) Ensuring that non-*de minimis* unanticipated GHG emissions have not occurred or are accounted for in net GHG calculations,
b) To verify that parameter values and simulated carbon pools are consistent with their ex ante estimates,
c) Ensuring that the other requirements of the PDD are tracked (i.e. leakage).

### 3.1. Data and Parameters Available at Validation:

A list of the data and parameters available at the time of validation is provided in Table 4.

**Table 4 - 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: | Required for baseline and project calculations |
| Comments: | |

| **Data/parameter** | $\mathbf{A_{BSL,i}}$, $\mathbf{A_{PRJ,i}}$ |
|---|---|
| Data unit | Ha |
| Description: | Respective areas of baseline and project |

| | |
|---|---|
| | subregion, *i* |
| Source of data | Latest Afognak GIS spatial inventory data (see Appendix 3). |
| 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 |
| Comments: | First used in equations 4 and 32, for the baseline and project cases, respectively |

| **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 |
| Comments: | First used in equations 4 and 32 for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{R_i}$ |
|---|---|
| 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). |

| | |
|---|---|
| Justification of choice of data or description of measurement methods and procedures applied: | Root biomass is difficult to measure directly. |
| Comments: | First used in equations 5b and 33b for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{f_{BSL,NATURAL,i,t}}$, $\mathbf{f_{PRJ,NATURAL,i,t}}$ |
|---|---|
| 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. |
| Comments: | First used in equations 7 and 35 for the baseline and project cases, respectively. |

| **Data/parameter** | $\mathbf{f_{BSL,HARVEST,i,t}}$, $\mathbf{f_{PRJ,HARVEST,i,t}}$ |
|---|---|
| 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 Table 14 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 | a. Annual harvest schedule constitutes |

| | |
|---|---|
| measurement methods and procedures applied: | the most reliable source of information for variable. |
| Comments: | First used in equations 8 and 36 for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{f_{BSL,DAMAGE,i,t}}$, $\mathbf{f_{PRJ,DAMAGE,i,t}}$ |
|---|---|
| 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: | b. 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. |
| Comments: | First used in equations 9 and 37 for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{f_{BSL,BLOWDOWN,i,t}}$, $\mathbf{f_{PRJ,BLOWDOWN,i,t}}$ |
|---|---|
| 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 $f_{BSL,NATURAL,i,t}$, $f_{PRJ,NATURAL,i,t}$<br><br>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: | c. 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. |
| Comments: | First used in equations 12 and 40 for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{f_{BSL,BRANCH,i,t}}$, $\mathbf{f_{PRJ,BRANCH,i,t}}$ |
|---|---|
| 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 | Allometric biomass equations constitute the most |

| | |
|---|---|
| measurement methods and procedures applied: | reliable source of information for variable. |
| Comments: | First used in equations 12 and 40 for the baseline and project cases, respectively |

| **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 and 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. |
| Comments: | First used in equations 12 and 40 for the baseline and project cases, respectively |

| **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. |

| | |
|---|---|
| Comments: | First used in equations 12 and 40 for the baseline and project cases, respectively. |

| **Data/parameter** | $\mathbf{f_{BSL,lwDECAY,i,t}}$, $\mathbf{f_{PRJ,lwDECAY,i,t}}$ |
|---|---|
| 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 a an exponential decay function similar to:<br><br>Mass loss occurs in proportion to the amount of mass remaining in accordance with an a single exponential model, of the general form:<br><br>$Y_t = Y_o e^{-kt}$<br><br>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) |
| Comments: | First used in equations 13 and 41 for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{f_{BSL,SWDECAY,i,t}}$, $\mathbf{f_{PRJ,SWDECAY,i,t}}$ |
|---|---|
| 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 |
| Comments: | First used in equations 13 and 41 for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{f_{BSL,dgbDECAY,i,t}}$, $\mathbf{f_{PRJ,dgbDECAY,i,t}}$ |
|---|---|
| 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 |
| Comments: | First used in equations 17d and 45d for the baseline and project cases, respectively |

| **Data/parameter** | $\mathbf{f_{BSL,PRODUCTk}}$, $\mathbf{f_{BSL,PROCESSk}}$, $\mathbf{f_{PRJ,PRODUCTk}}$, **and** $\mathbf{f_{PRJ,PROCESSk}}$ |
|---|---|

| | |
|---|---|
| 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 | See Appendix 2, Table 1 or Afognak Carbon Model spreadsheet. |
| Justification of choice of data or description of measurement methods and procedures applied: | |
| Comments: | First used in equations 20 and 48 for the baseline and project cases, respectively |

| | |
|---|---|
| **Data/parameter** | $\mathbf{f_{BSL,PERMHWPk}}$, $\mathbf{f_{PRJ,PERMHWPk}}$ |
| 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: | $f_{BSLPERMHWPk} = (1/(1 + (Ln(2)/HL_k)))^{\wedge}Y$<br><br>where:<br><br>$HL_k$ is the half-life of a given product type, *k* (years), and *Y* is the elapsed time (i.e, 100 years). See Appendix 2, Table 1 for $HL_k$ values. |
| Comments: | First used in equations 19 and 47 for the baseline and project cases, respectively |

| | |
|---|---|
| **Data/parameter** | **$f_{BSL,BARK}$, $f_{BSL,COARSE}$, and $f_{BSL,FINE}$**<br><br>**$f_{PRJ,BARK}$, $f_{PRJ,COARSE}$, 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 $f_{PRJ,BARK}$<br><br>42.9%, for $f_{BSL,COARSE}$ and $f_{PRJ,COARSE}$<br><br>30.7%, for $f_{BSL,FINE}$ and $f_{PRJ,FINE}$ |
| Justification of choice of data or description of measurement methods and procedures applied: | |
| Comments: | First used in equations 23a-c and 51a-c for the baseline and project cases, respectively |

| | |
|---|---|
| **Data/parameter** | **$f_{BSL,BARKUSE}$, $f_{BSL,COARSEUSE}$, and $f_{BSL,FINEUSE}$**<br><br>**$f_{PRJ,BARKUSE}$, $f_{PRJ,COARSEUSE}$, 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 $f_{PRJ,BARKUSE}$<br><br>85%, for $f_{BSL,COARSEUSE}$ and $f_{PRJ,COARSEUSE}$<br><br>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. |
| Comments: | First used in equations 23a-c and 51a-c for the baseline and project cases, respectively |

| **Data/parameter** | **$f_{BSL,PROCESSc}$ and $f_{BSL,PROCESSf}$**<br><br>**$f_{PRJ,PROCESSc}$ 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. |
| Comments: | First used in equations 24 and 52 for the baseline and project cases, respectively |

| **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 described above. |

| | |
|---|---|
| Justification of choice of data or description of measurement methods and procedures applied: | |
| 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. |
| Comments: | Are used in conjunction with permanent sample plot data to estimate biomass. |

## 3.2. Data and Parameters Monitored

A list of the data and parameters to be included in the monitoring program is provided in Table 5.

**Table 5 - Data and Parameters to be 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 3). |
| 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 Applied | |

| | |
|---|---|
| Monitoring equipment: | Visual, satellite, orthophotos |
| QA/QC procedures to be applied: | Standard GIS QA/QC procedures. Latest Afognak Standard Operating Procedures (SOP) |
| Calculation method: | |
| Comments: | First used in equations 4 and 32, for the baseline and project cases, respectively. |

| **Data/parameter** | $\mathbf{A_{PSP,i}}$ |
|---|---|
| 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 Applied | 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. |
| Calculation method: | GPS positioning of plot center. Tape measurements to calculate area. Potential use of prisms to derive plots size. |
| Comments: | |

| **Data/parameter** | $\mathbf{DBH_{i,t}}$ |
|---|---|
| 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 Applied | As measured |
| Monitoring equipment: | DBH tape, data logger |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Measured |
| 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 Applied | 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). |
| Calculation method: | Measured |
| 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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| 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 will be 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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Equation 28d |
| Comments: | Data will be used to validate ex-ante values from inventory + model output |

| **Data/parameter** | $\mathbf{B_{TOTALi,t}}$ |
|---|---|
| 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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Equation 28b |
| Comments: | Data will be used to validate ex-ante values from inventory + model output |

| **Data/parameter** | $\mathbf{C_{LB,i,t}}$ |
|---|---|
| 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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Equation 28c |
| Comments: | Data will be used to validate ex-ante values from inventory + model output |

| **Data/parameter** | $\mathbf{C_{DOM,i,t}}$ |
|---|---|
| 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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Equation 28e |

| | |
|---|---|
| Comments: | Data will be 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 Applied | Variable |
| Monitoring equipment: | Tree coring bit. |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| 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** | $\mathbf{f_{PRJ,NATURAL,i,t}}$ |
|---|---|
| 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 Applied | Proportion |
| Monitoring equipment: | Observation |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| 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: | First used in equations 7 and 35 for the baseline and project cases, respectively. |

| **Data/parameter** | $\mathbf{f_{PRJ,HARVEST,i,t}}$ |
|---|---|
| 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.<br><br>Wood density (see below) used to derive biomass estimates.<br><br>Modeled estimates of total biomass in subregion, *i*, used to derive parameter. |
| Frequency of monitoring/recording: | Every 5 years |
| Value Applied | Proportion |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Data will be verified by ground-truthing and comparison with remote sensing information. |
| Calculation method: | 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*. |
| Comments: | First used in equations 8 and 36 for the baseline and project cases, respectively. |

| **Data/parameter** | $\mathbf{f_{PRJ,DAMAGE,i,t}}$ |
|---|---|
| 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 Applied | Proportion |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Data will be verified by ground-truthing or remote sensing information. |
| Calculation method: | Areal estimate of removals is multiplied by average carbon density within a subregion. |
| Comments: | First used in equations 9 and 37 for the baseline and project cases, respectively. |

| **Data/parameter** | $\mathbf{DOM_{SNAG,i,t}}$ |
|---|---|
| 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 | Calculated from $Height_{i,t}$, $DBH_{i,t}$, and $A_{p,i,t}$ of dead |

| | |
|---|---|
| procedures to be applied: | trees measured in permanent sample plots described in Section 3 |
| Frequency of monitoring/recording: | Every 5 years |
| Value Applied | Variable |
| Monitoring equipment: | Observation |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| 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 Applied | Variable |
| Monitoring equipment: | Observation |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| 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 Applied | Variable |
| Monitoring equipment: | Observation |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| 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 Applied | Default 100m |
| Monitoring equipment: | Tape |

| | |
|---|---|
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | |
| Comments: | |

| **Data/parameter** | $\mathbf{d_{n,i,t}}$ |
|---|---|
| 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.<br><br>Minimum measurement diameter must not be less than 10cm. |
| Frequency of monitoring/recording: | Plot measurements are repeated on 5-year intervals |
| Value Applied | As measured |
| Monitoring equipment: | Caliper, diameter tape |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | |
| Comments: | Used to calculate mass of lying dead wood $DOM_{LDW}$ |

| **Data/parameter** | $\mathbf{N_{i,t}}$ |
|---|---|
| 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 Applied | As measured |
| Monitoring equipment: | Visual observation |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | |
| Comments: | Used to calculate mass of lying dead wood $DOM_{LDW}$ |

| **Data/parameter** | $\mathbf{D_{LDW,c,i,t}}$ |
|---|---|
| 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 Applied | As determined from estimated density class- (1) sound , (2) intermediate and (3) rotten. |

| | |
|---|---|
| Monitoring equipment: | Drying oven, scale |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Mass/Volume |
| 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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Equation 60a |
| Comments: | Used in the calculation of uncertainty factor (Section 4.5) |

| **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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Equation 60c |
| Comments: | Used in the calculation of uncertainty factor (Section 4.5) |

| **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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | Equation 60f |
| Comments: | Used in the calculation of uncertainty factor (Section 4.5) |

| **Data/parameter** | **$ER_{y,ERR,}$** |
|---|---|
| Data unit | % |
| Description: | The uncertainty factor calculated for year 'y' in Section 4.5 |
| 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 Applied | Variable |
| Monitoring equipment: | |
| QA/QC procedures to be applied: | Latest Afognak Standard Operating Procedures (SOP). |
| Calculation method: | As shown in Table 15. |
| Comments: | Used in the calculation of VCUs (Section 4.4) |

## 3.3. Description of the Monitoring Plan

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

Ongoing monitoring is the primary operational task for the project, all aspects of which will be under the project management responsibility of Camco as the Project Proponent Representative.

***Afognak Pre-Validation Monitoring Status:***
As detailed throughout this document (and outlined in more detail in the uncertainty factor calculations in Section 4.5), the Afognak property has a uniform and consistent forest cover with a single species in old growth age classes throughout (with the exception of harvested areas). Roads, stream, terrain, and other base data layers are available within the GIS database to typical Alaska state practices. Therefore, the forest inventory is suitably focused on visual assessment of recently updated digital orthophotos, in combination with a permanent plot network. Additional forest inventory data is available from the appraisal valuation work undertaken in 2006 (full property coverage using a set line transact pattern and variable radius prism plots) that supported the development of the initial appraisal logging plans for the baseline scenario (Forest and Land Management, Inc. , 2008). An additional set of early carbon plots was installed by Winrock in 2002, for which only the summarized data is available. The

detail for this Winrock data is not available, and therefore this data has only been used as supplemental and comparative purposes.

The Afognak properties therefore contain 3 primary stratifications: forest (entirely Sitka spruce old forest types), non-forest (including water, non-forest, and clearly non-productive forest), and non-timber harvesting areas (including anadromous fish stream buffers, eagle nest buffers, and inaccessible timber areas).

The GIS data is all up to date to the most available State of Alaska data, and the orthophotos up to date to 2006.

In 2011 an initial carbon plot network of 22 plots were installed in a random fashion across the property to collect above ground dead and alive biomass and stand age data. These plots provide the core ex-post carbon stock data.

The current gap in the property inventory is a detailed spatial assessment of stand age. Although the entire mature forest is clearly in mature late seral age classes, the plot network did reveal internal variation in maximum and average stand age of 190 (ranging from 115 to 271 years within the plots). This internal stand age variation is currently captured by the uncertainty factor calculations, and further discussed in Section 4.2.

The ongoing Afognak monitoring program may involve the installation of additional permanent sample plots and/or the future collection of detailed stand age classifications in future field seasons as necessary.

### *Afognak Monitoring Program*

Fundamentally, the Afognak project contains 4 monitoring activities, which will be managed by Camco as the Project Proponent Representative, and reported at each verification in a Monitoring Report:

1. **Annual Inventory Change Monitoring**

At a minimum, the project will undertake and document an annual update to the current state of the forest inventory data on the property. This will be undertaken using property aerial observation flight(s) covering the entire project area, in combination with individual ground observations and measurements from specific disturbance events (either field measured using aerial or ground-based GPS, or other remote sensing methods). At minimum, the inventory will be updated for (at a minimum scale of 4ha):

a. Natural disturbance events >4 ha (i.e. fires, high mortality pest and disease areas, blowdown areas, slides, etc.).
b. Any project activities (i.e. road construction/reclamation, reforestation/restoration, etc.)
c. Unplanned man-made disturbances (i.e. non-*de minimis* illegal or unplanned harvests, etc., if applicable)

These monitored spatial elements will be updated in the Afognak GIS database annually according to project SOP's for data collection and handling.

2. **Other Monitoring Requirements of the Project**

Afognak will also document other monitoring requirements of the PDD, including:

a. Activity shifting leakage (annually)
b. Annual market leakage calculations (annually)

Activity shifting leakage risks will be reported during verification by updating the timber harvest levels on other regional ALC/RMEF forest properties in Table 11 – as neither organization has any history of operational activities, it is expected these assessments will remain unchanged. Market leakage calculations will be confirmed at each verification using the baseline scenario harvest levels, and updates for the results of any spatial monitoring findings in the project scenario.

3. **Field plot monitoring**

At minimum, the Afognak project will update the inventory, uncertainty calculations, and carbon calculations from field plot measurement data as outlined in Sections 3.4 and 4.5. The following sections follow the methodology document, and outline the field plot monitoring plan elements:

### *Stratification of Land Area*

The project landbase has undergone a simplified stratification due to the uniform forest cover, as described in Section 4.1. Although not required (due to the error being captured by the uncertainty calculation), the project may choose to refine the stand age stratifications over time.

### *Post-stratification*

The inventory polygons and associated subregions will be updated if necessary following ground-truthing with field plots, or as the result of annual monitoring for natural and man-made disturbances and other inventory updates.

## Type and Number of Sampling Plots:

#### *Plot type*

The Afognak project has installed a permanent fixed and geo-located plot network for monitoring changes in stand level forest biomass stocks over time. Additional permanent plots may be installed over time to refine biomass stock inventory accuracy.

The project may utilize supplemental temporary plots as necessary to provide additional coverage or accuracy refinement in a cost effective manner.

#### *Number of Plots, Precision, and Sample Size*

A current carbon plot network of 22 plots has been installed on the property in 2011. The methodology does not specify a number of plots, with error over the target (10%@90%CI) being accounted for in the uncertainty factor deduction (Section 4.5). The plot data are provided in a file referenced in Appendix 3.

In 2012 the project team will review additional or future carbon inventory data needs, and may install additional permanent sample plots, may enhance detailed spatial stand age data, or undertake other inventory activities to improve the carbon stock inventory accuracy over time.

## Sampling Design

### *Plot Layout*

Permanent plot locations were located using randomly UTM coordinates randomly selected via GIS analysis tools. A total of 150 random plot locations were randomly distributed across the property parcels (limited to the mature spruce analysis unit within the baseline harvest area (see Figure 8) to ensure plot coverage across the property (i.e. a target number of plots was assigned to each parcel by area, then the GIS tools were used to select plots randomly from a randomly generated list of possible UTM locations). A total of 22 plots were sampled during Oct. 2011. The location of the monitoring plots is shown in Figure 2.

### *Size and Shape of Sample Plots*

Permanent plots were installed with a variable circular plot size with lying deadwood transects.

Plot size (radius = 4m, 14m, or 20m) was determined based upon the DBH range of the trees within the plots such that a minimum of 40 trees were measured in each plot. Crews were instructed to establish a plot center and to measure the top height and DBH of each standing stem with a diameter ≥ 5cm. Species and tree condition class (Live, Dead, Snag) were also recorded. 'Dead' indicated recently dead with branches still largely intact while 'Snag' indicated a standing dead stem with significant loss of branches. Crew also made note if a stem had a broken top and the recorded the height at break.

Carbon pools to be calculated from plot measurements:

- Live trees: above ground
- Standing dead trees: above ground
- Lying dead wood

## Measurement and Data Analysis Techniques

The standard operating procedures for field plot installation are available upon request and key elements summarized here to demonstrate consistency with the methodology.

### *Trees*

Tree biomass will be estimated from equations that relate biomass to DBH and/or height. Biomass equations for Sitka spruce developed in British Columbia were selected as applicable to the Afognak properties (Standish, Manning, & Demaerschalk, 1985). These equations were used in conjunction with the DBH and height data measured within the plot network to calculate total aboveground biomass within each plot ($t\ ha^{-1}$).

Aboveground biomass, $B_{AG}$, was measured in each permanent sample plot. Specifically, all living trees within a sample plot with dbh ≥ 5cm was measured including height (m) and diameter (cm) at breast height (1.3m). Belowground biomass ($t\ ha^{-1}$) was calculated using equations in (Li, Kurz, Apps, & Beukema, 2003) (see Appendix 2, equations 5b and 33b, for the baseline and project case, respectively). Tree-level measurements (kg biomass per tree) was converted to area-based stand-level measurements ($t\ ha^{-1}$) and a conversion factor used to convert biomass into carbon.

### *Dead organic matter*

The mass of lying dead wood, $DOM_{LDW}$, was measured in the permanent sampling plots using the line intersect method. Two 50-m sections of line were placed at right angles across the plot center, with the line ends permanently marked with metal stakes. The diameters of all pieces of wood $\geq$ 5 cm diameter that intersect the line are measured and the density class noted.

Each piece of deadwood was assigned to one of three density classes, sound (1), intermediate (2), and rotten (3). The volume per unit area was calculated for each density class using Equations 61a-c described in the VCS methodology document. For transparency, the equation numbers used here are the same as those used in the methodology document.

$$\mathbf{V_{LDW,c} = \pi^2 * [(d_1^2 + d_2^2 \ldots d_n^2)/8L]} \qquad \textbf{(60a)}$$

Where,

$d_1$, $d_2$, $d_n$ = diameter (cm) of each of *n* pieces intersecting the line, and

L = the length of the line (100 m default (Harmon, et al., 1986).

The mass of LDW in density class, *c* (t $ha^{-1}$), is:

$$\mathbf{M_{LDW,c} = V_{LDW,c} * D_{LDW,c}} \qquad \textbf{(60b)}$$

Where,

$V_{LDW,c}$ = the volume per unit area calculated for each density class, *c*, as calculated in 60a.

$D_{LDW,c}$ = the density of LDW in density class, *c* (t d.m. $m^{-3}$)

The total mass of LDW in each plot summed over all density classes (t $ha^{-1}$) is:

$$\mathbf{DOM_{LDW} = \sum M_{LDW,c}} \qquad \textbf{(60c)}$$

Where,

$M_{LDW,c}$ = the mass of LDW in density class, *c* (t $ha^{-1}$), is as calculated in 60b.

Mass of dead wood is calculated as the product of volume per density class and the wood density for that class (as per equations 60 a-c). The density of LDW in the 3 classes was assumed to be 0.43, 0.34, and 0.19 (t/$m^3$), for the sound, intermediate, and rotten classes, respectively. These values are based upon the default values provided in (Pearson, Brown, & Birdsey, 2007).

The total mass of lying dead wood was calculated as the average of all transects. This value was then used for calculations of carbon storage in dead organic matter ($DOM_{LDW,i,t}$).

Standing deadwood was measured according to the SOP as standing dead trees and standing snags.

The biomass of the standing dead trees and snags were calculated and converted to area-based stand-level measurements (t $ha^{-1}$) by summing the total mass (aboveground + belowground) of all the standing dead trees within a sample plot (converting kg to t) and dividing the sum by the plot area in ha. This value is an estimate of the average snag biomass variable ($DOM_{SNAG,i,t}$).

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 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.

Data results will be reported in the project monitoring plan for each verification.

### *QA/QC for Laboratory Measurements*

No laboratory measurements were take for the Afognak sampling, and this section is not applicable.

### *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.

### *QA/QC for Data Archiving*

Afognak has document control procedures which adapted to cover the carbon monitoring data, including retaining the following for 2 years past the duration of the project:

1. Original copies of the field measurement, check plots, and related data summaries will be maintained in their original and electronic form
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.
3. Records of the version and relevant change history of software or data storage media changed between monitoring periods.

### *Frequency of monitoring*

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.

### *Use of monitoring data to update carbon stock calculations*

Data gathered through the monitoring process will be used to:

1. Update the project inventory data and related modeling and monitoring stratification as per Section 3.4;
2. update the leakage calculations in Section 4.3;
3. update error estimates used in the calculation of the uncertainty factor as per Section 4.5; and,
4. Update and improve calculations of carbon stocks in Section 4.2 and possibly Section 4.1 as described in Sections 3.4 and 4.2.

### *Updating of Inventory*

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.

## 3.4. Ex-Post Calculations of Carbon Stocks

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 4.1) 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.

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

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 4.1. 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).

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

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

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*

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

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.

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

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).

### *Updating the Modeled Project Carbon Balance*

The precision of the modeled carbon stocks will be evaluated for each analysis unit using the method described for determining mean model error in 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 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 (Section 4.1).

# 4. Ex-Ante Calculation of GHG Emission Reductions and Removals:

## 4.1. Baseline Emissions

### Baseline Scenario Overview:

The baseline scenario is projection of a continuation of the previous owners logging practices across the project area over a 10-year timeframe. Technical data and details of the scenario modeling are described below..

Harvesting Operations - evidence of current and recent historical operational practices is available on the project properties, and on adjacent lands, including a 2009/2010 harvest adjoining the south boundary of the Delphin Point properties. Operations include a combination of ground-based mechanical and chainsaw activities (i.e. feller-bunchers, hoe-chucking, processor delimbing, and chainsaws where necessary). There is little evidence of observable in-cutblock log waste or unusual log defect bucking at the stump. Slash is usually spread at roadside, or occasionally piled and burned.

Inspection of new and older harvest areas, and areas visible from aerial flights and boat-based vantage points make it is clear that operators across Afognak follow the minimum legal requirements of the AK FRPA. There is little evidence of additional merchantable tree retention, aesthetic or shoreline buffers, or any other specific forest retention – operations are basic and remove all accessible and merchantable timber. The mature old growth forest types have limited understory, and advanced regeneration is limited, resulting in a very "clean" clear-cut overall.

Roads and Transportation – the current road network is well across the region and within for already harvested property areas. Roads are simple with narrow rights-of-way, built to a minimum level of construction. However, high quality on-site borrow gravel materials have resulted in an excellent all weather road system. Logs in the scenario are hauled about 26 miles (42km) south to existing sort yards/booming facilities. Logs are then shipped via bulk carrier to Asia.

Silviculture – silvicultural operations are limited to leaving for natural regeneration. There is no evidence or history of scarification, planting, or any additional silvicultural activities to ensure establishment, survival or free-to-grow conditions. Existing cutover areas on the Shuyak property were observed to be undergoing significant regeneration problems, with patchy Sitka spruce reestablishment and intense 1-2 meter tall, very dense brush competition. It is very likely these cutblocks will experience long (10-40 year) regeneration delays across a significant percentage of the area.

These observed practices are well supported by the acquisition appraisal documents, wherein foresters experienced across Alaska coastal forestry describe the same scenario as the most likely profit maximizing approach for valuation purposes (Forest and Land Management, Inc. , 2008). These appraisal documents also projected a relatively conservative, harvest plan spatially across the Shuyak and Uganik properties. Groundwork by the project team confirms that these harvest plans are a comprehensive and a reliable representation of the likely harvesting practices. Areas identified as projected for harvesting were consistently merchantable timber and clearly operable. Areas identified (in Uganik in particular) as unharvestable possessed steep terrain or contained only isolated patches of timber that may have been difficult to access.

Baseline Scenario Summary – The project used the appraisal harvesting plans from the Shuyak and Uganik properties as a reasonable representation of the previous operators intentions and practices, and the spatial model for harvesting in the baseline scenario. A similar harvest plan was used for the Waterfall, Paul's and Laura Lakes parcels where appraisal harvest plans were not available. Field reconnaissance of these areas by the project team suggested that these properties were very similar to the Shuyak property in terrain (perhaps with better timber), and contained few physical limitations to ground based harvesting operations across these properties. Spatial and non-spatial deductions were made to account for legal requirements and other known and unknown features within the timber harvesting landbase. Additional timber deductions were included in the baseline scenario to account for the possibility that the highest amenity sites near the lakes or ocean shores would be reserved for limited remote residential development in the baseline scenario. Silviculture was modeled based on natural regeneration, with a conservative regeneration delay included to reflect the observed regeneration issues.

Baseline Activities Timeframe – baseline scenario harvesting is projected to occur over a 10-year timeframe. It is assumed that the previous owners would have targeted a compressed harvest schedule to mitigate the high remote operational, mobilization, and log shipping costs. To be conservative, it was assumed that there was an initial 2-year planning delay before the harvesting plan was implemented (i.e. the project start date was 2006, the baseline scenario harvesting begins in 2008). The 10-year timeline was based on an original timber rights agreement that the previous owners held on the initial transactions. This equates to a harvest of less than 200 ha per year for 10 years over the period of 2006-2018. The balance of the project time is assumed to have no additional operations.

Future Carbon Sequestration in the Baseline – the project has taken an additional step to to ensure the 100-year carbon balance for the project case is never less than the corresponding balance in the baseline, by accounting for future sequestration in regrowing stands in the baseline scenario past the end of the project period (to 100 years) and capping the total claimed VCU's. This is not a requirement of VCS nor is it specified bythe methodology, but was included as an additional conservative measure. The result is a reduciton in the number of emission reductions claimed by the project.

Further details and technical specifications are outlined in detail in the following sections.

## Baseline Scenario Modeling and Technical Details:

The Afognak project meets the Valid Starting Inventory Requirements from the methodology (*methodology criteria in italics*):

1. *Pertaining directly to the entire project area; and,*

The Afognak inventory data covers the entire project area, and meets this criterion.

2. *Created, updated, or validated <10 years ago; and,*

The key inventory elements are the digital orthophotos, updated in 2006, and the carbon plot network, installed in 2011. Spatial stratification updates for forest/non-forest and baseline related assumptions were made in 2011/2012. The forested area consists only of Sitka spruce. The inventory meets this criterion.

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

The base inventory is created from standard data sources (i.e. aerial orthophotos). The PSP sampling procedures are fully described in the monitoring program and related SOPs. Additional descriptions of spatial GIS data handling and updates are available from 3GreenTree. These steps meet this criterion.

## Baseline Scenario Area Stratification

#### 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 the PDD 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 and given a 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 10. A map of the spatial distribution of the analysis units at project initiation is shown in Figure 7.

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 6. The assumptions in Table 6 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. Further descriptions are provided in the following text. 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 is 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 Figure 9).

**Table 6 - 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

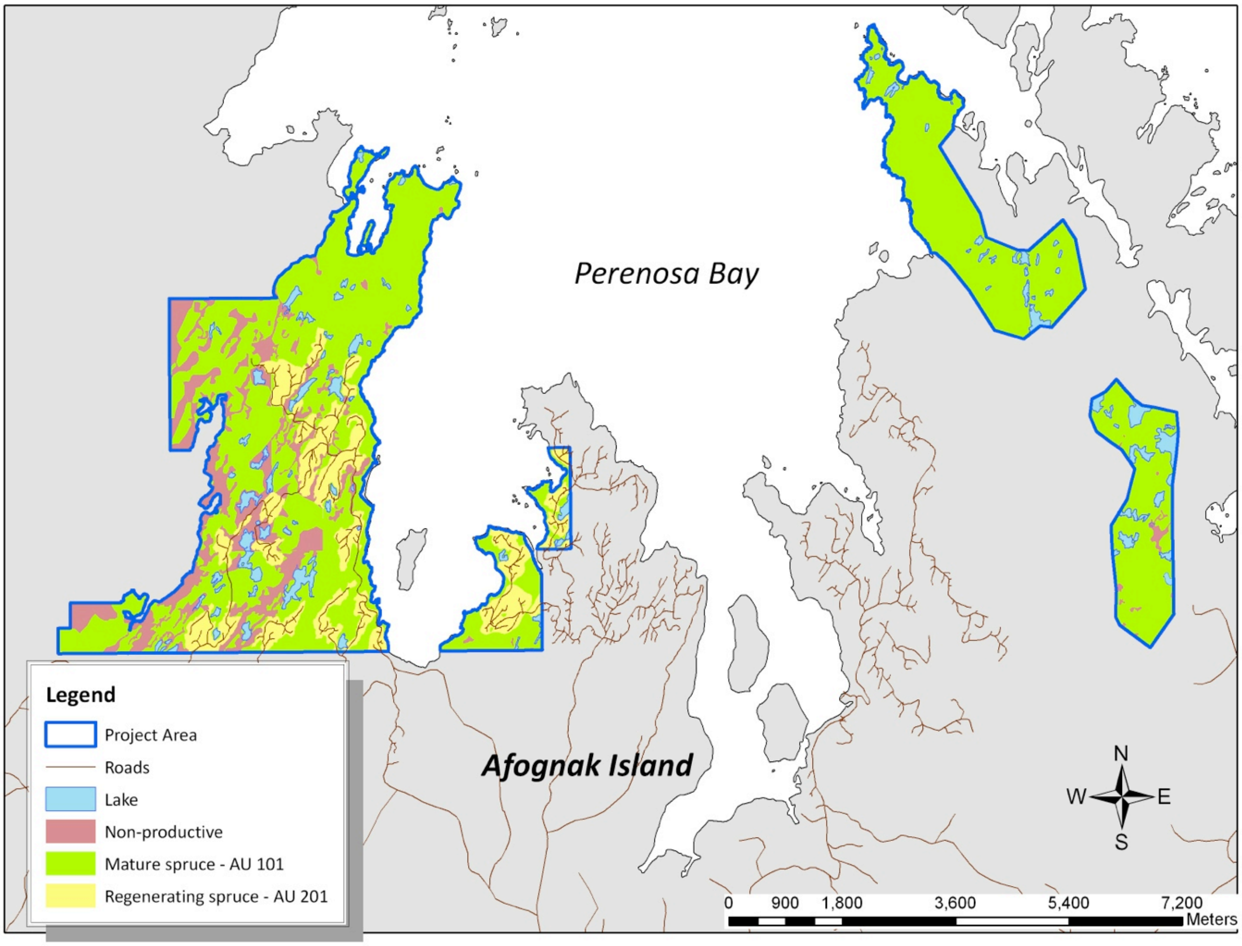



Figure 7. A map of the Afognak property showing the spatial distribution of analysis units at project initiation.

### 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 hydroriparian 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 7 and Figure 8. 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 7. 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.

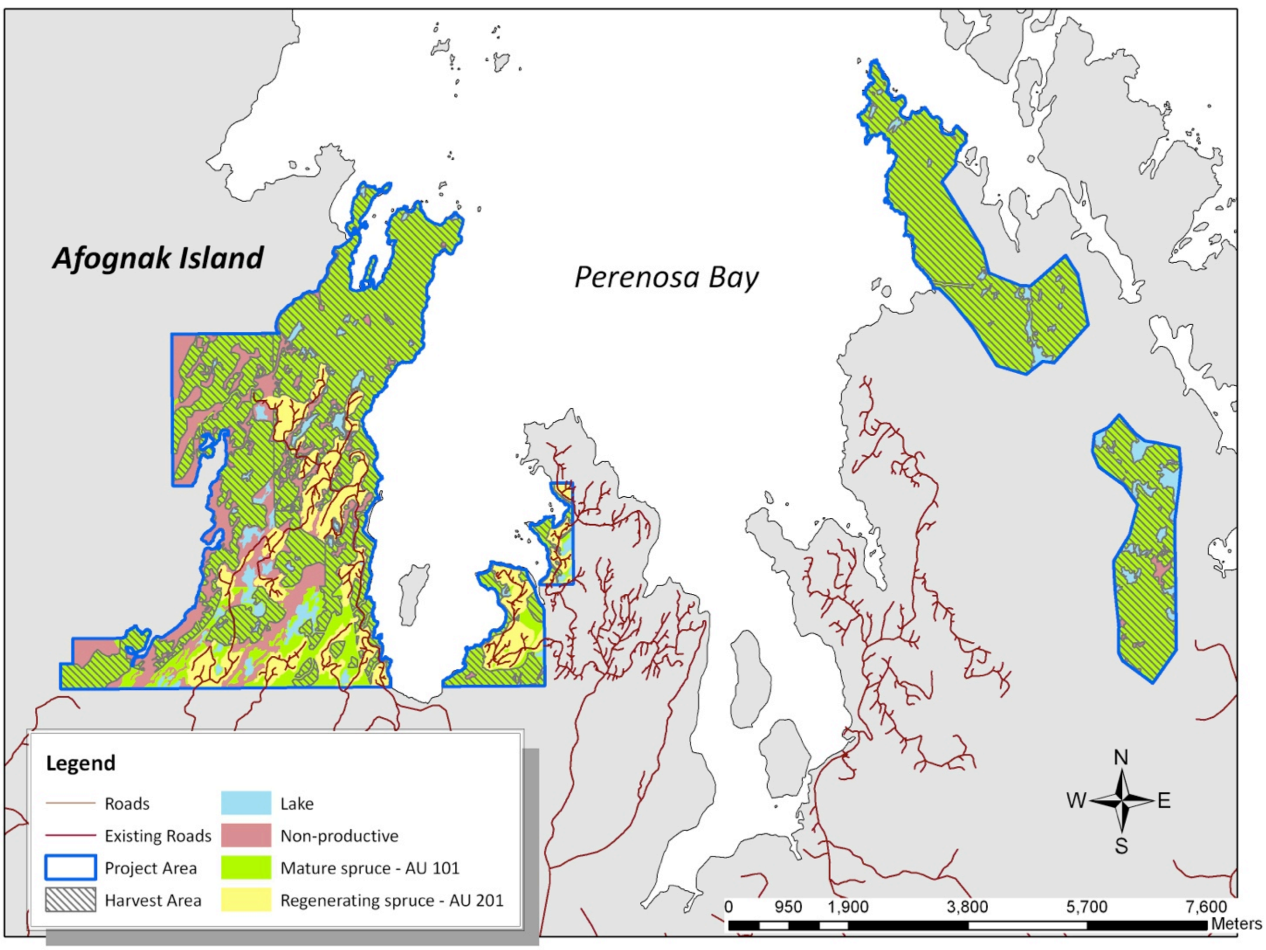



**Figure 8. The Afognak project area showing the potential harvest area for the baseline scenario.**

## 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 (Afognak Carbon Model v.1.2, as referenced in Appendix 3).

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.

## 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 (further details below). The stand-level output from FORECAST was linked to the Landscape Summary Tool using a shared database library 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 5-year time steps. These 5-year timesteps were converted to annual amounts by dividing results for each time step by 5. Figure 9 provides an overview of the model linkages and their relationship to input sources and output data.

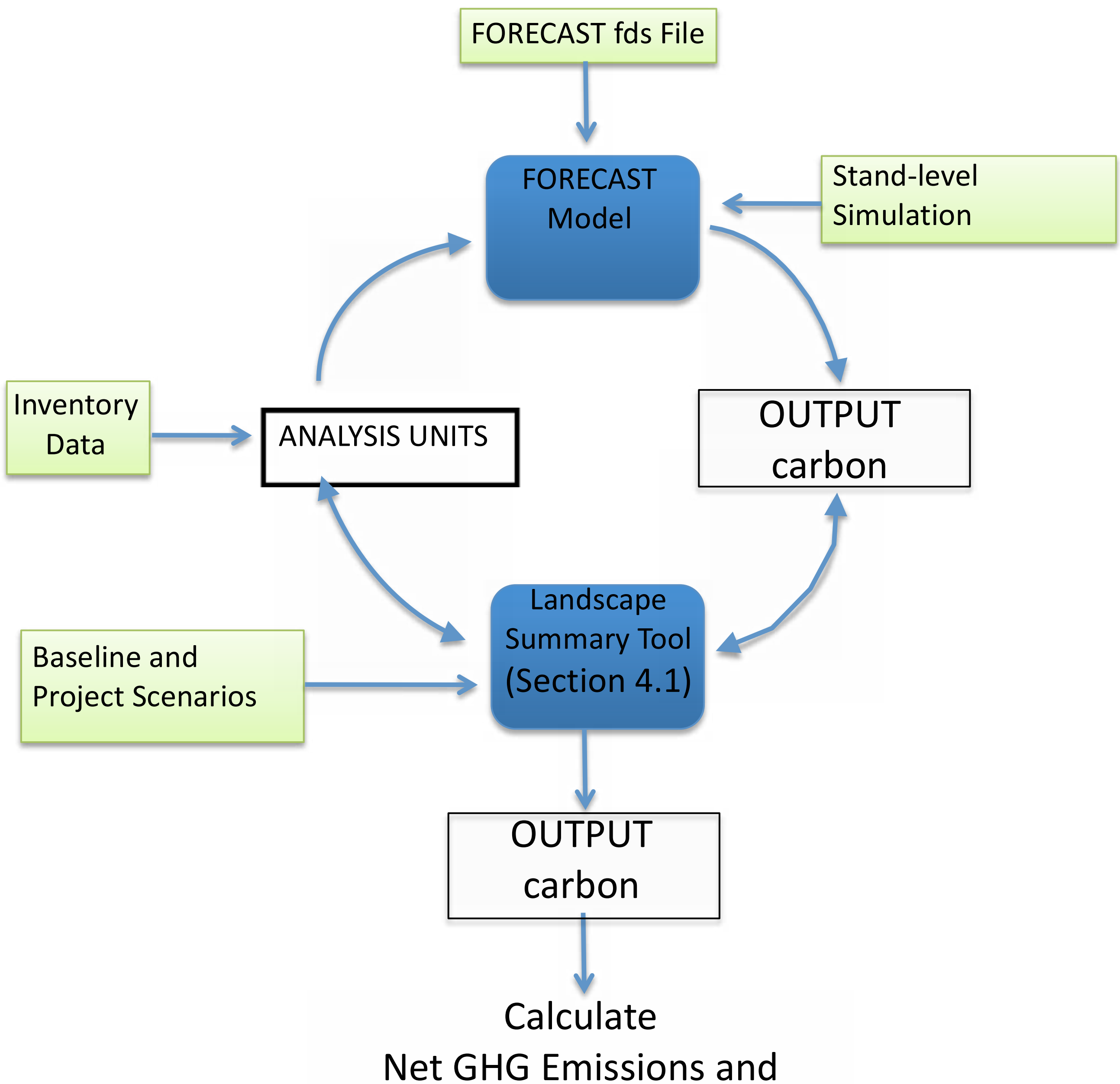



**Figure 9 - Model Interaction, input sources (green boxes) and outputs.**

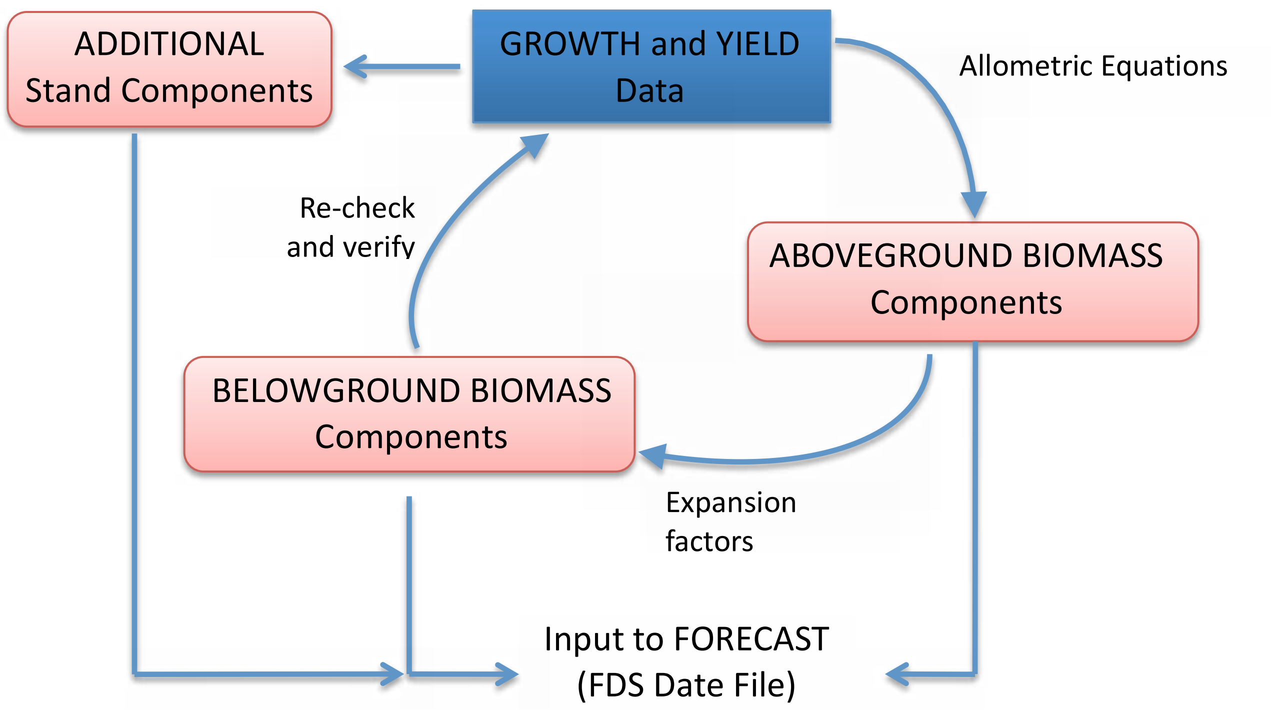



**Figure 10 - Creating the calibration data set for FORECAST simulations (as input into an fds file)[4].**

### *Stand-Level Calculations of Carbon Storage Using FORECAST*

FORECAST is a management-oriented, stand-level forest ecosystem dynamics simulator. It was constructed using a hybrid modeling approach whereby the rates of ecological processes are calculated from a combination of historical bioassay data (biomass accumulation in component pools, stand density, etc.) and calculated measures of specific ecosystem variables (decomposition rates, foliar N efficiency, nutrient uptake demand, for example). This is achieved by relating 'biologically active' biomass components (foliage and small roots) to calculations of nutrient uptake, the capture of light energy, and net primary production (see (Seely, Kimmins, Welham, & Scoullar, 1999); (Kimmins, Mailly, & Seely, 1999)). Since FORECAST is a biomass-based model, its core simulations routines reflect the accumulation and decay of all the principal biomass pools within a forest ecosystem, including foliage, branches, stemwood, bark, coarse and fine roots, and the various pools of dead organic matter (litter, snags & logs). As such it is well suited to carbon budget assessments (see, for example, (Seely, Welham, & Kimmins, 2002). Further detailed information on FORECAST, its structure and simulation algorithms, and application can also be found at www.forestry.ubc.ca/ecomodels/moddev/forecast/forecast.htm.

[4] Data derived from approved growth and yield models are used in conjunction with allometric volume equations and expansion factors to generate biomass estimates for living organic matter pools. Typically, growth and yield output provides information on stand characteristics (tree density, for example) that are also used as input to the fds file.

FORECAST has been subject to on-going development and testing for over 3 decades and its application documented in almost 40 refereed publications. The model has been applied in many parts of Canada, Europe (Norway, Spain, and the UK), China, and Cuba. The British Columbia Ministry of Forests has approved it in British Columbia as a model for carbon budget assessments.

FORECAST has been calibrated with a dataset that reflects the autecology and vegetation dynamics of Sitka spruce *(Picea sitchensis)*,the tree species that dominates the project area.

Assembling a calibration dataset for FORECAST typically begins with a set of growth and yield curves that predict volume accumulation over time for stands of varying site quality. In the case of the Afognak project, these curves were derived from the approved BC Ministry of Forests and Range models, VDYP (available at www.for.gov.bc.ca/hts/vdyp/) and TIPSY (www.for.gov.bc.ca/hre/gymodels/tipsy/index.htm). Although these Sitka spruce growth data were derived from coastal British Columbia, they are expected to be similar to growth rates for the Afognak area once site index is determined. Site index for the Afognak mature spruce was determined based upon the plot data collected during the field work conducted in 2011. The curves were first converted into their aboveground biomass equivalents through a series of allometric equations (for example, (Standish, Manning, & Demaerschalk, 1985)). An example of this exercise is provided in the file TIPSY Ss 12 output with Standish equations.xls. Next, belowground data was derived using biomass expansion factors, an example of which is provided in the file FORECAST calibration data example.xls. Additional calibration data associated with population dynamics were derived from the growth and yield models and also entered into the calibration data set. Figure 10 provides and overview of the calibration process. An example of the calibration dataset for sitka spruce, and used in the Afognak project is referenced in Appendix 3. Simulated biomass output from FORECAST is converted to its carbon equivalent using a simple multiplier (0.5; see Appendix 2). An example of FORECAST output (expressed in terms of carbon units) is contained in the file FORECAST output example.xls; referenced in Appendix 3.

### *Simulation of Landscape-Scale Carbon Storage Using The Landscape Summary Tool*

The Landscape Summary Tool is a relatively simple landscape-scale calculator designed in Microsoft Excel to facilitate the calculation of landscape scale carbon storage for a specific area and time period (See Appendix 3). It works by dividing the whole project area into discrete sub-regions with homogenous forest cover and management condtions and projecting the carbon storage in those areas for a set time period (5-year time steps) by aging the discrete areas each time-step and updating the landscape-level storage totals. The discrete sub-regions from the model are determined using pivot table functions to calculate the total area of each using the polygon-level data from the inventory data stored in the GIS. Once the areas have been determined, the appropriate analysis unit is assigned to each and stand-level output data is linked to the areas and time periods using a look-up function (Figure 9). The stand-level attribute tables (produced by FORECAST) contain information describing merchantable volume ($m^3$ $ha^{-1}$) and carbon storage within each ecosystem pool (t $ha^{-1}$) for annual time steps from age 1 to 300 years (see Appendix 3). The fact that the project area is relatively small and homogenous allows for the use of a relatively simple modeling tool such as the Landscape Summary Tool.

## Description of the Baseline Scenario Modeling

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 8.

**Table 8 - 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 case** | None | 0 | n/a |

Both the baseline and project scenarios in the Landscape Summary Tool were calculated with 5-year time steps for a total of 100 years. The annual rate of harvest was assumed to be constant during the first two 5-yr simulation steps and from there on.

## Baseline Scenario GHG Emissions Calculation Summary

Total GHG emissions for the selected Baseline Scenario described in Section 2.4 were calculated using a suite of carbon accounting tools. The pools included in the accounting are described in Section 2.3. The basic equations employed for emissions accounting are based on the IPCC gain-loss method (IPCC, 2006b).

The FORECAST model (v8.5) and the Landscape Summary Tool were used in combination with the updated spatial forest inventory data to calculate and track annual changes in both the biomass ($\Delta C_{BSL,LB,t}$) and dead organic matter pools ($\Delta C_{BSL,DOM,t}$) for the baseline scenario. Changes in storage in harvested wood products ($\Delta C_{BSl,HWP,t}$) and summarizing net carbon balances and buffer discounts were determined using the Afognak Carbon Model Microsoft Excel spreadsheet referenced in Appendix 3, using harvested wood volume data for the baseline scenario from the Landscape Summary Tool.

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

$$\Delta \boldsymbol{C}_{BSL,t} = \Delta \boldsymbol{C}_{BSL,P,t} \qquad (1)$$

*where:*

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

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

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

*where:*

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

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

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

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

$$\Delta \boldsymbol{C}_{BSL,LB,t} = \Delta \boldsymbol{C}_{BSL,G,t} - \Delta \boldsymbol{C}_{BSL,i,t} \qquad (3)$$

*where:*

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

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

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

$$\Delta \boldsymbol{C}_{BSL,DOM,t} = \Delta \boldsymbol{C}_{BSL,LDW,t} + \Delta \boldsymbol{C}_{BSL,SNAG,t} + \Delta \boldsymbol{C}_{BSL,DBG,t} \qquad (10)$$

*where:*

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

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

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

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

$$\Delta \boldsymbol{C}_{BSl,HWP,t} = \Delta \boldsymbol{C}_{BSL,PERMHWP1,t} + \Delta \boldsymbol{C}_{BSL,PERMHWP2,t} - \Delta \boldsymbol{C}_{BSL,EMITFOSSIL,t}, \quad \text{(18)}$$

*where:*

$\Delta C_{BSL,PERMHWP1,t}$ = *the annual harvested carbon that remains in permanent storage after conversion to wood products during primary processing (t C yr$^{-1}$)*

$\Delta C_{BSL,PERMHWP2,t}$ = *carbon that remains in permanent storage after accounting for secondary processing of the residue carbon (biomass) generated from primary processing (t C yr$^{-1}$)*

$\Delta C_{BSL,EMITFOSSIL,t}$ = *fossil fuel emissions from harvesting (logging and log transport) and processing of the various wood products.*

Equations for the derivation of the remaining variables, and a further discussion of the relationship of the models to equations 1 to 27 can be seen in Appendix 2.

### Results from the Baseline Scenario Analysis

Results for the baseline scenario carbon calculations are shown in: annual harvest volumes (Table 9); growing stock volume (Figure 12); net ecosystem carbon storage for the selected carbon pools (Figure 13); wood products, manufacturing wastes and logging emissions (Table 10); and net baseline scenario emissions (Table 13).

Total emissions including changes in net ecosystem carbon storage as well as net storage and emissions associated with the harvesting and production of wood products for the baseline scenario are presented in Table 13 (calculated in the Afognak Carbon Model).

## 4.2. Project Emissions

### Project Scenario Overview:

The project scenario is natural forest conservation in a protected forest, and hence has no non-diminimus emissions related to project activities.  Therefore, the project scenario simply includes the projected growth and yield of the existing mature and harvested stands over the project duration.

Further details related to the modeling within the project scenario can be found in the sections below.

## Project Scenario Modeling and Technical Details:

## Project Scenario Area Stratification

**STEP 1 – Stratify to create homogeneous units**

The same Afognak inventory data and stratification methods were used for the project scenario as described for the baseline scenario in Section 4.1. The analysis units described in Table 6 were also employed for the project scenario.

**STEP 2 – Identify areas eligible for specific management activities**

There were no specific management activities simulated for the project scenario as it represents conservation only.

## Description of the Project Scenario Modeling

As in the baseline scenario, the stand-level model FORECAST was used to model all ecosystem carbon flows by analysis unit, and the Landscape Summary Tool was used to calculate carbon storage in the selected ecosystem pools for each 5-year time step during the 100-year simulation period. There was no harvesting simulated in the project scenario.

## Determining Actual Ex-Post Onsite Carbon Stocks

The monitoring report will detail the data and calculations for ex-post onsite carbon stocks at the time of verification. However, as the project start date (2006) is prior to validation, the PDD has included the following summary of spatial inventory monitoring updates made prior to Jan. 2012. The GIS inventory database is updated to the end of 2011. Following steps from the methodology:

1) *Incorporating any new forest inventory data (including data from new or re-measured sampling plots and other monitored data, as outlined in Section 13 and 14) obtained during the previous year into the inventory estimate.*

The spatial inventory data was initially prepared during the forest land appraisal (Forest and Land Management, Inc. , 2008) and updated 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 (Section 4.1). 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 |

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

During the fieldwork activity the project area was partially reviewed on the ground during plot work, and was flown from a fixed wing aircraft to look for recent disturbances that would not have been present on the 2006 orthophotos. A new road segment was detected in the west Uganik parcel that had been recently constructed to link two existing road networks by the State of Alaska as part of a road and access management plan that was consolidating the road system and putting some roads to bed. This new section was mapped using a hand-held GPS and added to the inventory. A 5m buffer was created on either side of the road and the road area was reclassified as non-productive road.

3) *Using the selected model(s) to project prior-year data from the forest inventory to the current reporting year (as described in Section 9.3).*

The carbon accounting tools described in Section 4.1 were applied using the updated inventory to project forward prior-year data from forest inventory to the current reporting year.

4) *Comparing estimates of live biomass and dead organic matter in subregions and calculated from monitoring activities (Section 13 and 14) against current-year modeled values in the project scenario (see Section 9.2.2).*

Data from the monitoring plot sampling conducted in the fall of 2011 were used to evaluate output from the FORECAST model. The complete plot data are referenced in Appendix 3. A comparison of model output for total aboveground biomass and net ecosystem carbon (above and below-ground live biomass, dead below-ground biomass, snags, and lying deadwood) is shown in Figure 11. The model shows a good fit with field data.

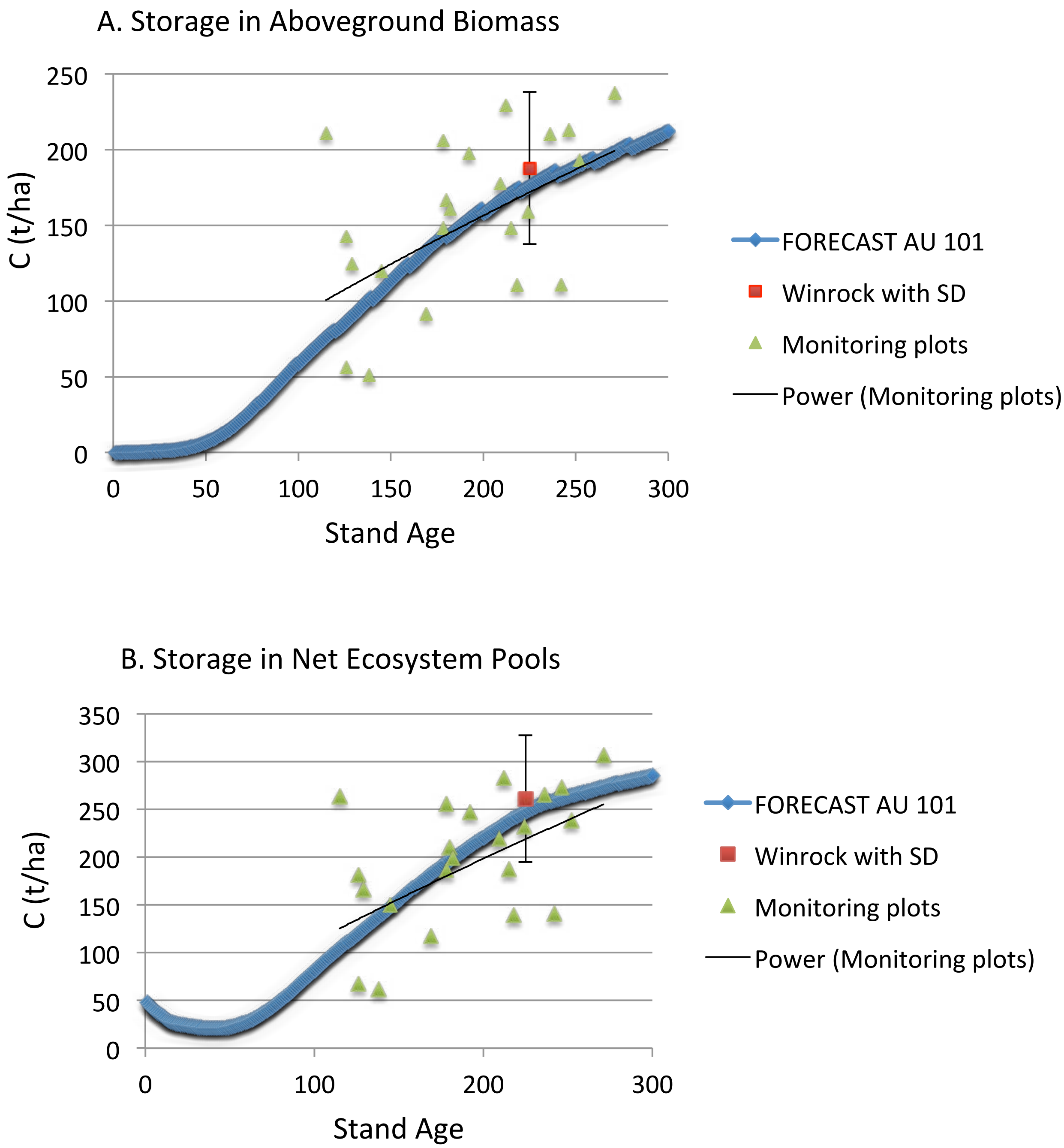



**Figure 11. A comparison of FORECAST output for AU 101 against data from the field monitoring plots. Data are shown for A) aboveground biomass, and B) net ecosystem pools (total live biomass, dead root biomass, and dead wood). The average value from the Winrock carbon plots (established in 2002) are shown as well as power-function regression fit for the monitoring plot data.**

5) *Making calibration adjustments to models and/or parameters such that the fit between the equivalent modeled and measured variables meets targets (as per Section 9.2.2).*

A comparison of FORECAST output for net ecosystem C to the field data using the average age of the field plots (190 years) for a comparison showed that the model was slightly higher than the field data. It appears from field observations that some of the lower values among the sampled plots were due to canopy gaps related to small areas of unmappable non-productive land within the plots. To correct for this unmappable non-productive area, a correction factor of (0.96 -- 4% non productive area) was applied to FORECAST carbon output for all analysis units.

6) *If any changes are made to the model assumptions or parameters used in Section 9, the calculation of baseline emissions (from the current date forward) must be redone using the updated model(s) and parameter sets.*

The projected ex-ante calculations of the baseline and project scenarios include the most up to date inventory data and model parameter sets (including the adjustment described in the previous step.

7) *Calculate the error terms for use in determining the uncertainty factor (Section 11.4).*
   The uncertainty factor was calculated using the adjusted FORECAST output for AU 101 and data from the 22 monitoring plots (see Section 4.5)

## Project Scenario GHG Emissions Calculation Summary

The FORECAST model (v8.5) and the Landscape Summary Tool were used in combination with the updated spatial forest inventory data to calculate and track annual changes in both the biomass ($\Delta C_{PRJ,LB,t}$) and dead organic matter pools ($\Delta C_{PRJ,DOM,t}$) for the project scenario. Changes in storage in harvested wood products ($\Delta C_{PRJ,HWP,t}$) and summarizing net carbon balances were determined using the Afognak Carbon Model Microsoft Excel spreadsheet referenced in Appendix 3, using harvested wood volume and carbon pool output data for the project scenario from the Landscape Summary Tool.

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

$$\Delta C_{PRJ,t} = \Delta C_{PRJ,P,t} \quad (29)$$

*where:*

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

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

$$\Delta C_{PRJ,P,t} = \Delta C_{PRJ,LB,t} + \Delta C_{PRJ,DOM,t} + \Delta C_{PRJ,HWP,t} \quad (30)$$

*where:*

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

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

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

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

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

*where:*

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

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

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

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

*where:*

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

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

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

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

$$\Delta C_{PRJ,HWP,t} = \Delta C_{PRJ,PERMHWP1,t} + \Delta C_{PRJ,PERMHWP2,t} - \Delta C_{PRJ,EMITFOSSIL,t} \quad (46)$$

*where:*

*$\Delta C_{PRJ,PERMHWP1,t}$ = the annual harvested carbon that remains in permanent storage after conversion to wood products during primary processing (t C $yr^{-1}$)*

*$\Delta C_{PRJ,PERMHWP2,t}$ = carbon that remains in permanent storage after accounting for secondary processing of the residue carbon (biomass) generated from primary processing (t C $yr^{-1}$)*

*$\Delta C_{PRJ,EMITFOSSIL,t}$ = fossil fuel emissions from harvesting (logging and log transport) and processing of the various wood products.*

Equations for the derivation of the remaining variables, and a further discussion of the relationship of the models to equations 29 to 55 can be seen in Appendix 2.

## Results from the Project Scenario Analysis

Results for the project scenario carbon calculations are shown in: annual harvest volumes (Table 9); growing stock volume (Figure 12); net ecosystem carbon storage for the selected carbon pools (Figure 13); wood products, manufacturing wastes and logging emissions (Table 10); and net project scenario emissions (Table 13).

Total emissions including changes in net ecosystem carbon storage as well as net storage and emissions associated with the harvesting and production of wood products for the project scenario are presented in Table 13.

**Table 9- Projected Harvest Area and Volume by Scenario (Year 1 = 2008). Data derived from the Landscape Summary Tool (referenced in Appendix 3).**

| Year | Baseline | | Project | |
|---|---|---|---|---|
| | Harvest Volume ($m^3$) | Harvest Area (ha) | Harvest Volume ($m^3$) | Harvest Area (ha) |
| 1 | 95,806 | 196.8 | 0 | 0 |
| 2 | 95,806 | 196.8 | 0 | 0 |
| 3 | 95,806 | 196.8 | 0 | 0 |
| 4 | 95,806 | 196.8 | 0 | 0 |
| 5 | 95,806 | 196.8 | 0 | 0 |
| 6 | 96,373 | 196.8 | 0 | 0 |
| 7 | 96,373 | 196.8 | 0 | 0 |
| 8 | 96,373 | 196.8 | 0 | 0 |
| 9 | 96,373 | 196.8 | 0 | 0 |
| 10 | 96,373 | 196.8 | 0 | 0 |
| 11 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 | 0 |

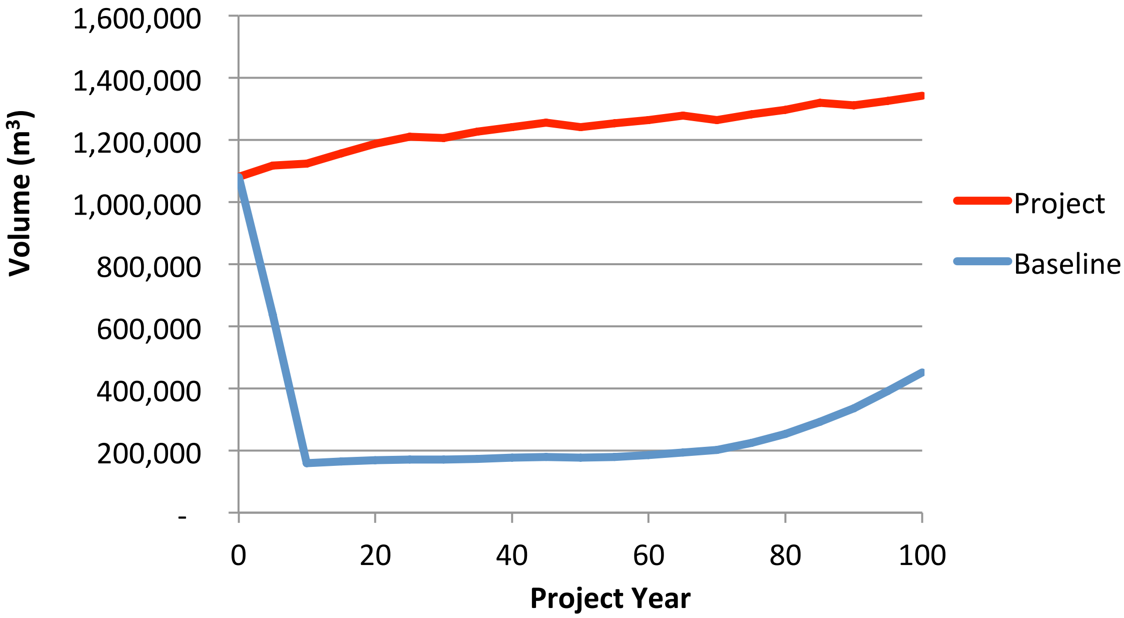



Figure 12 - 100-year growing stock projection by scenario (Year 1 = 2008).

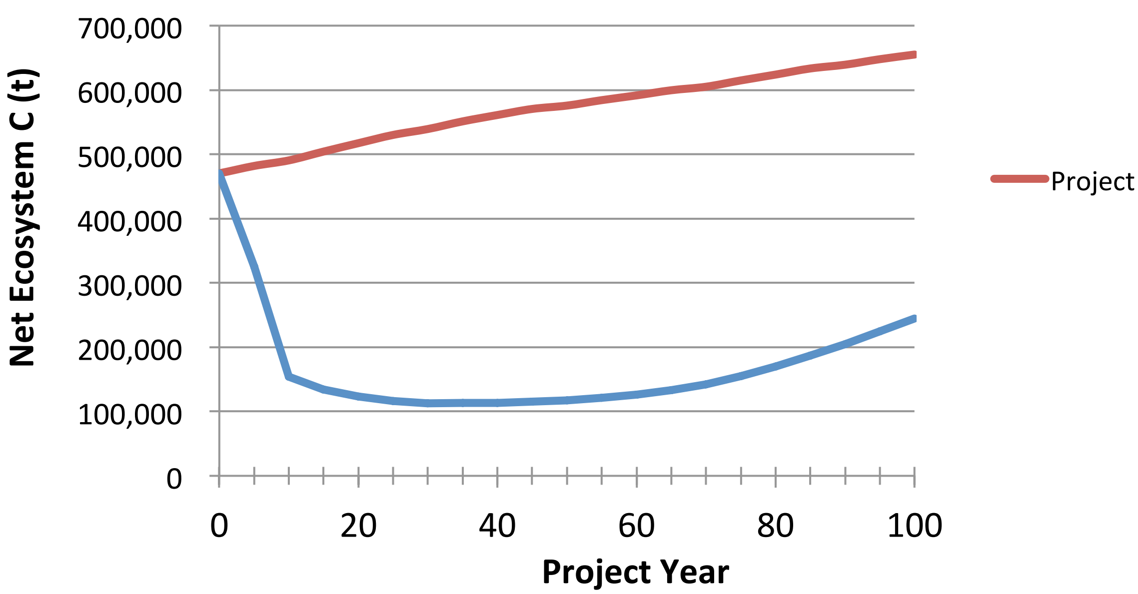



Figure 13 - Net Ecosystem Carbon Storage (Biomass + Deadwood + Belowground dead biomass) by Scenario (year 1 = 2008).

**Table 10 - Calculated HWP, Manufacturing Wastes, and Equipment Emissions (Year 1 = 2008). Source: Afognak Carbon Model; worksheet: Summary Tables and Figures**

| | Baseline | | | Project | | |
|---|---|---|---|---|---|---|
| | **Storage** HWP | **Storage** Waste Products | **Emissions** Equipment & Production | **Storage** HWP | **Storage** Waste Products | **Emissions** Equipment & Production |
| Year | (tC) | (tC) | (tC) | (tC) | (tC) | (tC) |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 6,110 | 1,968 | (9,162) | 0 | 0 | 0 |
| 10 | 6,146 | 1,980 | (9,216) | 0 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 |
| 45 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 |
| 55 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 |
| 65 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 |
| 75 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 |
| 85 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | 0 | 0 | 0 | 0 |
| 95 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | **12,255** | **3,948** | **(18,378)** | **0** | **0** | **0** |

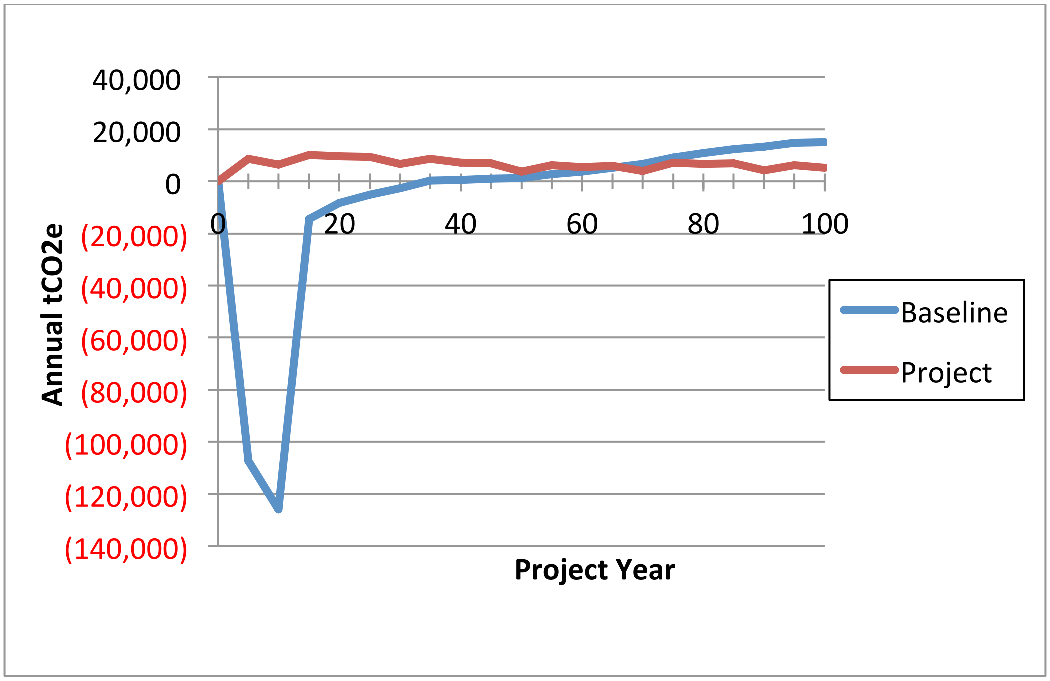



**Figure 14 - Net Annual Emissions/Sequestration Projection for the Baseline and Project Scenarios (Year 1 = 2008). Negative values indicate emissions and positive values indicated sequestration.**

## 4.3. Leakage

### *Activity Shifting Leakage*

ANC/RMEF have acquired properties and certain rights (i.e. easements or covenants) that are managed to achieve conservation objectives across the U.S. Both organizations either have, or may in the future, undertake timber harvesting activities on other properties to achieve conservation management objectives, however both organizations are mission-driven not-for-profit conservation organizations that do not undertake for-profit commercial harvesting (Email communication, Jan. 12, 2012. Kerry O'Toole, American Land Conservancy and Blake Henning, Rocky Mountain Elk Foundation). Additional details on other properties, programs, and non-for-profit mission can be found at: http://www.alcnet.org/about/mission and http://www.rmef.org/AboutUs. Camco is a carbon development and trading company and does not hold or manage forest properties or rights (Personal Communication, January 12, 2012, Charles Purshouse, Camco). Therefore there is no risk of activity shifting of commercial timber operations between currently or potentially operating project proponent properties (because there are none).

More specifically, neither ANC/RMEF have not undertaken any material level of commercial timber harvesting on any owned or managed property outside Afognak for the period 2006 to 2012[5], and therefore there is no risk of starting activity shifting risk.

---

[5] Note that RMEF has undertaken juniper chipping/grinding operations on a property in the US SW, however, no commercial timber production was included.

**Table 11 – ANC and/or RMEF Logging Activity on Other Properties (activity shifting risk)**

| Property | Year | Logging Volume ($m^3$) | Activity shifting evidence/comment |
|---|---|---|---|
| All properties outside Afognak | 2006 | 0.0 | n/a – no harvest |
| All properties outside Afognak | 2007 | 0.0 | n/a – no harvest |
| All properties outside Afognak | 2008 | 0.0 | n/a – no harvest |
| All properties outside Afognak | 2009 | 0.0 | n/a – no harvest |
| All properties outside Afognak | 2010 | 0.0 | n/a – no harvest |
| All properties outside Afognak | 2011 | 0.0 | n/a – no harvest |
| All properties outside Afognak | 2012 | 0.0 | Projected: no harvest activities |

### *Market Leakage*

The methodology provides 3 options for market leakage. The Afognak property has selected Market Leakage Option 2 – using the CAR market leakage formula (Figure 15). This method is derived from CAR forestry protocol, which is developed specifically for the North American market context, appears to rationally represent the potential change in market supply of logs, and is widely accepted in the largest set of forest carbon projects in this market region.

Forest Project Protocol — Version 3.2, August 2010

### 6.2.6 Quantifying Secondary Effects

For Improved Forest Management Projects, significant Secondary Effects can occur if a project reduces harvesting in the Project Area, resulting in an increase in harvesting on other properties. Changes in energy-related emissions, which could result from a Forest Project causing consumers of forest products to increase or decrease their use of alternative materials, are not accounted for because it is assumed that energy sector emissions will be capped in the relatively near future under a regulatory cap-and-trade system.

Equation 6.10 must be used to estimate Secondary Effects for Improved Forest Management Projects.

**Equation 6.10.** Secondary Effects Emissions

$$If \sum_{n=1}^{y-1}(AC_{hv,n} - BC_{hv,n}) > 0, then\ SE_y = 0$$

$$If \sum_{n=1}^{y-1}(AC_{hv,n} - BC_{hv,n}) < 0, then\ SE_y = (AC_{hv,y} - BC_{hv,y}) \times 20\%$$

*Where,*

| | | |
|---|---|---|
| $SE_y$ | = | Estimated annual Secondary Effects (used in Equation 6.1) |
| $AC_{hv,n}$ | = | Actual amount of onsite carbon harvested in reporting period n (prior to delivery to a mill), expressed in $CO_2$-equivalent tonnes |
| $BC_{hv,n}$ | = | Estimated average baseline amount of onsite carbon harvested in reporting period n (prior to delivery to a mill), expressed in $CO_2$-equivalent tonnes, as determined in Step 1 of Section 6.2.3 |
| y | = | The current year or reporting period |

**Figure 15 - Selected Market Leakage Method - CAR Forestry Protocol v.3.2 Market Leakage Process**

For the Afognak project, the calculations for the Option 2 Leakage were derived from output annual timber harvest volume data from the Forecast modeling (Table 10), and the leakage for each year ($LE_y$) was calculated as the annual net change in harvest volume between the baseline and project scenario (i.e. zero), in $tCO_2e$, multiplied by 20% (as per Figure 2 in the methodology and the related calculations - shown in Figure 15 here) as follows:

Utilize the CAR formulas (Equation 6.10 – shown in Figure 15), with variables calculated as follows:

Note: for consistency, y = n = t.

$$\mathbf{BC_{hv,n} = \Sigma[(LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i + LBL_{BSL,OTHER,i,t} - LBL_{BSL,Other,i,t} \bullet R_i) \bullet (1 - f_{BSL,BRANCH,i,t}) \bullet (1 - f_{BSL,BUCKINGLOSS,i,t})] \bullet CF \bullet 44/12} \quad \mathbf{(56c.1)}$$

As calculated using the *baseline scenario data*, and where:

$LBL_{BSL,FELLINGS,i,t}$ = annual removal of live tree biomass due to commercial felling in subregion, *i*; t d.m. $yr^{-1}$ (equation 6)

$LBL_{BSL,OTHER,i,t}$ = annual removal of live tree biomass from incidental sources in subregion, *i*; t d.m. $yr^{-1}$ (equation 6)

$1 - f_{BSL,BRANCH,i,t}$ the proportion of aboveground live tree biomass remaining after netting out branch biomass, in subregion *i* (unitless; $0 \leq f_{BRANCH,i,t} \leq 1$)(see equation 12)

$1 - f_{BSL,BUCKINGLOSS,i,t}$ = the proportion of the log bole remaining after processing for quality, in subregion, *i* (unitless; $0 \leq f_{BUCKINGLOSS,i,t} \leq 1$) (equation 12)

$R_i$ = the root:shoot ratio in subregion, *i*

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

$$\mathbf{AC_{hv,\,n} = \Sigma[(LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i + LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,Other,i,t} \bullet R_i) \bullet (1 - f_{PRJ,BRANCH,i,t}) \bullet (1 - f_{PRJ,BUCKINGLOSS,i,t})] \bullet CF \bullet 44/12} \quad \mathbf{(56c.2)}$$

As calculated using the *project scenario data*, and where:

$LBL_{PRJ,FELLINGS,i,t}$ = annual removal of live tree biomass due to restoration felling in subregion, *i*; t d.m. $yr^{-1}$ (equation 6)

$LBL_{PRJ,OTHER,i,t}$ = annual removal of live tree biomass from incidental sources in subregion, *i*; t d.m. $yr^{-1}$ (equation 6)

$1 - f_{PRJ,BRANCH,i,t}$ the proportion of aboveground live tree biomass remaining after netting out branch biomass, in subregion *i* (unitless; $0 \leq f_{BRANCH,i,t} \leq 1$)(see equation 12)

$1 - f_{PRJ,BUCKINGLOSS,i,t}$ = the proportion of the log bole remaining after processing for quality, in subregion, *i* (unitless; $0 \leq f_{BUCKINGLOSS,i,t} \leq 1$) (equation 12)

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

$$\mathbf{SE_y = LE_y} \quad \mathbf{(56c.3)}$$

Where,

$SE_y$ = Secondary Effects in year ‘y’ ($tCO_2e$) calculated using equations in Figure 2 and equations 56c.1, 56c.2 and 56c.3.

$LE_Y$ = Leakage in year y (in tonnes $CO_2e\ yr^{-1}$) – used in equation 58.

The outcome of this calculation ($LE_y$) is subtracted from the total net VCU's on an annual basis as per methodology in Equation 58.

The biomass calculations were obtained from the Landscape Summary Tool harvest volume output (i.e. equation 56c.1 and 56c.2, with the conversion to tC (i.e. *CF) and $tCO_2e$ (i.e. *44/12) made in the Afognak Carbon Model). Equation 56c.3 calculations (and the related calculations from Figure 15) were made for the Afognak project within the Afognak Carbon Model excel spreadsheet referenced in Appendix 3, and the annual results displayed in Table 12 and Table 14.

In summary, the leakage calculations result in an average annual leakage reduction factor of approximately 11.4% over the entire project duration, with a range of 0%-12.1% on an annualized basis as shown in Table 12[6].

[6] By way of comparison and context, this outcome is conservative in comparison on average with the robust forest carbon leakage analysis undertaken by the U.S. Environmental Protection Agency (U.S. EPA, 2005) which modeled an average U.S. leakage factor for logged to protected forests as *de minimis* (-2.8% leakage in Table 6-2) when looking across the U.S. and including the entire forest and agriculture sectors. They also refer to previous more constrained regional economic modeling (Murray, McCarl, & Lee, 2003) which showed a leakage rate of 7.9%-16% depending on ongoing forest activities (Table 6-4). This study also includes a brief review of other U.S. leakage studies, and in our opinion represents the most robust and complete economic modeling for leakage, and is therefore a rationale comparative data point for North American forest projects.

**Table 12 - Projected Leakage Risk Discounts on 5-year time steps.**

| Year | Change Harvest Vol. ($tCO_2e$) | -20% Change tCO2e Harvested | Discount % of total VCU's |
|---|---|---|---|
| 0 | 0 | 0 | |
| 5 | 70,322 | (14,064) | 12.1% |
| 10 | 70,738 | (14,148) | 10.7% |
| 15 | 0 | 0 | 0.0% |
| 20 | 0 | 0 | 0.0% |
| 25 | 0 | 0 | 0.0% |
| 30 | 0 | 0 | 0.0% |
| 35 | 0 | 0 | 0.0% |
| 40 | 0 | 0 | 0.0% |
| 45 | 0 | 0 | 0.0% |
| 50 | 0 | 0 | 0.0% |
| 55 | 0 | 0 | 0.0% |
| 60 | 0 | 0 | 0.0% |
| 65 | 0 | 0 | 0.0% |
| 70 | 0 | 0 | 0.0% |
| 75 | 0 | 0 | 0.0% |
| 80 | 0 | 0 | 0.0% |
| 85 | 0 | 0 | 0.0% |
| 90 | 0 | 0 | 0.0% |
| 95 | 0 | 0 | 0.0% |
| 100 | 0 | 0 | 0.0% |
| **Total** | **705,298** | **(28,212)** | **-1.9%** |

## 4.4. Net GHG Emission Reductions and Removals

### *Calculation of Gross Emissions Reductions*

*Gross* carbon emissions reductions ($ER_y$,gross; t $CO_2e\ yr^{-1}$) created by the Afognak carbon project were calculated annually as the difference between the baseline and project scenario net emission reductions/emissions:

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

Where,

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

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

44/12 = factor to convert C to $CO_2e$

This calculation was undertaken in the Afognak Carbon Model excel spreadsheet. The gross emissions reductions calculated for the Afognak project are shown in Table 13.

**Table 13 - Projected Emissions (Reductions) for the Afognak Project.**

| Year | Baseline (Emissions) Reductions (tCO2e) | Annualized Baseline (Emissions) Reductions (tCO2e) | Project (Emissions) Reductions (tCO2e) | Annualized Project (Emissions) Reductions (tCO2e) | Net Change (Emissions) Reductions (tCO2e) | Annualized Net Change (Emissions) Reductions (tCO2e) | Corrected[7] Annualized Net Change (Emissions) Reductions (tCO2e) |
|---|---|---|---|---|---|---|---|
| 0 | 0 | **0** | 0 | **0** | **0** | **0** | 0 |
| 5 | (537,345) | (107,469) | 43,287 | 8,657 | 580,632 | 116,126 | 116,126 |
| 10 | (629,867) | (125,973) | 31,664 | 6,333 | 661,531 | 132,306 | 132,306 |
| 15 | (72,644) | (14,529) | 50,355 | 10,071 | 123,000 | 24,600 | 24,600 |
| 20 | (41,190) | (8,238) | 47,938 | 9,588 | 89,128 | 17,826 | 17,826 |
| 25 | (25,365) | (5,073) | 47,066 | 9,413 | 72,431 | 14,486 | 11,712 |
| 30 | (12,742) | (2,548) | 33,684 | 6,737 | 46,426 | 9,285 | 0 |
| 35 | 1,051 | 210 | 43,643 | 8,729 | 42,592 | 8,518 | 0 |
| 40 | 2,999 | 600 | 36,264 | 7,253 | 33,265 | 6,653 | 0 |
| 45 | 5,317 | 1,063 | 34,655 | 6,931 | 29,338 | 5,868 | 0 |
| 50 | 6,913 | 1,383 | 19,106 | 3,821 | 12,193 | 2,439 | 0 |
| 55 | 13,686 | 2,737 | 31,045 | 6,209 | 17,359 | 3,472 | 0 |
| 60 | 19,137 | 3,827 | 27,028 | 5,406 | 7,891 | 1,578 | 0 |
| 65 | 26,619 | 5,324 | 29,431 | 5,886 | 2,813 | 563 | 0 |
| 70 | 33,492 | 6,698 | 20,079 | 4,016 | (13,413) | (2,683) | 0 |
| 75 | 45,275 | 9,055 | 35,892 | 7,178 | (9,382) | (1,876) | 0 |
| 80 | 54,086 | 10,817 | 33,355 | 6,671 | (20,731) | (4,146) | 0 |
| 85 | 61,889 | 12,378 | 34,882 | 6,976 | (27,007) | (5,401) | 0 |
| 90 | 66,086 | 13,217 | 21,522 | 4,304 | (44,564) | (8,913) | 0 |
| 95 | 73,364 | 14,673 | 31,517 | 6,303 | (41,847) | (8,369) | 0 |
| 100 | 75,290 | 15,058 | 26,484 | 5,297 | (48,806) | (9,761) | 0 |
| **Total** | **(833,327)** | | **679,521** | | **1,512,849** | **1,512,849** | **1,512,849** |

[7] The change in net emissions has been corrected to account for the fact that there are time periods (after year 60) for which the net change is negative. The cumulative corrected values are only allowed to reach the maximum 100-year value (1,512,849 t) and then forced to 0.

### *Calculation of Net Emissions Reductions*

The annual *net* carbon emissions reductions is the actual net GHG removals by sinks from the project scenario minus the net GHG removals by sinks from the baseline scenario, were then calculated by applying the leakage and uncertainty discount factors (but not the VCS permanence buffer), on an annualized basis:

$$\mathbf{ER_y = ER_{y,GROSS} - LE_y} \quad \textbf{(58)}$$

Where,

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

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

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

This calculation occurs within the Afognak Carbon Model Spreadsheet, using the data shown in Table 12 and Table 13.

### *Calculation of Voluntary Credit Units (VCUs)*

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

$$\mathbf{VCU_y = ER_y \cdot (1 - ER_{y,ERR}) - BR_y} \quad \textbf{(59)}$$

Where,

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

$ER_{y,ERR}$ = the uncertainty factor for year, y, (calculated in Section 4.5), expressed as a proportion.

$BR_y$ = estimated VCU-equivalent $tCO_2e$ issued to the VCS Buffer Pool in year, *y*, calculated using the latest version of the VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer (Voluntary Carbon Standard, 2008c). BRy is calculated by multiplying the most current verified permanence risk Buffer Withholding Percentage for the project by the change in carbon stocks (difference between baseline and project scenario) for the project area.

The VCS Buffer Discount Factor ($BR_Y$) was calculated as **13%**, as per the non-permanence risk assessment in Appendix 1. The BR factor will be re-assessed at each verification as necessary.

The uncertainty factor was conservatively estimated at **11.9%**, as per Section 4.5. The uncertainty factor will be re-calculated from field plot data at each verification.

Equation 59 is calculated in the Afognak Carbon Model spreadsheet)

Table 14 shows the calculated annual VCUs projected for the Afognak Project.

**Table 14 - Calculated Annual VCUs for the Afognak Project. Source: Afognak Carbon Model: Summary Tables and Figures.**

| Project Year (Years) | Annualized Net Emissions Reductions (tCO2e) | Non-Perm Buffer Release (tCO2e) | Annual Saleable VCU's (tCO2e) |
|---|---|---|---|
| 0 | | | |
| 1 | 84,323 | | **84,323** |
| 2 | 84,323 | | **84,323** |
| 3 | 84,323 | | **84,323** |
| 4 | 84,323 | | **84,323** |
| 5 | 84,323 | 8,022 | **92,346** |
| 6 | 97,697 | | **97,697** |
| 7 | 97,697 | | **97,697** |
| 8 | 97,697 | | **97,697** |
| 9 | 97,697 | | **97,697** |
| 10 | 97,697 | 16,051 | **113,747** |
| 11 | 20,443 | | **20,443** |
| 12 | 20,443 | | **20,443** |
| 13 | 20,443 | | **20,443** |
| 14 | 20,443 | | **20,443** |
| 15 | 20,443 | 15,488 | **35,931** |
| 16 | 14,813 | | **14,813** |
| 17 | 14,813 | | **14,813** |
| 18 | 14,813 | | **14,813** |
| 19 | 14,813 | | **14,813** |
| 20 | 14,813 | 14,502 | **29,315** |
| 21 | 9,733 | | **9,733** |
| 22 | 9,733 | | **9,733** |
| 23 | 9,733 | | **9,733** |
| 24 | 9,733 | | **9,733** |
| 25 | 9,733 | 13,205 | **22,937** |
| 26 | 0 | | **0** |
| 27 | 0 | | **0** |
| 28 | 0 | | **0** |
| 29 | 0 | | **0** |
| 30 | 0 | 11,224 | **11,224** |
| **TOTAL:** | **1,135,040** | **78,492** | **1,213,532** |

## 4.5. Calculation of the Uncertainty Factor

The methodology monitoring section specifies that all analysis units will have representation by one or more field plots. Due to the fact all of the subregions assigned to AU 201 (spruce regeneration after harvest) are still in the regeneration phase of stand development (< 10 years old) no plots have been established in this analysis unit, as yet. Additional plots will be installed in AU 201 as part of future monitoring activities. A total of 22 plots were randomly established in tthe mature spruce component (AU 101) of the project area (Figure 7).

The project-level uncertainty factor is calculated as follows:

**Step 1** – Calculate the average percent model error ($E_M$) for the project based on the average area-weighted difference between measured values in monitored plot observations and model-predicted values using Equations 60a,b. In the case where analysis units have been used for stratification, the difference between the plot observation and model-predicted value (both expressed on a per hectare basis) for a given analysis unit ($y_{d,h,i}$) is weighted by the area of its associated analysis unit ($A_{PRJ,h}$) (Eq. 60a). The use of an area-weighting factor places more emphasis on analysis units that represent a relatively larger proportion of the total project area.

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

Where,

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

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

$E_M$ = Mean model error for the project (%)

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

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

$y_{p,h,i}$ = carbon storage predicted by model for analysis unit , h, plot observation, i (t C $ha^{-1}$)

$A_{PRJ,h}$ = area of project analysis unit, h (ha)

**Step 2** – Calculate the inventory error ($E_I$) at a 90 percent confidence interval expressed as a percentage of the mean area-weighted inventory estimate from the measured plots.

This methodology was designed to accommodate complex landscapes consisting of hundreds to thousands of polygons, which can be further grouped into analysis units. Inventory error is estimated based upon the difference between modeled and measured values for monitoring plots established in polygons or in polygons grouped within analysis units.

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

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

Where,

$E_I$ = Inventory error for the project (%)

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

N = total number of plot observations in all analysis units

1.654 = the 90% confidence interval t-value

All other terms as defined in equation 60a.

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

Where,

N = total number of plot observations in all analysis units

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

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

Where,

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

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

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

$$E_P = E_M + E_I \quad \textbf{(60f)}$$

**Step 4** – Compare the result of Step 3 against Table 15 to determine the uncertainty factor:

Table 15 - Uncertainty Factor Calculation

| Estimated Project Error, $E_P$ (%) | Uncertainty Factor (=$ER_{Y,ERR}$) |
|---|---|
| 0 – 10% | = 1.5%[8] |
| >10% | = 1.5% + $E_P$ – 10% |

### *Initial Estimate of Uncertainty*

Calculations for the Uncertainty factor are provided in the file referenced in Appendix 3. The inventory error term ($E_I$) was calculated to be 11.9% while the model error term ($E_M$) was 3.5%. As shown in Equation 60f , the project error term ($E_P$) was calculated as the sum of $E_M$ and $E_I$ to be 15.4%. Thus, the uncertainty factor ($ER_{Y,ERR}$) was calculated (based upon Table 15) to be 6.9%.

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

## 5. Environmental Impact:

There are no known environmental impacts to assess for the retention of natural forest. This carbon project enhances all aspects of biodiversity, water, and other environmental attributes by retaining and protecting the existing forest in an intact, fully functioning ecosystem. Project scenario management activities will be minimal, low impact operations focused on salvage, restoration, or preventative management activities on small areas annually.

There are no direct socio-economic impacts on the project area, as there are no communities/residents or parties directly dependant on the physical project area for economic livelihood. The local communities have retained full access to the project area for subsistence and recreational use. There are offsite parties which may be affected by the project, including the potential for negative impacts on a limited number of forest workers who may have less opportunity than in the baseline scenario (however, these are highly diversified developed country economies with significant replacement employment potential regardless of the project; and these are remote sites for these forestry workers, for which Afognak provides temporary work within a larger package). The larger impact is within the Native Corporations, where the underlying community shareholders are affected by the economic success of the corporations. In this light, the project is likely a positive outcome, wherein the corporations were able to extract the land and timber value through the transaction which could be then re-invested in more lucrative ventures, and/or otherwise generate at least equivalent wealth to the timber (i.e. it was acquired at a market valuation) for shareholders. The financial dealings of these corporations is private, however, their corporate websites list extensively diversified business portfolios through aggressive investment over the past 10 years (i.e. see the profile videos on the Afognak Native Corp. website: http://www.afognak.com).

[8] To be conservative, the minimum uncertainty factor is set to 1.5% to account for possible uncertainty within other unmeasured assumptions used in calculations and modeling.

## 6. Stakeholders Comments:

RMEF/ALC and their principle staff have undertaken extensive stakeholder engagement during the years leading up to the historic purchases of lands and timber rights. The debates on the appropriate use and ownership of the lands contained in the Kodiak Archipelago, and Afognak Island in particular, are a matter of regional, state and national concern and have been extensively covered in national and local newspapers.

RMEF/ALC participated in numerous targeted meetings since their partnership began in 2000 with all relevant stakeholders, including local government, local industry, chambers of commerce, local recreational use groups, and general public meetings island-wide.

The idea of using private funds, government grants and Exxon Valdez oil spill dollars attracted broad consensus. There was widespread media coverage in Kodiak, statewide and in national press such as the Washington Post.

In the public comment process for Exxon Valdez restoration, habitat protection was the favorite choice of over 80% of nationwide respondents and over 60% of Alaskan respondents.

It should be noted that the primary topic of all such engagements has been about the acquisition and the project scenario property management activities. RMEF/ALC have chosen, so far, to emphasize the need for broad minded conservation, and have not explicitly held stakeholder discussions specifically regarding the carbon project until there was a level of certainty in the validation and verification process.

Over the period of 2000-2011, the following is a non-exhaustive list of stakeholders meetings:

**Table 16 – Afognak Stakeholders Meetings**

| Timeline | Stakeholders Met | Comments |
|---|---|---|
| | • Kodiak Island Borough Assembly<br>• Kodiak Chamber of Commerce<br>• Homer Chamber of Commerce<br>• Alaska State Legislature<br>• Nine Native corporations with boards and shareholders<br>• Bear Management Citizens Advisory Group<br>• Alaska Department of Fish and Game<br>• Alaska Department of Natural Resources<br>• U.S. Fish and Wildlife Service<br><br>Over sixty conservation non-profits with extensive depth among hunting and fishing organizations including, Alaska Outdoor Council, National Rifle Assn., Boone & Crockett Club, Safari Club International, | This project has attracted support from a large diversity of sources.<br><br>Alaska is a rough and tumble political environment with strongly held views, but habitat conservation was a unifying cause that met support from over 80% of stakeholders locally, statewide and nationally. |

| | | |
|---|---|---|
| | Territorial Sportsmen, Wildlife Forever and several leading environmental groups such as National Audubon Society, World Wildlife Fund, Natural Resources Defense Council<br><br>Kodiak Regional Aquaculture Association And Kodiak Brown Bear Trust were two important and influential local support groups. Local lodges, guides and outfitters were strongly supportive.<br><br>Scientific organizations such as the Smithsonian Institute, National Geographic Society, the Wildlife Society, the Geos Institute all supported the Afognak work.<br><br>Donors included Paul G. Allen Family Foundation, Thorsen Foundation, Vital Ground Foundation, Alaska Conservation Foundation | |

# 7. Ownership:

## 7.1. Proof of Title:

This section provides documentation of ownership interests and right of use associated with the land containing the Afognak Island Forestry Project. The references to lands, parcels and plats in this section are consistent with the State of Alaska's Recorder's Office[9] which preserves the permanent public record of deeds, mortgages, assignments, interests, associated surveys and documents that identify property ownership, liens, and other recordings against real property.

Rocky Mountain Elk Foundation and American Land Conservancy (RMEF/ALC), as Tenants in Common, are the Owners of the Afognak Island Forestry Project and have overall control and responsibility for the project. Camco International Group, Inc. (Camco) is assisting RMEF/ALC in project implementation and has been designated a Project Proponent Representative.

Together, RMEF/ALC has demonstrated clear title to exclusive ownership of carbon rights associated with the preservation, in perpetuity, of the forested lands constituting the project. The following section describes the transactional history of the project and summarizes the chain of events, actions, purchases, transfers, and outcomes that establish their undisputed ownership of the project.

[9] A searchable database from the State of Alaska Recorder's Office can be found at www.recorder.alaska.gov

## Transactional History and Ownership

Over the course of the past decade, RMEF/ALC devised and enacted a strategy to develop a carbon project on Northern Afognak Island to protect as much of the forest as possible from the imminent threat of logging. The key element in the strategy was to acquire the surface estate and/or timber harvest rights to the project lands, which were previously under private ownership by a Native Corporation, Afognak Joint Venture (AJV). As the documentation shows, after purchasing the surface estate and/or timber rights, RMEF/ALC then arranged to transfer the surface estate to the State of Alaska while retaining the rights to the carbon project. The phraseology used in the limited Warranty Deeds to retain property rights in the carbon project while transferring property from RMEF/ALC to the State of Alaska is as follows:

"*Excepting and Reserving unto the Grantor, the rights to any and all air emission offset or credit values that may be derived from the timber and timber harvest rights hereby conveyed, including but not limited to such offset or credit values as may be derived from the carbon sequestration capacity of the timber and harvest right*."

This carefully worded clause in the limited warranty transfer deeds established the intent to create a carbon project at the time and reserves to RMEF/ALC the rights to conduct the Afognak Island Forestry Project. In other words, RMEF/ALC owns the right to conduct the project, and such right was never transferred to the Federal or State government.

While each parcel has its own acquisition history and chain of encumbrances and conveyance documents, the end result has been that all the five parcels are now in public ownership and protected in perpetuity for conservation and wildlife protection purposes under Federal easements, with the United States Bureau of Land Management as conservation easement holder and the State of Alaska Department of Natural Resources as owner of the surface estates. For each parcel, RMEF/ALC reserved the carbon credit rights associated with the preservation in perpetuity of the forested lands from commercial timber harvesting. The unique and exclusive right to develop a carbon project resides with RMEF/ALC.

As a result of the Federal conservation easement placed on all of the five parcels through the actions of RMEF/ALC, no party or government entity may lawfully conduct or allow timber harvests to take place on the parcels except for local subsistence purposes and as is reasonably necessary for protection of public safety or natural resources, or for research or management consistent with the goal of maintaining the property in perpetuity for conservation and wilderness purposes. The United States, as holder of the conservation easement, is responsible for administering and enforcing the conservation easement to ensure against unlawful commercial timber harvests. Also, for the waterfall, Shuyak and Uganik parcels, the State of Alaska Division of Outdoor Parks and Recreation (Alaska DOPR) has additional responsibility for administering certain conservation easement restrictions and supervising the parcels. RMEF/ALC, by virtue of its property rights in the carbon credits, has ongoing property and financial interests in ensuring the continued protection of the Afognak Island Forestry Project against unlawful commercial timber harvesting. As a result, RMEF/ALC may also have certain legal rights to enforce the conservation easement.

The conveyance and encumbrance history for each parcel is itemized below:

## Waterfall Parcel

| Recording Doc # | Date | Document | Purpose |
|---|---|---|---|
| 2005-0033340-0 | 12/19/2005 | Limited Warranty Deed between AJV (grantor) and RMEF and ALC, as Tenants in Common | Conveys surface estate to Waterfall Parcel to RMEF and ALC, as Tenants in Common. |
| 2005-003338-0 | 12/19/2005 | Federal Conservation Easement between RMEF and ALC, as Tenants in Common (grantor) and United States | Established Federal conservation easement over surface estate to Waterfall Parcel including prohibition on timber harvesting except for subsistence uses. |
| 2005-003340-0 | 12/19/2005 | Limited Warranty Deed between RMEF and ALC, as Tenants in Common (grantor) and State of Alaska | Conveys surface estate to Waterfall Parcel to State of Alaska; subject to (i) RMEF/ALC's reservation of rights to air emissions offsets derived from timber and timber harvest rights and access to property for monitoring and verification; and (ii) United States' enforcement rights as holder of conservation easement. |

## Shuyak Parcel

| Recording Doc # | Date | Document | Purpose |
|---|---|---|---|
| 2009-001279-0 | 7/17/2009 | Limited Warranty Deed between Shuyak, Inc. (grantor) and RMEF and ALC, as Tenants in Common (grantee) | Conveys surface estate to Shuyak Parcels to RMEC and ALC, as Tenants in Common. |
| 2009-001281-0 | 7/17/2009 | Federal Conservation Easement between RMEF and ALC, as Tenants in Common (grantor) and United States (grantee) | Established Federal conservation easement over surface estate to Shuyak Parcels including prohibition on timber harvesting except for subsistence uses. |
| 2009-001282-0 | 7/17/2009 | Limited Warranty Deed between RMEF and ALC, as Tenants in Common (grantor) and State of Alaska (grantee) | Conveys surface estate to Shuyak Parcels to State of Alaska; subject to (i) RMEF/ALC's reservation of rights to air emissions offsets derived from timber and timber harvest rights and access to property for monitoring and verification; and (ii) United States' |

| | | | |
|---|---|---|---|
| | | | enforcement rights as holder of conservation easement. |

## Uganik Parcel

| Recording Doc # | Date | Document | Purpose |
|---|---|---|---|
| 2009-001274-0 | 7/17/2009 | Limited Warranty Deed between Uganik Natives, Inc. (grantor) and RMEF and ALC, as Tenants in Common (grantee) | Conveys surface estate to Uganik Parcels to RMEF and ALC, as Tenants in Common. |
| 2009-001276-0 | 7/17/2009 | Federal Conservation Easement between RMEF and ALC, as Tenants in Common (grantor) and United States (grantee) | Established Federal conservation easement over surface estate to Uganik Parcels including prohibition on timber harvesting except for subsistence uses. |
| 2009-001277-0 | 7/17/2009 | Limited Warranty Deed between RMEF and ALC, as Tenants in Common (grantor) and State of Alaska (grantee) | Conveys surface estate to Uganik Parcels to State of Alaska; subject to (i) RMEF/ALC's reservation of rights to air emissions offsets derived from timber and timber harvest rights and access to property for monitoring and verification; and (ii) United States' enforcement rights as holder of conservation easement. |

## Paul's Lake Tract A[10]

| Recording Doc # | Date | Document | Purpose |
|---|---|---|---|
| BK00174PG0491 | 9/24/2000 | Federal Conservation Easement between AJV (grantor) and State of Alaska (grantee) | Establishes Federal conservation easement over surface state for Paul's and Laura Lakes Tracts A and B; subject to AJV's reservation of commercial timber harvest rights through November 16, 2013. |
| BK00174PG0507 | 9/24/2000 | State Warranty Deed between AJV (grantor) and State of Alaska (grantee) | AJV conveys surface estate to Paul's and Laura Lakes Tracts 5A and 5B to State of Alaska; subject to (i) Federal conservation easement and |

[10] Also referred to as Laura Lakes Tract A.

| | | | |
|---|---|---|---|
| | | | (ii) AJV's reservation of commercial timber harvest rights through November 16, 2013 |
| 2005-003333-0 | 12/19/2005 | Limited Warranty Deed between AJV (grantor) and RMEF and ALC, as Tenants in Common | AJV conveys its commercial timber harvest rights to Paul's Lake Tract A to RMEF/ALC |
| 2009-001270-0 | 7/17/2009 | Subordination Agreement among RMEF and ALC, as Tenants in Common (timber owners), State of Alaska (fee owner), and United States (conservation easement owner) | Subordinates RMEF/ALC's commercial timber harvest rights in Paul's Lake Tract A to the Federal conservation easement's prohibition on timber harvesting (except for subsistence uses) |
| 2009-001271-0 | 7/17/2009 | Limited Warranty Deed between RMEF and ALC, as Tenants in Common (grantor) and State of Alaska (grantee) | RMEF/ALC convey its commercial timber harvest rights in Paul's Lake Tract A to State of Alaska; subject to (i) the subordination of those rights under the Federal conservation easement and United States enforcement rights as easement holder, and (ii) RMEF/ALC's reservation of the air emission offsets derived from the timber and timber harvest rights. |

## Laura Lake Tract B

| Recording Doc # | Date | Document | Purpose |
|---|---|---|---|
| BK00174PG0491 | 9/24/2000 | Federal Conservation Easement between Alaska Joint Venture (AJV) (grantor) and State of Alaska (grantee) | Establishes Federal conservation easement over surface state for Paul's and Laura Lakes Tracts 5A and 5B; subject to AJV's reservation of commercial timber harvest rights through November 16, 2013. |
| BK00174PG0507 | 9/24/2000 | State Warranty Deed between AJV (grantor) and State of Alaska (grantee) | AJV conveys surface estate to Paul's and Laura Lakes Tracts 5A and 5B to State of Alaska; subject to (i) Federal conservation easement and (ii) AJV's reservation of commercial timber harvest rights through November 16, 2013 |

| | | | |
|---|---|---|---|
| 2005-003332-0 | 12/19/2005 | Limited Warranty Deed between AJV (grantor) and RMEF and ALC, as Tenants in Common | AJV conveys its commercial timber harvest rights to Laura Lake Tract B to RMEF/ALC |
| 2005-003339-0 | 12/19/2005 | Subordination Agreement among RMEF and ALC as Tenants in Common (Timber Owners), State of Alaska (fee owners) and United States (conservation easement owner) | Subordinates RMEF/ALC's commercial timber harvest rights in Laura Lake Tract B to Federal conservation easement's prohibition on timber harvesting (except for subsistence uses) |
| 2005-003341-0 | 12/19/2005 | Limited Warranty Deed between RMEF and ALC, as Tenants in Common (grantor) and State of Alaska (grantee) | RMEF/ALC convey the commercial timber harvest rights in Laura Lake Tract B to State of Alaska; subject to (i) the subordination of those timber harvest rights to the Federal conservation easement and the United States' enforcement rights as easement holder, and (ii) RMEF/ALC's reservation of the air emission offsets derived from the timber and timber harvest rights. |

## Proof of Title and Right of Use

This Section addresses the core elements required under the VCS 3.1 Standard, VCS 3.1 Program Definitions, and VM0012 related to Proof of Title and Right of Use. These elements are primarily concerned with establishing evidence of the nexus of control over the activities that generate the reductions / removals as supported by the status of a land's title.

VCS Standard 3.1 states in Section 3.12.1 that the project description shall be accompanied by proof of title in respect of one or more of the following rights of use accorded to the project proponent(s):

1) A right of use arising or granted under statute, regulation or decree by a competent authority.
2) A right of use arising under law.
3) A right of use arising by virtue of a statutory, property or contractual right in the plant, equipment or process that generates GHG emission reductions and/or removals (where such right includes the right of use of such reductions or removals and the project proponent has not been divested of such right of use).
4) A right of use arising by virtue of a statutory, property or contractual right in the land, vegetation or conservational or management process that generates GHG emission reductions and/or removals (where such right includes the right of use of such reductions or removals and the project proponent has not been divested of such right of use).
5) An enforceable and irrevocable agreement with the holder of the statutory, property or contractual right in the plant, equipment or process that generates GHG emission reductions and/or removals which vests the right of use in the project proponent.

6) An enforceable and irrevocable agreement with the holder of the statutory, property or contractual right in the land, vegetation or conservational or management process that generates GHG emission reductions or removals which vests the right of use in the project proponent.

Elements contained in paragraph 4) and 6) above have been documented and addressed in the previous Section covering the deed transfers and transactional history. In other words, RMEF/ALC has "an enforceable and irrevocable agreement" with the State of Alaska and the Federal Government in the "land, vegetation or conservational or management process that generates GHG emission reductions or removals which vests the right of use in the project proponent."

VCS 3.1 Program Definitions define Right of Use as follows: "In respect of a GHG emission reduction or removal, the unconditional, undisputed and unencumbered ability to claim that the relevant project will or did generate or cause such reduction or removal. Distinct from proof of right."

Taken together the Standard and Definitions provide a clear framework for establishing RMEF/ALC's Proof of Title and Right of Use:

RMEF/ALC's Right of Use is Unconditional – there is no condition or term in the Warranty Deeds that would require additional permission or consent that could be denied. RMEF/ALC's ability to undertake the carbon project as agreed in the deeds is established and protected by Federal and State law as well as literally hundreds of years of common law covering property rights, and is not materially subject to conditions precedent or subsequent.

RMEF/ALC's Right of Use is Uncontested – The ability of RMEF/ALC to develop the carbon project and claim credits generated thereby has not been disputed by another party. No legal proceedings or lawsuits have been filed and RMEF/ALC has no knowledge of any objections or complaints to their proceeding with the project. No Administrative actions have been launched challenging the conveyances that established RMEF/ALC's ownership of the carbon rights and/or ability to claim reductions or sequestration that has or will occur.

RMEF/ALC's Right of Use is Materially Unencumbered – Technically a Conservation Easement is itself an encumbrance on land since it establishes a claim and affects or limits the title of a property. In this case, the encumbrance does not materially weaken RMEF/ALC's Right of Use and in fact strengthens and supports the establishment of the carbon project.

The following Table summarizes the tests for Proof of Title and Right of Use for the Afognak Island Forestry Project and concisely states the manner in which the project satisfies the VCS 3.1 and VM0012 requirements: .

| ELEMENTS OF RIGHT OF USE AND PROOF OF TITLE - AFOGNAK | |
|---|---|
| **1. Enforceable** | The agreement between the Project Proponents (ALC/RMEF/Camco) and AK (the holder of the property) establishes a contractual and property right (via obtaining the surface and/or timber rights and transferring or subordinating them subject to federal conservation easements) is enforceable. |
| **2. Irrevocable** | The agreement between the Project Proponents (ALC/RMEF/Camco) and AK (the holder of the property) establishes a contractual and property right) is irrevocable. |
| **3. Unconditional** | The Project Proponent's ability to claim the project's reductions / removals will happen / have happened, as vested by the agreements between ALC / RMEF, the State of Alaska and BLM, is not materially subject to conditions precedent or subsequent. There is not a consent and/or an occurrence that must happen for ALC / RMEF to claim the project will perform. |
| **4. Undisputed** | The Project Proponent's ability to claim the project's reductions / removals will happen / have happened, as vested by the agreements between ALC / RMEF, the State of Alaska and BLM, is not materially disputed by another party. No lawsuits or administrative actions have been launched challenging the conveyances that create ALC's / RMEF's right to claim the reductions / removals will or did occur. |
| **5. Unencumbered** | The Project Proponent's ability to claim the project's reductions / removals will happen / have happened, as vested by the agreements between ALC / RMEF, the State of Alaska and BLM, is not subject to being materially encumbered. There is no material scenario in the future wherein ALC's / RMEF's ability to claim the project's reduction / removals will be encumbered. While a conservation easement is legally an encumbrance, under the VCS standard it can help ensure that a project proponent's ability to claim reductions will occur is unencumbered. |

## 7.2. Emissions Trading Program:

Not Applicable – neither the U.S. nor Alaska are involved in any state, national, or international binding emissions trading program.

State, Federal, and International government activities relating to GHG emissions will be monitored closely on an ongoing basis to identify regulatory or other agreements that affect the emission reductions claimed by this project.

## Bibliography


Alaska Department of Natural Resources. (1999). *Exxon Valdez Oil Spill Restoration Habitat Protection and Acquisition Atlas.* Anchorage, Alaska: Exxon Valdez Oil Spill Trustee Council.

Berg, E. E., Henry, J. D., Fastie, C. L., De Volder, A. D., & Matsuoka, S. (2006). Spruce beetle outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory: Relationship to summer temperatures and regional differences in disturbance regimes. *Forest Ecology and Management* , 227:219-232.

Briggs, D. (1994). *Forest products measurements and conversion factors : with special emphasis on the U.S. Pacific Northwest.* Seattle, WA: University of Washington. Institute of Forest Resources.

Burns, R. M. (1990). *Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654.* Washington, DC: U.S. Department of Agriculture, Forest Service.

Cairns, M. A. (1997). Root Biomass Allocation in the World's Upland Forests. *Oecologia* , 111:1-11.

CAR. (2010). *Climate Action Reserve, Forestry Protocol v.3.2 - Appendix F Mill Efficiency Data.* San Francisco, CA: Climate Action Reserve.

Climate Action Reserve. (2010). *Forest Project Protocol Version 3.2.* San Francisco: Climate Action Reserve.

Eggler, W. (1967). Influence of volcanic eruptions on xylem growth patterns. *Ecology , 48*, 644647.

Forest and Land Management, Inc. . (2008). *Timber Appraisal, Afognak Joint Venture (Uganik Natives, Inc.), Property at Waterfall Lake, North Afognak Island, Kodiak Island Borough, Alaska. Report submitted to the Rocky Mountain Elk Foundation.* Missoula, MT: Unpublished Report.

Gonzalez, J. (1990). *Wood density of Canadian Tree species.* Northern Forestry Centre. Forestry Canada.

Harmon et al. (2008). *Woody Detritus Density and Density Reduction Factors for Tree Species in the United States: A Synthesis.* USDA Forest Service GTR NRS-29.

Harmon, M., & Sexton, J. (1996). *Guidelines for measurements of woody detritus in forest ecosystems. US LTER Publication No. 20.* Seattle, WA: US LTER Network Office, University of Washington.

Harmon, M., Franklin, J., Swanson, F., Sollins, P., Gregory, S., Lattin, J., et al. (1986). *Ecology of coarse woody debris in temperate ecosystems.*

Heath, L., Maltby, V., Miner, R., Skog, K., Smith, J., Unwin, J., et al. (2010). Greenhouse gas and carbon profile of the U.S. forest products industry value chain.< http://www.treesearch.fs.fed.us/pubs/35039>. *Environ. Sci. Technol.* , 44: 3999-4005. Supplementary data.

Hunt, J. (2010). *Mission without a map : the politics and policies of restoration following the Exxon Valdez oil spill. Rev. ed. .* Anchorage, Alaska: Exxon Valdez Oil Spill Trustee Council.

IPCC. (2006b). *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* IGES, Japan: National Greenhouse Gas Inventories Programme.

IPCC. (2003a). *Estimation, reporting and accounting of harvested wood products – technical paper.* Bonn, Germany: UNFCCC paper FCCC/TP/2003/7, UNFCCC Secreariat.

IPCC. (2003). *Good Practice Guidance for Land Use, Land-Use Change and Forestry (GPG-LULUCF).* Japan: Institute for Global Environmental Strategies (IGES) for the IPCC.

IPCC. (2006a). *Good Practice Guidance for Land Use, Land-Use Change and Forestry.* Japan: Institute for Global Environmental Strategies (IGES) for the IPCC.

Kimmins, J., Mailly, D., & Seely, B. (1999). Modelling forest ecosystem net primary production: the hybrid simulation approach used in FORECAST. *Ecol. Modeling* , 122: 195-224.

Kurz, W., & Apps, M. (2006). Developing Canada's national forest carbon monitoring, accounting and reporting system to meet the reporting requirements of the Kyoto Protocol. . *Mitigation and Adaptation Strategies for Global Change* , 11(1): 33-43.

Kurz, W., & et al. (2009). CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards. *Ecological modelling* , 220: 480–504.

Laiho, R., & and Prescott, C. (2004). Decay and nutrient dynamics of coarse woody debris in northern coniferous forests: a synthesis. . *Can. J. For. Res.* , 34: 763–777.

Li, Z., Kurz, W., Apps, M., & Beukema, S. J. (2003). Belowground biomass dynamics in the Carbon Budget Model of the Canadian Forest Sector: recent improvements and implications for the estimation of NPP and NEP. . *Can. J. For. Res.* , 33: 126–136.

Melin, Y., Petersson, H., & Nordfjell, T. (2009). Decomposition of stump and root systems of Norway spruce in Sweden : a modeling approach. *Forest Ecology and Management* , 257: 1445-1451. .

Miner, R. (2006). The 100-year method for forecasting carbon sequestration in forest products in use. *Mitigation and Adaptation Strategies for Global Change* , 1-12.

Moore, T., Trofymow, J., Siltanen, M., Prescott, C., & CIDET, W. G. (2005). Patterns of decomposition and carbon, nitrogen, and phosphorus dynamics of litter in upland forest and peatland sites in central Canada. *Can. J. For. Res.* , 35: 133-142.

Murray, B., McCarl, B., & Lee, H. (2003). *ESTIMATING LEAKAGE FROM FOREST CARBON SEQUESTRATION PROGRAMS.* Research Triangle Park, NC: RTI International.

Parish, R., Antos, J., Ott, P., & Di Lucca, M. (2010). Snag longevity of Douglas-fir, western hemlock, and western redcedar from permanent sample plots in coastal British Columbia. . *Forest Ecology and Management* , 259: 633–640.

Pearson, T., Brown, S., & Birdsey, R. (2007). *Measurement guidelines for the sequestration of forest carbon.* USDA For Serv., North. Res. Station. Gen. Tech. Rep. NRS-18.

Perlack, R., Wright, L., Turhollow, A., Graham, R., Stodkes, B., & Erback, D. (2005). *Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply.* Oak Ridge, Tennessee: ORNL.

Pingoud, K., & Lehtila, A. (2002). Fossil Carbon Emissions Associated with Carbon Flows of Wood Products. *Mitigation and Adaptation Strategies for Global Change* , pp. 7: 63–83.

Runkle, J. (2000). Canopy tree turnover in old-growth mesic forests of eastern North America. . *Ecology* , 81: 554-567.

Seely, B., Kimmins, J., Welham, C., & Scoullar, K. (1999). Defining stand-level sustainability, exploring stand-level stewardship. *J. For.* , 97: 4-11.

Seely, B., Nelson, J., Wells, R., Peter, B., Meitner, M., et al. (2004). The application of a hierarchical, decision-support system to evaluate multi-objective forest management strategies: A case study in northeastern British Columbia, Canada. *For. Ecol. Manage.* , 199: 283-305.

Seely, B., Welham, C., & Kimmins, J. (2002). Carbon sequestration in a boreal forest ecosystem: results from the ecosystem simulation model, FORECAST. *For. Ecol. Manage.* , 169: 123-135.

Smith, W., Miles, P., Vissage, J., & Pugh, S. (2004). Forest resources of the United States, 2002. *North Central Research Station, Forest Service - USDA* , Gen. Tech. Rep. NC-241. .

Standish, J., Manning, G., & Demaerschalk, J. (1985). *Development of Biomass Equations for British Columbia Tree Species. Rep. BC-X-264* . Victoria, BC: Canadian Forestry Service, Pacific Forest Research Centre.

U.S. Corps of Engineers. (2002). *Existing Riparian Management Zone (RMZ) Regulations Throughout Alaska.* U.S. Corps of Engineers.

U.S. EPA. (2005). *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture.* Washington D.C. : United States Environmental Protection Agency.

US Fish and Wildlife Service. (2007). *National Bald Eagle Management Guidelines.* Washington D.C. : U.S. Fish and Wildlife Service, Department of the Interior.

Vanderwel, M., Caspersen, J., & Woods, M. (2006a). Snag dynamics in partially harvested and unmanaged northern hardwood forests. . *Can. J. For. Res.* , 36: 2769–2779.

Vanderwel, M., Malcolm, J., & Smith, S. (2006b). An integrated model for snag and downed woody debris decay class transitions. *Forest Ecology and Management* , 234: 48–59.

VCS. (2011). *Agriculture Forestry and Other Landuse Guidelines v.3.0.* Washington, D.C.: Verified Carbon Standard Association.

Voluntary Carbon Standard. (2008c). *Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination.* Washington D.C.: VCS Association.

Voluntary Carbon Standard. (2010b). *Tool for the Demonstration and Assessment of Additionality in VCS Agriculture, Forestry and Other Land Use (AFOLU) Project Activities.* Washington D.C.: VCS Association.

Winrock International. (2002). *Measuring and Monitoring Plan for the Forests Around Perenosa Bay, Afognak Island, Alaska. Report prepared for the American Land Conservancy and the Rocky Mountain Elk Foundation.* Arlington, VA: Winrock International.

Zhang, Y. M., Cormier, D., Lyng, R., Mabee, W., Ogino, A., & McLean, H. (2010). Life cycle emissions and cost of producing electricity from coal, natural gas, and wood pellets in Ontario, Canada. . *Environ. Sci. Technol.* , 44: 538-544.

# Appendix 1 – NON-PERMANENCE RISK ASSESSMENT

This assessment uses the latest approvaed VCS non-permanence tool as per the methodology requirement: VCS AFOLU Non-Permanence Risk Tool, v.3.1.

## Non-Permanence Risk Assessment Summary and Buffer Determination:

**Table 17 - Afognak Non-Permanence Risk Rating**

| RISK CRITERIA | Afognak RISK RATING | RISK SCORE |
|---|---|---|
| **INTERNAL RISKS** | | |
| **1. Project Management** | | |
| a) Species Planted | The project does not involve operational reforestation, and reforestation within the baseline (and relating to previous management) are based on natural regeneration from on-site native tree sources. | **0** |
| b) Ongoing Enforcement | The project area is now managed by the State of Alaska DNR staff along with adjacent state managed forests. No history of illegal activities (and the access and infrastructure requirements are clear barriers) exist in the region. No supplemental enforcement is required. | **0** |
| c) Management Team | LOW – The project management team at ALC/RMEF, Camco, and 3GreenTree hold all necessary experience related to all project activities, including experience developing and managing VCS forest and non-forest carbon projects. Camco, as the Project Proponent Partner and primary project manager, is one of the world's leading carbon project companies, with extensive experience globally across all major carbon standards, for multiple project types. 3GreenTree, as the Project Implementing Partner, is one of the leading forest carbon project developers with experience including creating methodology VM0012, developing the largest VCS forest carbon project in North America, and extensive forest management and ecosystem modeling expertise. Additional details on key staff have been provided to the audit team. | **0** |
| d) Project Team Location | The ALC and RMEF have an ongoing active programs in Alaska and proximal to Afognak Island. Camco and 3GreenTree are located within easy travel distance to the project site in Colorado and British Columbia, respectively. Camco is the primary project manager, and the base for the project is considered their offices near Denver, Colorado. | **0** |
| e) Mitigation: Team AFOLU/Carbon Experience | 3GreenTree holds significant experience developing and managing VCS AFOLU projects (further details at: http://3greentree.com/whatwe'vedone.html). Key staff include Mike Vitt BScF, MBA; Clive Welham, PhD., RPBio, and Brad Seely, PhD. | **-2** |

| | | |
|---|---|---|
| | (http://3greentree.com/team.html) .<br><br>Camco holds significant experience developing and managing VCS non-AFOLU projects and projects under other carbon standards (further details at: http://www.camcoglobal.com/en/ourexpcarb.html). Key project staff include Charles Purshouse and Wiley Barbour (http://www.camcoglobal.com/en/managementteam.html). | |
| f) Adaptive Management Plan | As a protected forest conservation project, no specific additional adaptive management plans exist beyond retaining a robust fully functional native ecosystem. | **0** |
| Total Project Management (PM) = [a + b + c + d +e +f] | **PM = 0 + 0 + 0 + 0 + -2 + 0 =** | **-2** |
| **2. Financial Viability** | | |
| a, b, c, d) Project Cashflow BreakEven Timeline | The acquisition costs and subsequent donation are complete and considered sunk costs. The project operating costs will be breakeven in less than 4 years from this risk assessment, leading to the selection of risk rating "d". See tab "Financial Viability" in the Afognak Carbon Model listed in Appendix 3. | **0** |
| e, f, g, h) Funding Securement | The project has all of the necessary funding to cover the total cash required until breakeven, and therefore the selected risk rating is "h". | **0** |
| i) Mitigation: Project Callable Financial Resources | The project management team have the callable financial resources to finance the project through operating breakeven, and hence has selected the mitigation rating "i". See http://www.camcoglobal.com/en/invsannouncements.html for extensive financial reporting related to Camco that demonstrate callable financial assets to cover the project operating costs. | **-2** |
| Total Financial Viability (FV) | **FV = 0 + 0 + -2 =**<br><br>**(may not be less than zero)** | **0** |
| **3. Opportunity Cost** | | |
| a, b, c, d, e, f) NPV of Most Profitable Alternative | The NPV of the timber harvesting in the baseline scenario is likely between 20% more to 20% less than the returns from carbon in the project scenario, on an operational EBITDA basis and excluding consideration of acquisition capital. This leads to the selection of risk rating "d". The range is dependent on market conditions for logs and comparative VCU market price projections. See tab "Financial Viability" in the Afognak Carbon Model listed in Appendix | **0** |

| | | |
|---|---|---|
| | 3 for a basic demonstration NPV calculation. | |
| g) Mitigation: Non-profit project proponent | ALC/RMEF are non-profit conservation organizations, however the project has selected risk mitigation rating "i" instead. | **0** |
| h) Mitigation: Legal Commitments over Project Period | Afognak is protected by a Federal Conservation Easement over 100 years vs. a project crediting period of 30 years, , however the project has selected risk mitigation rating "i" instead. | **0** |
| i) Mitigation: Legal Commitments over Project Period | The Afognak project area is protected by a legally binding perpetual Federal Conservation Easement over 100 years, so the project has applied the risk mitigation rating "i" | **-8** |
| **Total Opportunity Cost (OC)** | **OC = 0 + -2 + -8 =**<br><br>**(may not be less than zero)** | **0** |
| **4. Project Longevity** | | |
| a, b) Length of legal agreement vs. crediting period | The Afognak has a legally binding Federal Conservation Easement that mandates continuation of the project scenario conservation management in perpetuity. The project crediting period is 30 years, however as per Section 2.2.4, Item 5 in the risk rating tool, the presence of a legally binding perpetual (i.e. >100 year) conservation rating assigns the project longevity score of zero. This risk rating assignment over-rides the internal risk calculations in "a" and "b". | |
| **Total Project Longevity (PL)** | **PL = Default risk rating of zero =** | **0** |
| | **TOTAL INTERNAL RISKS = (PM + FV + OC + PL)**<br><br>**= -2 + 0 + 0 + 0 =**<br><br>**(may not be less than zero)** | **0** |
| **<u>EXTERNAL RISKS</u>** | | |
| 6. Land Tenure | | |
| a, b) Ownership of rights | The carbon proof of right and right of use are held by ALC and RMEF, while the surface rights are owned by the State of Alaska under a Federal Conservation Easement, which results in a selection of risk rating "b". | **2** |
| c, d) Ownership disputes | There are no known land ownership disputes, as asserted by ALC/RMEF as per title search and insurance processes and government due diligence during the transactions. Given the history of the land transaction (from long | **0** |

| | | |
|---|---|---|
| | held federal land to native corporations in land treaty settlement, to willing sale from native corporation to ALC/RMEF/State of Alaska as fee simple, the likihood of outstanding land ownership dispute is very low. Therefore the project has selected a risk rating of zero (as per 2.3.1, Item 2 – there are no additional disputes to be added to the risk score), and neither "c" nor "d" are applicable. | |
| e) Mitigation: Legal Commitment > Project | The Afognak project is protected by a Federal Conservation Easement to continue project scenario management practices in perpetuity (>100 years), therefore the project has applied the risk mitigation "e". | **-2** |
| f) Mitigation: Dispute Resolution | There are no land or tenure disputes related to the Afognak Property, therefore risk mitigation "f" is not applicable. | **0** |
| **Total Land Tenure (LT)** | **LT = 0 + -2 + 0**<br><br>**(total may not be less than zero)** | **0** |
| **7. Community Engagement** | | |
| a, b, c) | No populations are living on the project area or within 20km of the project area; nor are populations reliant on the property area for subsistence purposes. Therefore this risk rating is not applicable to the project, as per section 2.3.2 in the tool. | **0** |
| **Total Community Engagement (CE)** | **CE =** | **0** |
| **8. Political Risks** | | |
| a, b, c, d, e) WGI Governance Score | United States average for the period of 2006-2010 = 1.22, therefore risk rating "e" has been applied. WBI Governance Indicators for this period: | **0** |

| Sources | Year | Percentile Rank (0-100) | Governance Score (-2.5 to +2.5) | Standard Error |
|---|---|---|---|---|
| 13 | 2010 | 87.2 | 1.16 | 0.14 |
| 13 | 2009 | 86.3 | 1.13 | 0.14 |
| 13 | 2008 | 85.1 | 1.08 | 0.14 |
| 13 | 2007 | 84.1 | 1.09 | 0.14 |
| 12 | 2006 | 86.1 | 1.09 | 0.14 |
| 8 | 2010 | 56.6 | 0.31 | 0.23 |
| 8 | 2009 | 55 | 0.32 | 0.23 |
| 8 | 2008 | 60.1 | 0.43 | 0.24 |
| 8 | 2007 | 52.9 | 0.23 | 0.23 |
| 8 | 2006 | 57.2 | 0.35 | 0.24 |
| 7 | 2010 | 90 | 1.44 | 0.22 |
| 7 | 2009 | 88.5 | 1.4 | 0.21 |
| 7 | 2008 | 89.3 | 1.52 | 0.22 |
| 7 | 2007 | 90.8 | 1.58 | 0.21 |
| 7 | 2006 | 89.8 | 1.55 | 0.19 |
| 7 | 2010 | 90.4 | 1.42 | 0.23 |
| 7 | 2009 | 90.9 | 1.39 | 0.22 |
| 7 | 2008 | 93.2 | 1.55 | 0.22 |
| 7 | 2007 | 92.2 | 1.5 | 0.22 |
| 7 | 2006 | 95.6 | 1.65 | 0.2 |
| 12 | 2010 | 91.5 | 1.58 | 0.15 |
| 12 | 2009 | 91.5 | 1.54 | 0.15 |
| 11 | 2008 | 91.8 | 1.66 | 0.16 |
| 11 | 2007 | 91.9 | 1.6 | 0.16 |
| 10 | 2006 | 91.4 | 1.59 | 0.15 |
| 11 | 2010 | 85.6 | 1.23 | 0.15 |
| 11 | 2009 | 84.7 | 1.16 | 0.15 |
| 11 | 2008 | 91.7 | 1.45 | 0.15 |
| 10 | 2007 | 85.9 | 1.29 | 0.17 |
| 10 | 2006 | 85.4 | 1.27 | 0.16 |

| Year: | Average Scor |
|---|---|
| 2010 | 1.19 |
| 2009 | 1.16 |
| 2008 | 1.28 |
| 2007 | 1.22 |
| 2006 | 1.25 |
| **5 Yr. Avg:** | **1.22** |

| | | |
|---|---|---|
| f) Mitigation: Activities in 2.3.3 | The U.S. has an established FSC standard body, hence risk mitigation rating "f" has been applied. | **-2** |
| **Total Political (PC)** | **PC = 0 + -2**<br><br>**(may not be less than zero)** | **0** |
| **TOTAL EXTERNAL RISKS** | **= LT + CE + PC**<br><br>**= 0 + 0 + 0 =** | **0** |
| **NATURAL RISKS** | | |
| a) Fire (F) | Likelihood: >100 years<br><br>- These are very wet coastal rainforests with fire return intervals in excess of 500 years.<br><br>Significance: Major<br><br>- Spatial separation of properties and breaks created by logging inside and | **0** |

| | | |
|---|---|---|
| | outside the project area, lakes, ocean, etc. reduce the risk of extensive damage.<br><br>Mitigation: The Alaska DNR has extensive fire fighting expertise and capability, however this remote location and lack of other valuable development assets would reduce their response spending. The existing all weather road system would contribute ground based fire capabilities, and mobile fire fighting equipment would conceivably be available from Kodiak and mainland Alaska. We have not applied the mitigation factors because of the remote project location. | |
| b) Pest and Disease (PD) | Likelihood: Every 50-100 years (conservatively)<br><br>- While Sitka spruce is susceptible to several pest and disease agents through its range in the northwestern coastal region of North America, it is clear that the risk of stand-replacing events is much greater in the southern portion of its range (e.g south of Alaska) (Burns, 1990). Agents that can impact sitka spruce include the following:<br>o White pine weevil (Pissodes strobe) – significant damaging agent in Oregon, Washington and southern British Columbia. Not a problem in Alaska due to cooler temperatures (Burns, 1990)<br>o Spruce aphid – mainly a problem for ornamental trees, short-lived epidemics (Burns, 1990)<br>o Root-collar weevil (Stremnius carinatus) – only causes mortality in seedlings (Burns, 1990).<br>o Spruce bark beetle (Dendroctonus rufipennis) – periodically damages stands throughout the range (Burns, 1990), but tends to 'thin' stands instead of causing stand replacing mortality. Berg et al ( (Berg, Henry, Fastie, De Volder, & Matsuoka, 2006)) report a mean return interval of 52 years on the Kenai Peninsula and found that it outbreaks generally cause a thinning effect after which residual trees show a positive growth response and generally close canopy within a 5-10 year period.<br><br>- There is no evidence or record of extensive pest or disease outbreaks in the Afognak forests. The project area is old growth, native forest that would be naturally resilient to most pest and disease. Based on the forest age, it is clear no observable stand changing outbreak has occurred in the past 150-250 years.<br>- To account for the impact of endemic gap disturbance events from natural disturbance agents, the stand-level simulations conducted in FORECAST included the periodic disturbance events for sitka spruce. These events occurred every 20 years beginning at age 40 and caused mortality of 3% of the live spruce stems distributed evenly across the size profile. This modeled disturbance regime produces a snag population that is consistent with the snag population observed in the field plots. | **1** |

| | | |
|---|---|---|
| | Significance: Major<br><br>- However, as the Afognak forest is a single tree species, there is risk that IF an outbreak was to occur, there could be damage across the forest. We are unaware of an example of a devastating, stand replacing type of outbreak in natural coastal rainforest ecosystems on Afognak, so the risk of devastating outbreak is low or non-existent.<br><br>Mitigation: The project proponents and Alaska DNR have extensive experience with forest health assessments and management, and therefore if an encroaching outbreak was found, management actions could be undertaken to avoid expansion. However, we have not applied the risk assessment mitigation factor as a conservative measure. | |
| c) Extreme Weather (W) | Likelihood: Every 50 to 100 years<br><br>- Although this area is subject to severe marine weather, and particularly wind, there is no visible evidence of large areas of blowdown or other weather induced damage on the project site. In fact, ground reconnaissance saw a notable lack of even single tree blowdown and breakage (as would be expected in this coastal environment). This site had none of the blowdown evidence common to, for example, coastal BC. These forests appear remarkably well adapted to their environment. To be conservative, we have assumed that some type of major wind event might affect the property on a 50-100 year interval.<br><br>Significance: Insignificant<br><br>- there is no evidence of visible or stand replacing weather damage events on the project area. Stand ages are consistently above 160 years. Therefore we have assumed that extreme weather might impact individual or small groups of trees via blowdown or breakage, the openings of which would be recovered relatively rapidly by the surrounding stand.<br><br>Mitigation: No mitigation factor has been applied. | **0** |
| d) Geological Risk (G) | Likelihood: >100 years<br><br>- The Afognak properties lie within an active volcanic and tectonic region. There are no active volcanoes or active fault lines on Afognak Island (http://www.avo.alaska.edu/map), however, similar to the west coast of North America there is a major fault line several hundred miles southwest which caused a major earthquake and tsunami in 1964. The property was also subject to significant ash fall from a volcano on mainland Alaska (Novarupta, 161km NW) in 1912, which was the largest global volcanic eruption of the 20th century, and the largest in Alaskan recorded history. No other major events have occurred since white settlement in the late 1700's, and the likely return interval is in the hundreds, if not thousands of years. | **0** |

| | | |
|---|---|---|
| | Significance: Minor<br><br>- The 1964 earthquake was the largest ever recorded in North America (9.2) and the second largest in the world, with an epicenter within 150km of Afognak. This major earthquake, aftershocks and landslides on the mainland unleashed a series of the largest tsunamis ever recorded. Kodiak and Afognak Islands were hit by 6-20m waves (i.e. see www.wcatwc.arh.noaa.gov/web_tsus/19640328/kodiak.gif), which affected manmade structures in Kodiak and various other villages significantly. However, there is no obvious evidence of impact in the forests along the beach on the properties. The terrain is rolling and would be very stable landforms, and certainly the current forests have stood for at least 160-250 years. The lack of damage from the very large tsunami shows either the bay was relatively protected on this event and/or that there is enough elevation gain from the shoreline to prevent significant forest damage. It is our assessment that given the magnitude of the events on the record and the lack of material damage to the project area forests, that the risk of an earthquake or tsunami impacting a significant amount of carbon biomass on the properties is low, and under the worst conditions might be related to lower elevation shoreline areas involving a very low proportion of the carbon involved in the project.<br><br>- Similarly, the 1912 Novarupta eruption blanketed Afognak and Kodiak Islands with over 1 foot of ash, which had detrimental affects on humans and wildlife; however the affects on spruce trees were short-lived. Tree ring studies by Eggler (Eggler, 1967) showed spruce on the mainland near Afognak had depressed growth for 2-4 years, followed by an increase in growth for the following decade. Other studies show short term growth can be limited after major ash events, but trees survive and can improve growth in future years. It is our assessment that there is no direct damage threat from volcanoes on the property, and the impacts of major ash events are limited to short term growth inhibition followed by longer term growth enhancement; and such the overall significance to the site carbon balance will be minor (or even positive).<br><br>Mitigation: No mitigation adjustment has been made. | |
| e) Other Natural Risk (ON) | No other known natural risks affect the property, and hence this risk element is not applicable. | **0** |
| **Total Natural Risk (NR)** | **NR = 0 + 1 + 0 + 0 + 0** | **1** |
| **4. OVERALL RISK RATING** | | |
| **a) INTERNAL RISK** | **= 0** | |

| | | |
|---|---|---|
| **b) EXTERNAL RISK** | **= 0** | |
| **c) NATURAL RISK** | **= 1** | |
| **TOTAL RISK RATING = 1 (default minimum risk rating = 10%, as per Section 2.5.2)**<br>**THE PROJECT WILL APPLY A PERMANENCE BUFFER RISK RATING OF 10.0%** | | |

# Appendix 2 – Methodology Equations Usage

The following sections provide a listing of equations described in the VCS methodology document, and used to calculate the carbon balance in the baseline and project case, for the Afognak property. Estimated values for all parameters are listed either in Table 4 of the PDD, two tables provided in this Appendix for HWP, or directly specified within the models being used. Selection of parameter (and input) values requires a balance between accuracy and conservativeness. Accuracy should always prevail except when alternative values are of equivalent accuracy, in which case the more conservative value is used. Details regarding model selection (i.e., FORECAST, Landscape Summary Tool, and growth and yield models used to derive input values to FORECAST) and their appropriateness are provided in section 4 of the PDD.

As noted in the PDD (section 4.1), the project area was stratified into a total of 2 homogeneous analysis units. In practice, the biomass dynamics of each ecosystem pool for a given analysis unit were simulated in FORECAST, and converted into its carbon equivalent. The resulting output was then assembled into a library database. This database was used by Landscape Summary Tool to track the carbon stored in all of the inventory subregions to which an analysis unit is assigned. A schematic representation of model interactions is presented in Figure 9 of the PDD and further details are described in section 4.1. The equation list in this Appendix represents the summarized carbon or biomass pools by subregion. At relevant points, reference is provided to summary documents of the actual calculations reported in the PDD.

In each section below a description of how the equations are represented within the modeling tools used in the project. These sections are highlighted in non-italics & green text, while the quoted methodology text is in italics, black text.

All equation and section numbering and cross-referencing is related to the methodology document unless otherwise noted:

## Calculating the Baseline Carbon Balance

The total annual carbon balance for each inventory subregion within the project landbase is tracked using the Landscape Summary Tool model in combination with the ecosystem carbon storage curves generated using FORECAST for each analysis unit. The annual carbon content (tracked for each ecosystem pool) is then summed each year for the whole landbase in baseline scenario by Landscape Summary Tool (see Appendix 3), and then summarized in the Afognak Carbon Model spreadsheet ((Equations 1-3, 10). The annual change in harvested wood products storage (Equations 2, 18) is calculated in the Afognak Carbon Model sheet (see below) using the annual simulated harvested wood volume output from Landscape Summary Tool to drive the calculations.

*This methodology employs the IPCC gain-loss method* (IPCC, 2006a)*, which requires the biomass carbon loss be subtracted from the biomass carbon increment for the reporting year. This method is particularly appropriate for areas with a mix of stands of different forest types, and/or where biomass* *change is very small compared to the total amount of biomass. Further details can be found in* (IPCC, 2006a) *(Ch. 4).*

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

$$\Delta \boldsymbol{C}_{BSL,t} = \Delta \boldsymbol{C}_{BSL,P,t} \quad (1)$$

*where:*

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

$$\Delta \boldsymbol{C}_{BSL,P,t} = \Delta \boldsymbol{C}_{BSL,LB,t} + \Delta \boldsymbol{C}_{BSl,HWP,t} \quad (2)$$

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

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

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

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

*where:*

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

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

*If the project area has been stratified, carbon pools are calculated for each subregion, i and then summed during a given year, t.*

### Live Biomass Gain

The total annual live biomass gain for each subregion, *i* within the project landbase is tracked using the Landscape Summary Tool model in combination with the ecosystem carbon storage curves generated using FORECAST for each analysis unit. Landscape Summary Tool determines the amount of C storage in each inventory subregion using its tracked age to lookup the live biomass value from the carbon curve assigned to the subregion (based upon its assigned analysis unit). The FORECAST carbon table provides values in t ha-1, which are then converted to total tons by Landscape Summary Tool by multiplying by the area of the subregion (Equation 4). The amount carbon stored in above and below ground live biomass is calculated by FORECAST (Equations 5a-b) based upon the age dependent root shoot ratio ($R_i$) represented in the model. (see Table 4).

*Live biomass gain in year, t, subregion, i ($\Delta C_{BSL,G,i.t}$) is calculated as:*

$$\Delta \boldsymbol{C}_{BSL,G,t} = \Sigma(\boldsymbol{A}_{BSL,i} \bullet \boldsymbol{G}_{BSL,i,t}) \bullet \boldsymbol{CF} \quad (4)$$

*where:*

*$A_{BSL,i,}$ = area (ha) of forest land in subregion, i;*

*$G_{BSL,i,t}$ = annual increment rate in tree biomass (t d.m. $ha^{-1}$ $yr^{-1}$), in subregion, i, and;*

*CF = carbon fraction of dry matter t C $t^{-1}$ d.m. (IPCC default value = 0.5).*

$$G_{BSL,i,t} = G_{BSL,AG,i,t} + G_{BSL,BG,i,t} \qquad (5a)$$

*where $G_{BSL,AG,i,t}$ and $G_{BSL,BG,i,t}$ are the annual above- and below-ground biomass increment rates (t d.m. $ha^{-1}$ $yr^{-1}$);*

$$G_{BSL,BG,i,t} = G_{BSL,AG,i,t} \bullet R_i \qquad (5b)$$

*where $R_i$ is the root:shoot ratio in subregion, i.*

## Live Biomass Loss

The total annual live biomass loss for each subregion, *i* within the project landbase (Equations 6-8) is tracked using the Landscape Summary Tool model in combination with the ecosystem carbon storage curves generated using FORECAST for each analysis unit. Within-stand losses related to natural mortality and stand-self thinning are captured within the carbon storage curves generated by FORECAST for each analysis unit. Live biomass loss through harvesting is represented using the harvest areas shown in the Landscape Summary Tool to determine when a specified area is harvested. When this occurs, the specified area has its age reset to 1 and switches to the associated managed stand analysis unit. Losses through road construction and landings (Equation 9) are conservatively assumed to be 0 in the baseline scenario because of the existing road network on the property.

*The annual decrease in live biomass tree carbon from live biomass loss ($\Delta C_{BSL,L,t;}$ t C $yr^{-1}$) is the sum of losses from:*

1. *Natural mortality (i.e. insects, disease, competition, wind, etc.)*
2. *Commercial round wood felling*
3. *Incidental sources.*

*Losses must be specific to a given subregion ; each subregion must be summed in order to calculate total annual loss across the project activity area. The live biomass losses are not emitted directly, but rather are transferred to dead organic matter pools.*

$$\Delta C_{BSL,L,t} = \Sigma(LBL_{BSL,NATURALi,t} + LBL_{BSL,FELLINGS,i,t} + LBL_{BSL,OTHER,i,t}) \bullet CF \qquad (6)$$

*where:*

*$LBL_{BSL,NATURALi,t}$ = annual loss of live tree biomass due to natural mortality in subregion, i; t d.m. $yr^{-1}$*

*$LBL_{BSL,FELLINGS,i,t}$ = annual loss of live tree biomass due to commercial felling in subregion, i; t d.m. $yr^{-1}$*

*$LBL_{BSL,OTHER,i,t}$ = annual loss of live tree biomass from incidental sources in subregion, i; t d.m. $yr^{-1}$*

*CF = carbon fraction of dry matter; t C $t^{-1}$ d.m. (IPCC default value = 0.5).*

$$LBL_{BSL,NATURALi,t} = A_{BSL,i} \bullet LB_{BSL,i,t} \bullet f_{BSL,NATURAL,i,t} \qquad (7)$$[11]

*where*

$A_{BSL,i}$ = *area (ha) of forest land in subregion, i;*

$LB_{BSL,i,t}$ = *average live tree biomass (t d.m. ha*$^{-1}$*) in subregion, i, for year, t*

$LB_{BSL,i,t}$ *is calculated for year, t, beginning with biomass estimates in year t=1 (the project start year) and with annual biomass increments (*$G_{BSL,i,t}$*) added as per calculations in equation 5a.*

$f_{BSL,NATURAL,i,t}$ = *the annual proportion of biomass that dies from natural mortality in subregion , i (unitless;* $0 \leq f_{BSL,NATURALi} \leq 1$*), year, t. Tree mortality is an ongoing process during stand development. Trees die as a consequence of insect attack, disease, competition, or some combination thereof. Hence, mortality can be highly variable between years. This parameter can be applied uniformly across an analysis unit , or individually to a given subregion. Sources for mortality estimates include permanent sample plots in similar stand types, literature reports, and inventory data.*

$$LBL_{FELLINGS,i,t} = A_{BSL,i} \bullet LB_{BSL,i,t} \bullet f_{BSL,HARVEST,i,t} \qquad (8)$$

*where:*

$A_{BSL,i}$ = *area (ha) of forest land in subregion, i*

$LB_{BSL,i,t}$ = *average live tree biomass (t d.m. ha*$^{-1}$*) in subregion, i, for year, t (see equation 7 for its calculation).*

$f_{BSL,HARVEST,i,t}$ = *the proportion of biomass removed by harvesting from subregion, i, (unitless;* $0 \leq f_{BSL,HARVESTIi} \leq 1$*), in year, t. Data for this variable should be obtained from harvest schedule information. Values may be constrained by (a) the value of* $f_{BSL,NATURAL,i,t}$ *(i.e.,* $f_{BSL,HARVEST,i,t} < 1- f_{BSL,NATURAL,i,t}$*), and/or (b) the area of timber available for commercial harvest.*

*Incidental loss (*$LBL_{BSL,OTHER,i,t}$*; t d.m. yr*$^{-1}$*) is the additional live tree biomass removed for road and landing construction in the subregion, i, and is calculated as a proportion of biomass removed by harvesting:*

$$LBL_{BSL,OTHER,i,t} = A_{BSL,i} \bullet LB_{BSL,i,t} \bullet f_{BSL,DAMAGE,i,t} \qquad (9)$$

*where:*

$A_{BSL,i}$ = *area (ha) of forest land in subregion, i;*

$LB_{BSL,i,t}$ = *average live tree biomass (t d.m. ha*$^{-1}$*) in subregion, i, for year, t*

$f_{BSL,DAMAGE,i,t}$ = *the proportion of additional biomass removed by for road and landing construction in subregion, i, year, t (unitless;* $0 \leq f_{BSL,DAMAGE,i,t} \leq 1$*)*[12]*. Data for this variable should be based on regional and local comparative studies and experiential information* derived from the local forest industry[13].

---

[11] Note, for Equation 7, 8, and 9: $(f_{BSL,NATURAL,i,t} + f_{BSL,HARVEST,i,t} + f_{BSL,DAMAGE,i,t}) \leq 1.0$

### Dead Organic Matter Dynamics ($\Delta C_{BSL,DOM}$)

Dead organic matter dynamics including dead wood and snag creation and decay have been simulated using FORECAST for each analysis unit. Thus, Equations 10-17 are captured within the carbon curves generated by FORECAST for each analysis unit and tracked on the landbase using the Landscape Summary Tool in conjunction with the spatial inventory data.

*Dead organic matter (DOM) included in this methodology comprises three components: standing dead wood (minimum $\geq$ 5 cm DBH and 1.3 m height; termed snags), lying dead wood (minimum $\geq$ 5 cm DBH; LDW), and belowground dead wood (i.e., dead roots). Standing dead wood is < 45º of vertical, while lying dead wood is $\geq$ 45º of vertical.*

*The annual change in carbon stocks in DOM ($\Delta C_{BSL,DOM}$; t C $yr^{-1}$) is calculated as:*

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

*where:*

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

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

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

$$\Delta C_{BSL,LDW,t} = \Sigma(LDW_{BSL,IN,i,t} - LDW_{BSL,OUT,i,t}) \bullet CF \quad (11a)$$

$$LDW_{BSL,i,t+1} = LDW_{BSL,i,t} + (LDW_{BSL,IN,i,t} - LDW_{BSL,OUT,i,t}) \quad (11b)$$

*where:*

$LDW_{BSL,,i,t}$ = *The total mass of lying dead wood accumulated in subregion i , at time, t (t d.m.).*

$LDW_{BSL,IN,i,t}$ = *annual increase in LDW biomass for subregion i, year, t (t d.m $yr^{-1}$). LDW increases occur as a result of natural mortality (typically, blowdown), and as a direct or indirect result of harvesting.*

$LDW_{BSL,OUT,i,t}$ = *annual loss in LDW biomass through decay, for subregion i, year, t, (t d.m $yr^{-1}$)*

$LDW_{BSL,IN,i,t}$ *and* $LDW_{BSL,OUT,i,t}$ *are summed across subregions.*

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

$$LDW_{BSL,IN,i,t} = (LBL_{BSL,NATURALi,t} - LBL_{BSL,NATURALi,t} \bullet R_i) \bullet f_{BSL,BLOWDOWN,i,t} +$$

---

[12] Projecting ex-ante road and landing removals beyond a few years is difficult and complex. As described, $f_{BSL,DAMAGE,i,t}$ functions as a proxy for estimating biomass impacts of all new roads and landings associated with annual harvesting in subregion, i. Project proponents can simulate $LBL_{BSL,OTHER,i,t}$ directly, if appropriate models are available.
[13] $f_{BSL,DAMAGE,i,t}$ may be zero or de minimis in cases where a subregion is already roaded.

$$((LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i) +$$

$$(LBL_{BSL,OTHER,i,t} - LBL_{BSL,OTHER,i,t} \bullet R_i)) \bullet f_{BSL,BRANCH,i,t} +$$

$$((LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i) +$$

$$(LBL_{BSL,OTHER,i,t} - LBL_{BSL,OTHER,i,t} \bullet R_i)) \bullet$$

$$(1 - f_{BSL,BRANCH,i,t}) \bullet f_{BSL,BUCKINGLOSS,i,t} + SNAG_{BSL,,i,t} \bullet f_{BSL,SNAGFALLDOWN,i,t} \quad (12)$$

*where:*

*$LBL_{BSL,NATURALi,t}$, $LBL_{BSL,FELLINGS,i,t,}$ and $LBL_{BSL,OTHER,i,t}$ are as calculated in equations 7, 8, and 9, respectively.*

*$R_i$ is the root:shoot ratio in subregion, i (see equation 5b).*

*$f_{BSL,BLOWDOWN,i,t}$ = the annual proportion of live aboveground tree biomass subject to blowdown in subregion, i, year, t (unitless; $0 \leq f_{BSL,BLOWDOWN,i,t} \leq 1$). Ex ante estimates shall be derived preferably from regional reports in similar forest types.*

*$f_{BSL,BRANCH,i,t}$ = the annual proportion of aboveground tree biomass comprised of branches ≥ 5 cm diameter in subregion, i (unitless; $0 \leq f_{BSL,BRANCH,i,t} \leq 1$). Ex ante data are available from allometric equations and models (for example,* (Kurz & Apps, 2006) *for Canada;* (Smith, Miles, Vissage, & Pugh, 2004) *for the U.S.). In the event slash burning was undertaken as part of regular management activities, this parameter should be reduced accordingly to reflect the proportion of biomass remaining. Estimates should be obtained from expert opinion; as a default, assume 100% consumption if slash burning occurs.*

*$f_{BSL,BUCKINGLOSS,i,t}$ = the annual proportion of the log bole biomass left on site after assessing and/or merchandizing the log bole for quality, in subregion, i (unitless; $0 \leq f_{BSL,BUCKINGLOSS,i,t} \leq 1$). Preferably, data for this variable shall be based on regional and local comparative studies and experiential information derived from the local forest industry. Otherwise, an average default value of 21% can be used, based on US national summary statistics* (Smith, Miles, Vissage, & Pugh, 2004).

*$SNAG_{BSL,,i,t}$ = the total mass of the snag pool in subregion, i, year, t (see equation 14b).*

*$f_{BSL,SNAGFALLDOWN,i,t}$ = the annual proportion of snag biomass in subregion, i, year, t, that falls over and thus is transferred to the LDW pool (unitless; $0 \leq f_{SNAGFALLDOWN,i,t} \leq 1$). Ex ante estimates for this parameter can be derived from peer reviewed literature (for example,* (Parish, Antos, Ott, & Di Lucca, 2010) *and forest carbon accounting models that track the rates of input and losses from dead organic matter pools (for example,* (Kurz & et al, 2009).

$$LDW_{BSL,OUT,i,t} = LDW_{BSL,,i,t} \bullet f_{BSL,lwDECAY,i,t} \quad (13)$$

*where:*

*$LDW_{BSL,,i,t}$ = the total amount of lying deadwood mass in subregion i, year, t (see equation 11b).*
*$f_{BSL,lwDECAY,i,t}$ = the annual proportional loss of lying dead biomass due to decay, in subregion i, year, t*

*(unitless; ; $0 \leq f_{BSL,lwDECAY,i,t} \leq 1$). A common approach to ex ante estimation of $f_{BSL,lwDECAY,i,t}$ is to assume mass loss occurs in proportion to the amount of mass remaining in accordance with 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* (Harmon, et al., 1986)*. Other types of exponential models are available (reviewed in* (Harmon, et al., 1986)*) and may be more appropriate to particular forest types (to be described and justified by the project proponent, if used). Ex ante estimates for the decay parameter appropriate for the project should be derived from peer-reviewed literature (for example,* (Harmon, et al., 1986)*;* (Laiho & and Prescott, 2004)*;* (Harmon et al, 2008)*).*

*The change in standing dead wood (snag) carbon stock in year, t (t C $yr^{-1}$) is calculated as:*

$$\Delta C_{BSL,SNAG,t} = \Sigma(SNAG_{BSL,IN,i,t} - SNAG_{BSL,OUT,i,t}) \bullet CF \quad (14a)$$

$$SNAG_{BSL,i,t+1} = SNAG_{BSL,i,t} + (SNAG_{BSL,IN,i,t} - SNAG_{BSL,OUT,i,t}) \quad (14b)$$

*where:*

$SNAG_{BSL,i,t}$ *= The total mass of snags accumulated in subregion i, at time t (t d.m.).*

$SNAG_{BSL,IN,i,t}$ *= annual gain in snag biomass for subregion i, year, t (t d.m $yr^{-1}$). Snag biomass develops as a result of natural mortality. In cases where snags are created through management activities, these should be accounted for here.*

$SNAG_{BSL,OUT,i,t}$ *= annual loss in snag biomass through decay, or falldown (i.e, transfer to the LDW pool)(t d.m $yr^{-1}$)*

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

*Note that $SNAG_{BSL,IN,i,t}$ and $SNAG_{BSL,OUT,i,t}$ are summed across subregions.*

$$SNAG_{BSL,IN,i,t} = (LBL_{BSL,NATURALi,t} - LBL_{BSL,NATURALi,t} \bullet R_i) \bullet (1 - f_{BSL,BLOWDOWN,i,t}) \quad (15)$$

*where:*

$LBL_{BSL,NATURALi,t}$ *is as calculated in equation 7, and*

*$1 - f_{BSL,BLOWDOWN,i,t}$ is the proportion of live tree aboveground biomass that dies in subregion, i, year, t, but remains as standing dead organic matter (i.e., snags) (unitless; $0 \leq f_{BSL,BLOWDOWN,i,t} \leq 1$). Ex ante default estimates for this calculation can be derived from literature values (for example* (Harmon, et al., 1986)*;* (Runkle, 2000)*;* (Harmon et al, 2008)*) and should be matched to the ecosystems that most closely characterize the project area.*

$$SNAG_{BSL,OUT,i,t} = SNAG_{BSL,i,t} \bullet f_{BSL,SWDECAY,i,t} + SNAG_{BSL,i,t} \bullet f_{BSL,SNAGFALLDOWN,i,t} \quad (16)$$

*where:*

*$SNAG_{BSL,i,t}$ = the total amount of snag mass in subregion i, year, t (see equation 14b). $f_{BSL,SWDECAY,i,t}$ = the annual proportional loss of snag biomass due to decay, in subregion, i, year, t (unitless; $0 \leq f_{BSL,SWDECAY,i,t} \leq 1$). As with lying dead wood, a common approach to estimating $f_{BSL,SWDECAY,i,t}$ is to assume mass loss occurs in proportion to the amount of mass remaining in accordance with a single exponential model (see equation 13). Ex ante estimates for this parameter should be derived from peer reviewed literature appropriate for the project site (for example, Vanderwel et al. 2006a) and forest carbon accounting models that track the rates of input and losses from dead organic matter pools for each forest type, productivity, and age-class (see, for example, Vanderwel et al., 2006b;* (Kurz & et al, 2009)*).*

*$f_{BSL,SNAGFALLDOWN,i,t}$ = the annual proportion of snag biomass in subregion, i, that falls over and thus is transferred to the LDW pool (unitless; $0 \leq f_{BSL,SNAGFALLDOWN,i,t} \leq 1$). See equation 12 for parameter estimates.*

*The annual change in DOM derived from dead belowground biomass ($\Delta C_{BSL,DBG,,t}$; t C $yr^{-1}$) is calculated for each subregion as per equation 17a. Calculation of $\Delta C_{BSL,DBG,t}$ is specific to a given subregion; each subregion must therefore be summed in order to calculate total annual loss across the project activity area.*

$$\Delta C_{BSL,DBG,t} = \Sigma(DBG_{BSL,IN,i,t} - DBG_{BSL,OUT,i,t}) \bullet CF \qquad (17a)$$

$$DBG_{BSL,i,t+1} = DBG_{BSL,i,t} + (DBG_{BSL,IN,i,t} - DBG_{BSL,OUT,i,t}) \qquad (17b)$$

*where:*

*$DGB_{BSL,i,t}$ = The total quantity of dead belowground biomass accumulated in subregion i, at time, t (t d.m.).*

*$DBG_{BSL,IN,i,t}$ = annual gain in dead belowground biomass for subregion i, year, t (t d.m $yr^{-1}$). Dead belowground biomass develops as a result of mortality through natural causes or through harvesting activities.*

*$DBG_{BSL,OUT,i,t}$ = annual loss in dead belowground biomass through decay, (t d.m $yr^{-1}$)*

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

$$DBG_{BSL,IN,i,t} = [(A_{BSL,i} \bullet LB_{BSL,i,t} \bullet R_i) \bullet (f_{BSL,NATURAL,i,t} + f_{BSL,HARVEST,i,t} + f_{BSL,DAMAGE,i,t})] \qquad (17c)$$

*where:*

*$A_{BSL,i}$ = area (ha) of forest land in subregion, i;*

*$LB_{BSL,i,t}$ = average live tree biomass (t d.m. $ha^{-1}$) in subregion, i, for year, t. $LB_{BSL,i,t}$ is calculated for year, t, beginning with biomass estimates in year t=1 (the project start year) and with annual biomass increments ($G_{BSL,i,t}$) added as per calculations in equation 5 a, b. This value is then multiplied by $A_{BSL,i,}$ the area (ha) of forest land in subregion, i.*

*$R_i$ is the root:shoot ratio in subregion, i (see equation 5b).*

*$f_{BSL,NATURAL,i,t}$ = the annual proportion of biomass that dies from natural mortality in subregion, i (unitless; $0 \leq f_{NATURALi} \leq 1$), year, t (see equation 7),*

*$f_{BSL,HARVEST,i,t}$ = the proportion of biomass removed by harvesting from subregion, i, (unitless; $0 \leq f_{HARVESTIi} \leq 1$), year, t (see equation 8),*

*$f_{BSL,DAMAGE,i,t}$ = the proportion of additional biomass removed by for road and landing construction in subregion, i (unitless; $0 \leq f_{DAMAGE,i,t} \leq 1$), year, t (see equation 9)*

$$DBG_{BSL,OUT,i,t} = DBG_{BSL,i,t} \bullet f_{BSL,dgbDECAY,i,t} \qquad (17d)$$

*where:*

*$DBG_{BSL,i,t}$ = the total quantity of dead belowground in subregion i, year, t (see equation 17b).*

*$f_{BSL,dgbDECAY,i,t}$ = the annual proportional loss of dead belowground biomass due to decay, in subregion i, year, t (unitless; ; $0 \leq f_{BSL,lwDECAY,i,t} \leq 1$). The ex ante estimation of the decay of dead belowground biomass should be done using a similar single exponent decay function as that described above for lying deadwood biomass. Estimates for the decay parameter appropriate for specific project should be derived from peer-reviewed literature (see for example:* (Moore, Trofymow, Siltanen, Prescott, & CIDET, 2005)*); Melin et al. (2009);* (Melin, Petersson, & Nordfjell, 2009)*).*

## Harvested Wood Products

All harvested wood products calculations are made within the Afognak Carbon Model; worksheet: Summary Tables and Figures (see references, Appendix 3), using key output data from the Landscape Summary Tool. Key assumptions used for the project in the Afognak Carbon Model spreadsheet are summarized Appendix 2, Table 1 and Appendix 2, Table 2 below. Additional assumptions and variables not described here are found in the Afognak Carbon Model spreadsheet.

*The annual change in the carbon stored in harvested wood products (HWP), $\Delta C_{BSl,HWP,t}$, is calculated as:*

$$\Delta C_{BSl,HWP,t} = \Delta C_{BSL,PERMHWP1,t} + \Delta C_{BSL,PERMHWP2,t} - \Delta C_{BSL,EMITFOSSIL,t}, \qquad (18)$$

*$\Delta C_{BSL,PERMHWP1,t}$ = the annual harvested carbon that remains in permanent storage after conversion to wood products during primary processing ($t\ C\ yr^{-1}$)*

*$\Delta C_{BSL,PERMHWP2,t}$ = carbon that remains in permanent storage after accounting for secondary processing of the residue carbon (biomass) generated from primary processing ($t\ C\ yr^{-1}$)*

*$\Delta C_{BSL,EMITFOSSIL,t}$ = fossil fuel emissions from harvesting (logging and log transport) and processing of the various wood products.*

## Permanent carbon storage from primary processing ($\Delta C_{BSL,PERMHWP1,t}$)

*The IPCC LUCF Sector Good Practice Guideline* (IPCC, 2003) *for country calculations recommends estimating changes in current stocks of carbon in products-in-use. This approach is not well suited at the project level, however, because of the necessity and difficulty of assembling historical production data, estimating current stocks, and then calculating their relative decay rates. The recommended method is therefore to calculate the long-term storage in HWP stocks attributable to current production. This approach avoids any post-project calculation of carbon emissions associated with product decay, and accounts only for the fraction of wood products in permanent storage over a defined period (100 years is the time frame acceptable to the IPCC) (IPCC, 2000). Application of this 100-year method involves five steps (detailed in* (Miner, 2006)*):*

1. *Identify the types and amounts of biomass-based products that are made in the year of interest and end up in a final product.*
2. *Express this annual production in terms of the amount of biomass carbon per year for each product.*
3. *Divide the products into categories based on function and allocate the carbon to the functional categories.*
4. *Use decay curves or other time-in-use information to estimate the fraction of the carbon in each functional category, expected to remain in use for 100 years.*
5. *Multiply the amount of carbon in annual production in products in each functional category by the fraction remaining at 100 years. The result is the amount of sequestered carbon in the products in each functional category attributable to this year's production.*

*A variety of equations are available to apply this method* (Miner, 2006)*; see below). Results are sensitive to the selection of time-in-use distributions. Existing time-in-use distributions, many of which have been created to develop national carbon inventories, should be used in the 100-year method only after their suitability for making long-term projections has been established. In some cases, this can be done with available data. Data for U.S. housing, for instance, have been analyzed to confirm that time-in-use information from the U.S. national inventory can be used in the 100-year method without over estimating carbon sequestration* (Miner, 2006)*.*

*The total carbon in permanent storage from primary processing in year t ($\Delta C_{BSL,PERMHWP1,t}$; t C $yr^{-1}$) is:*

$$\Delta C_{BSL,PERMHWP1,t} = \Sigma[(LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i + LBL_{BSL,OTHER,i,t} - LBL_{BSL,OTHER,i,t} \bullet R_i) \bullet (1 - f_{BSL,BRANCH,i,t}) \bullet (1 - f_{BSL,BUCKINGLOSS,i,t})] \bullet \Sigma(RE_{BSL,k} \bullet f_{BSL,PERMHWPk}) \bullet CF \quad (19)$$

*where:*

$LBL_{BSL,FELLINGS,i,t}$ *= annual removal of live tree biomass due to commercial felling in subregion, i; t d.m. yr-1 (see equation 8)*

$LBL_{BSL,OTHER,i,t}$ *= annual removal of live tree biomass from incidental sources in subregion, i; t d.m. yr-1 (see equation 9)*

*$R_i$ = the root:shoot ratio in subregion, i (see Table 4)*

*1 - $f_{BSL,BRANCH,i,t}$ the proportion of live tree biomass remaining after netting out branch biomass, in subregion i (unitless; 0 < - $f_{BSL,BRANCH,i,t}$ < 1)(see equation 12)*

*1 - $f_{BSL,BUCKINGLOSS,i,t}$ = the proportion of the log bole remaining after processing for quality, in subregion, i (unitless; 0 < $f_{BSL,BUCKINGLOSS,i,t}$ < 1) (see equation 12)*

*$RE_{BSL,k}$ = the recovery efficiency for each product type, k (unitless; 0 < $RE_{BSL,k}$ < 1).*

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

*Note that calculation of $LBL_{BSL,FELLINGS,i,t}$ , $LBL_{BSL,OTHER,i,t}$, $f_{BSL,BRANCH,i,t}$, and - $f_{BSL,BUCKINGLOSS,i,t}$ occurs internally within the FORECAST and/or ATLAS models, and are thus reflected in the value reported in the spreadsheet model for Carbon Removed in Harvested Logs (see Table 4 for additional information on these variables).*

$$RE_{BSL,k} = f_{BSL,PRODUCTk} \bullet f_{BSL,PROCESSk} \quad (20)$$

*where:*

*$f_{BSL,PRODUCTk}$, and $f_{BSL,PROCESSk}$, are the respective fractions allocated to a given forest product type, k, and its associated processing efficiency (unitless; $0 \leq f_{BSL,PRODUCTk}$, $f_{BSL,PROCESSk} < 1$).*

*Bucking loss (see equation 12), product allocation, and primary processing efficiency estimates are project specific and may be derived from local or regional average harvesting operations and wood processing facilities when available. Alternatively, project proponents shall select local or regionally appropriate primary processing efficiencies for milling based on published data. One source of information is the CAR Forestry Protocol 3.2, Appendix C* (Climate Action Reserve, 2010)*; national and regional published sources are also available (see for example,* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*,* (Smith, Miles, Vissage, & Pugh, 2004)*, and references therein).*

*$f_{BSL,PERMHWPk}$ = the fraction of biomass allocated to permanent storage after a 100-year time period, for each product type, k (unitless; $0 \leq f_{BSLPERMHWPk} < 1$). The simplest (i.e., default) approach is to use a first order decay function, of the following form* (Miner, 2006)*:*

$$f_{BSLPERMHWPk} = (1 / (1 + (Ln(2) / HL_k)))^{\wedge}Y \quad (21)$$

*where:*

*$HL_k$ is the half-life of a given product type, k (years), and Y is the elapsed time (i.e, 100 years). A number of other more complex decay functions are available (reviewed in* (Miner, 2006)*). See Appendix 2, Table 1 for default values. Values for permanent storage are entered in the spreadsheet model as Carbon Stored in Wood Products (After 100 years - 100 year method)*

*Bucking loss (see equation 12), product allocation (equation 20), and primary processing efficiency (equation 20) estimates are project specific and may be derived from local or regional average harvesting operations and wood processing facilities when available. Alternatively, project proponents shall select local or regionally appropriate primary processing efficiencies for milling based on published* *data. One source of information is the CAR Forestry Protocol 3.2, Appendix C* (Climate Action Reserve, 2010)*; national and regional published sources are also available (see for example,* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*,* (Smith, Miles, Vissage, & Pugh, 2004)*, and references therein).*

Table 1 - Wood Product Allocation Assumptions, Processing Efficiency ( (Briggs, 1994), (CAR, 2010)), and Product Half-Life (Miner, 2006).

| Product | Allocation | Processing efficiency | Half life (yrs) |
|---|---|---|---|
| Sawnwood | 0.58 | 0.637 | 35 |
| Veneer, plywood, structural panels | 0.26 | 0.445 | 30 |
| Non-structural panels | 0.0 | 0.501 | 20 |
| Paper | 0.16 | 0.50 | 2 |

### *Secondary processing of the residue carbon (biomass) generated from primary processing ($\Delta C_{BSL,PERMHWP2,t}$)*

*Primary timber processing mills (facilities that convert roundwood into products such as lumber, plywood, and wood pulp) generate residues that are used for secondary processing. These residues fall into three categories — bark, coarse residues (chunks and slabs), and fine residues (shavings and sawdust). For paper production, Kraft (or sulfate) pulping is the most common processing technology. In Kraft pulping about half the wood is converted into fiber and other half becomes black liquor, a by-product containing unutilized wood fiber and valuable chemicals. Pulp and paper facilities combust black liquor in recovery boilers to produce energy* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*.*

*The total residual biomass remaining in year t after primary product processing ($B_{BSL,RESIDUAl,t}$; t d.m. yr$^{-1}$) is:*

$$B_{BSL,RESIDUAl,t} = \Sigma[(LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i + LBL_{BSL,OTHER,i,t} - LBL_{BSL,OTHER,i,t} \bullet R_i) \bullet (1 - f_{BRANCH,i,t}) \bullet (1 - f_{BSL,BUCKINGLOSS,i,t})] \bullet \Sigma(f_{BSL,PRODUCTk} - RE_{BSL,k}) \quad (22)$$

*where:*

*$f_{BSL,PRODUCTk}$ is as defined in equation 20; all other terms are defined in equation 19.*

*For purposes of secondary manufacturing, it is assumed that any residual biomass derived from paper production (i.e., black liquor) is combusted at 100% efficiency* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*, a conservative assumption. Hence, the final summation term in $B_{RESIDUAl,t}$ is therefore calculated for all product types, except paper.*

*Let $f_{BARK}$, $f_{COARSE}$, and $f_{FINE}$, be the proportions of bark, coarse, and fine residual biomass, respectively, (unitless; $0 \leq f_{BARKt}$, $f_{COARSEt}$, $f_{FINEt} < 1$) that comprise $B_{BSL,RESIDUAl,t}$. In addition, let $f_{BARKUSE}$, $f_{COARSEUSE}$, and $f_{FINEUSE}$ be the proportions of each of these biomass categories that are allocated to secondary manufacturing (unitless; $0 \leq f_{BARKUSE}$, $f_{COARSEUSE}$, $f_{FINEUSE} < 1$).*

*The biomass allocated to secondary processing of bark, and coarse and fine residuals, in year, t (t d.m. $yr^{-1}$), is therefore:*

$$B_{BSL,BARK,t} = B_{BSL,RESIDUAl,t} \bullet f_{BSL,BARK} \bullet f_{BSL,BARKUSE} \quad (23a)$$

$$B_{BSL,COARSE,t} = B_{BSL,RESIDUAl,t} \bullet f_{BSL,COARSE} \bullet f_{BSL,COARSEUSE} \quad (23b)$$

$$B_{BSL,FINE,t} = B_{BSL,RESIDUAl,t} \bullet f_{BSL,FINE} \bullet f_{BSL,FINEUSE} \quad (23c)$$

*Default values are 26.5%, 42.9%, and 30.6%, for $f_{BARK}$, $f_{COARSE}$, and $f_{FINE}$, respectively* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005). *Default values are 85%, and 42%, for $f_{COARSEUSE}$, and $f_{FINEUSE}$, respective* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*). Evidence indicates that on average 80% of bark is combusted for energy, with the remainder used principally as mulch* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*. Decay rates for mulch are difficult to estimate. Hence, as a default, all bark is assumed to be 100% combusted, a conservative assumption. Local data should be used for all variables, if available.*

*$B_{COARSE,t}$ and $B_{FINE,t}$ must now be allocated to particular product classes in order to derive estimates of permanence from secondary manufacturing using the 100-year method ($\Delta C_{BSL,PERMHWP2,t}$).*

$$\Delta C_{BSL,PERMHWP2,t} = B_{BSL,COARSE,t} \bullet f_{BSL,PROCESSc} \bullet f_{BSL,PERMHWPc} + B_{BSL,FINE,t} \bullet f_{BSL,PROCESSf} \bullet f_{BSL,PERMHWPf} \quad (24)$$

*Processing efficiencies of coarse and fine residuals ($f_{BSL,PROCESSc}$ and $f_{BSL,PROCESSf}$, respectively) in secondary manufacturing are typically much higher than primary manufacturing. A default value of 85 % can be used* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005) *if project-specific values are not available. With respect to calculating permanent storage, the default approach is to assume that $B_{BSL,COARSE,t}$ has a half-life equivalent to sawnwood, and $B_{BSL,FINE,t}$ has a half-life equivalent to non-structural panels (see Appendix 2, Table 2). These values are then used in equation 24 to calculate the fraction of biomass allocated to permanent storage after a 100-year time period, for the coarse and fine material. Alternative half-lives (see* (Miner, 2006)*) can be used if justified from industry-specific information.*

## Fossil fuel emissions associated with logging, transport, and manufacture

*Annual fossil fuel emissions from harvesting and processing of the various wood products ($C_{BSL,EMITDIRECT,t}$) are calculated as:*

$$C_{BSL,EMITFOSSIL,t} = \Delta C_{BSL,EMITHARVEST,t} + \Delta C_{BSL,EMITMANUFACTURE,t} + \Delta C_{BSL,EMITTRANSPORT,t} \quad (25)$$

*where:*

$\Delta C_{BSL,EMITHARVEST,t}$ *is the annual fossil fuel emissions associated with harvesting of raw material (t C yr$^{-1}$)*

$\Delta C_{BSL,EMITMANUFACTURE,t}$ *is the annual fossil fuel emissions associated with the manufacturing of raw material (t C yr$^{-1}$)*

$\Delta C_{BSL,EMITTRANSPORT,t}$ *is the annual fossil fuel emissions associated with the transport of raw material (t C yr$^{-1}$)*

*The simplest approach to calculating $C_{BSL,EMITFOSSIL,t}$ is to use published or derived carbon emission intensity factors. In the case of harvesting, $\Delta_{BSL,}C_{EMITHARVEST,t}$; t C yr$^{-1}$), can be calculated as:*

$$\Delta C_{BSL,EMITHARVEST,t} = \Sigma[(LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i + LBL_{BSL,OTHER,i,t} - LBL_{BSL,OTHER,i,t} \bullet R_i) \bullet (1 - f_{BSL,BRANCH,i,t}) \bullet (1 - f_{BSL,BUCKINGLOSS,i,t})] \bullet CF \bullet c_{HARVEST} \quad (26a)$$

*where:*

$c_{HARVEST}$ *is the carbon emission intensity factor (t C emitted/t C raw material) associated with harvesting (see Appendix 2, Table 2 for default values); ; all other terms are as defined in equation 19.*

$\Delta C_{BSL,EMITTRANSPORT,t}$ *must be calculated after consideration of the transport distance from harvest to processing facility, and the means of transportation. This term can be calculated as follows (after* (Heath, et al., 2010)*):*

$$\Delta C_{BSL,EMITTRANSPORT,t} = \Sigma[(LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i + LBL_{BSL,OTHER,i,t} - LBL_{BSL,OTHER,i,t} \bullet R_i) \bullet (1 - f_{BSL,BRANCH,i,t}) \bullet (1 - f_{BSL,BUCKINGLOSS,i,t})] \bullet CF \bullet \Sigma(f_{BSL,TRANSPORTk} \bullet d_{TRANSPORTk} \bullet c_{TRANSPORTk}) \quad (26b)$$

*where:*

$f_{BSL,TRANSPORTk} =$ *the fraction of raw material transported by transportation type, k. (unitless; $0 \leq f_{BSL,TRANSPORTk} < 1$).*

$d_{TRANSPORTk} =$ *the distance transported by transportation type, k. (km);*

$c_{TRANSPORTk}$ *is the carbon emission intensity factor (kg C emitted/t C raw material) associated with transportation type, k (see Appendix 2, Table 2 for default values); all other terms are as defined in equation 19.*

$$\Delta C_{BSL,EMITMANUFACTURE,t} = \Sigma[(LBL_{BSL,FELLINGS,i,t} - LBL_{BSL,FELLINGS,i,t} \bullet R_i + LBL_{BSL,OTHER,i,t} - LBL_{BSL,OTHER,i,t} \bullet R_i) \bullet (1 - f_{BSL,BRANCH,i,t}) \bullet (1 - f_{BSL,BUCKINGLOSS,i,t})] \bullet \Sigma(f_{BSL,PRODUCTk} \bullet c_{MANUFACTUREk}) \bullet CF \quad (27)$$

*$c_{MANUFACTUREk}$ is the carbon emission intensity factor (t C emitted/t C raw material) associated with manufacture of product type, k; all other terms are as defined in equation 19.*

(Heath, et al., 2010) Estimates for $c_{MANUFACTUREk}$ are provided in Appendix 2,Table 2.

Table 2 – Carbon emission intensity factors for harvesting, manufacture, and transportation associated with different product categories

| Activity | Value | Reference |
|---|---|---|
| **Harvesting ($c_{HARVEST}$) (t C emitted/t C raw material)** | | |
| Clearcut harvest | 0.016 | (Zhang, Cormier, Lyng, Mabee, Ogino, & McLean, 2010) |
| **Manufacturing ($c_{MANUFACTUREk}$) (t C emitted/t C raw material)** | | |
| Sawnwood | 0.04 | (Pingoud & Lehtila, 2002) – Calculated from Table I & III |
| Veneer, plywood and structural panels | 0.06 | (Pingoud & Lehtila, 2002) – Calculated from Table I & III |
| Non-structural panels | 0.12 | (Pingoud & Lehtila, 2002) – Calculated from Table I & III |
| Paper | | (Pingoud & Lehtila, 2002) – Calculated from Table I & III |
| Mechanical pulping | 0.48 | (Pingoud & Lehtila, 2002) – Calculated from Table I & III |
| Chemical pulping | 0.13 | (Pingoud & Lehtila, 2002) – Calculated from Table I & III |
| **Transportation** | | |
| $f_{BSL,TRANSPORTm}$ (unitless) | | |
| Truck | 1.0 | (Forest and Land Management, Inc. , 2008) |
| Rail | 0.0 | (Forest and Land Management, Inc. , 2008) |
| Ship | 1.0 | (Forest and Land Management, Inc. , 2008) |
| $d_{TRANSPORTm}$ (km) | | |
| Truck | 36.8 | (Forest and Land Management, Inc. , 2008) |
| Rail | 0.0 | (Forest and Land Management, Inc. , 2008) |
| Ship | 6219 | (Forest and Land Management, Inc. , 2008) |
| **$c_{TRANSPORTm}$ (t C emitted/t C raw material./km)** | | |
| Truck | $7.0*10^{-5}$ | (Heath, et al., 2010) From Supporting Information Table S16 |
| Rail | $8.2*10^{-6}$ | (Heath, et al., 2010) From Supporting Information Table S16 |
| Ship | $5.2*10^{-6}$ | Appendix 5, Afognak carbon model spreadsheet, for its calculation |

## Ex Post Calculations of Carbon Stocks

The calculation of actual (ex post) carbon stocks is undertaken using field plot sampling data. At the time of validation 22 field plots had been installed on the Afognak property to provide ex-post calculation data.

*Actual (ex post) annual net carbon stocks are calculated using the equations in this section.*

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

*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 subregion, i, in year, t ($B_{AG,i,t}$) is determined by converting the aboveground, tree-level measurements (kg biomass per tree) described in Section 13.2 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 subregion should 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 subregion, 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 subregion i, time t, ($B_{TOTAL,i,t}$). $R_i$ is described in Section 8.2.1. Finally, the average measured carbon stock in living tree biomass for measured subregion i, time t, ($C_{LB,i,t}$) is calculated as shown in equation 28c. This value of $C_{LB,i,t}$ must be compared to the equivalent calculation of live biomass ($LB_{PRJ,i,t}$) calculated in the project scenario (Section 9.3) (see comparison method and steps 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 subregion, i, year, t*

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

*$B_{TOTAL,i,t}$ = total tree biomass (t d.m. $ha^{-1}$) measured in subregion, 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 subregion, 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 subregion, i, in year, t ($DOM_{LDW,i,t}$) is calculated according to equations 60a-c in Section 13.2. The value of $DOM_{LDW,i,t}$ must be compared to the equivalent calculation of lying dead wood mass ($LDW_{PRJ,i,t}$) in the project scenario (Section 9.3.3) (see comparison method and steps below).*

*The average quantity of dead organic matter contained in standing snags for measured subregion, 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 13.2). The belowground component of snags is treated as dead below ground biomass (See Section 9.3.3) and is not directly measured. All plots within a particular subregion should be averaged to get an average estimate of $DOM_{SNAG,i,t}$. The value of $DOM_{SNAG,i,t}$ must be compared to the equivalent calculation of standing dead tree mass ($SNAG_{PRJ,i,t}$) in the project scenario (Section 9.3.3) (see comparison method and steps below).*

## Calculating the Project Carbon Balance

The total annual carbon balance for specified areas (specific subregions are not tracked only aspatial calculations are made based upon areas that have similar ages and management) within the project landbase are tracked using the Landscape Summary Tool model in combination with the ecosystem carbon storage curves generated using FORECAST for each analysis unit. The annual carbon content (tracked for each ecosystem pool) is then summed each year for the whole landbase in baseline scenario by the Landscape Summary Tool (see Appendix 3), and then summarized in the Afognak Carbon Model spreadsheet ((Equations 29-31, 38). The annual change in harvested wood products storage (Equations 30, 46) is calculated in the Afognak Carbon Model sheet (see below) using the annual simulated harvested wood volume output from the Landscape Summary Tool to drive the calculations.

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

$$\Delta C_{PRJ,t} = \Delta C_{PRJ,P,t} \quad (29)$$

*where:*

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

$$\Delta C_{PRJ,P,t} = \Delta C_{PRJ,LB,t} + \Delta C_{PRJ,DOM,t} + \Delta C_{PRJ,HWP,t} \quad (30)$$

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

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

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

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

*where:*

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

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

*If the project area has been stratified, carbon pools are calculated for each subregion, i, and then summed during a given year, t.*

### Live Biomass Gain

The total annual live biomass gain for each subregion, *i* within the project landbase is tracked using the Landscape Summary Tool model in combination with the ecosystem carbon storage curves generated using FORECAST for each analysis unit. Landscape Summary Tool determines the amount of C storage in each inventory subregion using its tracked age to lookup the live biomass value from the carbon curve assigned to the subregion (based upon its assigned analysis unit). The FORECAST carbon table provides values in t $ha^{-1}$, which are then converted to total tons by the Landscape Summary Tool by multiplying by the area of the subregion (Equation 32). The amount carbon stored in above and below ground live biomass is calculated by FORECAST (Equations 33a-b) based upon the age dependent root shoot ratio ($R_i$) represented in the model. (see Table 4).

*Live biomass gain in year, t, subregion, i ($\Delta C_{PRJ,G,i.t}$) is calculated as:*

$$\Delta C_{PRJ,G,t} = \Sigma(A_{PRJ,i} \bullet G_{PRJ,i,t}) \bullet CF \quad (32)$$

*where:*

*$A_{PRJ,i,}$ = area (ha) of forest land in subregion, i;*

*$G_{PRJ,i,t}$ = annual increment rate in tree biomass (t d.m. $ha^{-1}$ $yr^{-1}$), in subregion, i, and;*

*CF = carbon fraction of dry matter t C $t^{-1}$ d.m. (IPCC default value = 0.5).*

$$G_{PRJ,i,t} = G_{PRJ,AG,i,t} + G_{PRJ,BG,i,t} \quad (33a)$$

*where $G_{PRJ,AG,i,t}$ and $G_{PRJ,BG,i,t}$ are the annual above- and below-ground biomass increment rates (t d.m. $ha^{-1}$ $yr^{-1}$);*

$$G_{PRJ,BG,i,t} = G_{PRJ,AG,i,t} \bullet R_i \quad (33b)$$

*where $R_i$ is the root:shoot ratio in subregion, i. $R_i$ should ideally be estimated for each subregion, but these data are difficult to derive empirically. Hence, general relationships are acceptable* (Cairns, 1997)*.*

*Equations 32 and 33 can be used directly to calculate $\Delta C_{PRJ,G,t}$ when all tree cover within a subregion is removed by harvesting (i.e., clearfelling) and no residual structure is retained. In cases of partial harvesting and/or multiple entries into a subregion. A given subregion must be split into a homogenous subregion.*

### Live Biomass Loss

The total annual live biomass loss for each subregion, *i* within the project landbase (Equations 34-36) is tracked using the Landscape Summary Tool model in combination with the ecosystem carbon storage curves generated using FORECAST for each analysis unit. Within-stand losses related to natural mortality and stand-self thinning are captured within the carbon storage curves generated by FORECSAST for each analysis unit. Live biomass loss through harvesting is represented using the harvest schedule determined by the Landscape Summary Tool to determine when a specific inventory subregion is harvested. When this occurs, the subregion has its age reset to 1 and switches to the associated managed stand analysis unit. For example, if a subregion with an age of 150y that was assigned as AU = 101 is selected for harvesting, it age would be reset to 1 and the subregion would be reassigned to AU = 201. In this example AU 201 was simulated to reflect the dead organic matter conditions created after a clearcut harvest (of AU 101) where 90% of the stemwood biomass (present in AU 101, age 150y before the harvest) has been removed as harvested wood. Losses through road construction and landings (Equation 37) will be assessed through monitoring activities in the project scenario. Any losses of area due to management activities will be updated in the spatial inventory. However, we expect this term to be minor because of the existing road network on the property.

*The annual decrease in aboveground tree carbon from live biomass loss ($\Delta C_{PRJ,L,t}$; t C $yr^{-1}$) is the sum of losses from:*

1. *Natural mortality (i.e. insects, disease, competition, wind, etc.)*
2. *Commercial round wood felling*
3. *Incidental sources.*

*Losses must be specific to a given subregion; each subregion must be summed in order to calculate total annual loss across the project activity area. The live biomass losses are not emitted directly, but rather are transferred to dead organic matter pools.*

$$\Delta C_{PRJ,L,t} = \Sigma(LBL_{PRJ,NATURALi,t} + LBL_{PRJ,FELLINGS,i,t} + LBL_{PRJ,OTHERi,t}) \bullet CF \qquad (34)$$

*where:*

$LBL_{PRJ,NATURALi,t}$ = *annual loss of live tree biomass due to natural mortality in subregion, i; t d.m. $yr^{-1}$*

$LBL_{PRJ,FELLINGS,i,t}$ = *annual loss of live tree biomass due to commercial felling in subregion, i; t d.m. $yr^{-1}$*

$LBL_{PRJ,OTHER,i,t}$ = *annual loss of live tree biomass from incidental sources in subregion, i; t d.m. $yr^{-1}$*

*CF = carbon fraction of dry matter; t C $t^{-1}$ d.m. (IPCC default value = 0.5).*

$$LBL_{PRJ,NATURALi,t} = A_{PRJ,i} \bullet LB_{PRJ,i,t} \bullet f_{PRJ,NATURAL,i,t} \quad (35)^{14}$$

*where*

*$A_{PRJ,i}$ = area (ha) of forest land in subregion, i;*

*$LB_{PRJ,i,t}$ = average live tree biomass (t d.m. $ha^{-1}$) in subregion, i, for year, t*

*$LB_{PRJ,i,t}$ is calculated for year, t, beginning with biomass estimates in year t=1 (the project start year) and with annual biomass increments ($G_{PRJ,i,t}$) added as per calculations in equation 33a.*

*$f_{PRJ,NATURAL,i,t}$ = the annual proportion of biomass that dies from natural mortality in forest type , i (unitless; $0 \leq f_{PRJ,NATURALi} \leq 1$), year, t. Tree mortality is an ongoing process during stand development. Trees die as a consequence of insect attack, disease, competition, or some combination thereof. Hence, mortality can be highly variable between years. This parameter can be applied uniformly across an analysis unit, or individually to a given subregion. Ex post estimates from regional data sources in corresponding stand types are preferred. Sources for mortality estimates include permanent sample plots in similar stand types, literature reports, and inventory data. Some models (the FORECAST model, for example) simulate annual background mortality rates directly and can accommodate variable age structures following partial harvesting.*

$$LBL_{PRJ,FELLINGS,i,t} = A_{PRJ,i} \bullet LB_{PRJ,i,t} \bullet f_{PRJ,HARVEST,i,t} \quad (36)$$

*where:*

*$A_{PRJ,i}$ = area (ha) of forest land in subregion, i*

*$LB_{PRJ,i,t}$ = average live tree biomass (t d.m. $ha^{-1}$) in subregion, i, for year, t (see equation 7 for its calculation).*

*$f_{PRJ,HARVEST,i,t}$ = the proportion of biomass removed by harvesting from subregion, i, (unitless; $0 \leq f_{PRJ,HARVESTIi} \leq 1$), in year, t. Data for this variable should be obtained from harvest schedule information. Values may be constrained by (a) the value of $f_{PRJ,NATURAL,i,t}$ (i.e., $f_{PRJ,HARVEST,i,t} < 1 - f_{PRJ,NATURAL,i,t}$), and/or (b) the area of timber available for commercial harvest.*

*Incidental loss ($LBL_{PRJ,OTHER,i,t}$; t d.m. $yr^{-1}$) is the additional live tree biomass removed for road and landing construction in the subregion, i, and is calculated as a proportion of biomass removed by harvesting:*

$$LBL_{PRJ,OTHER,i,t} = A_{PRJ,i} \bullet LB_{PRJ,i,t} \bullet f_{PRJ,HARVEST,i,t} \bullet f_{PRJ,DAMAGE,i,t} \quad (37)$$

*where:*

*$A_{PRJ,i}$ = area (ha) of forest land in subregion, i;*

*$LB_{PRJ,i,t}$ = average live tree biomass (t d.m. $ha^{-1}$) in subregion, i, for year, t*

[14] Note, for Equation 35, 36, and 37: $(f_{PRJ,NATURAL,i,t} + f_{PRJ,HARVEST,i,t} + f_{PRJ,DAMAGE,i,t}) \leq 1.0$

*$f_{PRJ,HARVEST,i,t}$ = the proportion of biomass removed by harvesting from subregion, i, in year, t (unitless; $0 \leq f_{PRJ,HARVEST,i,t} \leq 1$).*

*$f_{PRJ,DAMAGE,i,t}$ = the proportion of additional biomass removed for road and landing construction in subregion, i, year, t (unitless; $0 \leq f_{PRJ,DAMAGE,i,t} \leq 1$)[15]. Data for this variable should be based on regional and local comparative studies and experiential information derived from the local forest industry[16].*

## Dead Organic Matter Dynamics ($\Delta C_{PRJ,DOM,t}$)

Dead organic matter dynamics including dead wood and snag creation and decay have been simulated using FORECAST for each analysis unit. Thus, Equations 38-45 are captured within the carbon curves generated by FORECAST for each analysis unit and tracked on the landbase using the Landscape Summary Tool in conjunction with the spatial inventory data.

*Dead organic matter (DOM) included in this methodology comprises three components: standing dead wood (minimum ≥ 5 cm DBH and 1.3 m height; termed snags), lying dead wood (minimum ≥ 5 cm DBH; LDW), and belowground dead wood (i.e., dead roots). Standing dead wood is < 45º of vertical, while lying dead wood is ≥ 45º of vertical.*

*The annual change in carbon stocks in DOM ($\Delta C_{PRJ,DOM}$; t C $yr^{-1}$) is calculated as:*

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

*where:*

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

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

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

$$\Delta C_{PRJ,LDW,t} = \Sigma(LDW_{PRJ,IN,i,t} - LDW_{PRJ,OUT,i,t}) \bullet CF \quad (39a)$$

$$LDW_{PRJ,i,t+1} = LDW_{PRJ,i,t} + (LDW_{PRJ,IN,i,t} - LDW_{PRJ,OUT,i,t}) \quad (39b)$$

*where:*

*$LDW_{PRJ,i,t}$= The total mass of lying dead wood accumulated in subregion i at time t (t d.m.).*

*$LDW_{PRJ,IN,i,t}$ = annual increase in LDW biomass for subregion i, year, t (t d.m $ha^{-1}$ $yr^{-1}$). LDW increases occur as a result of natural mortality (typically, blowdown), and as a direct or indirect result of harvesting.*

*$LDW_{PRJ,OUT,i,t}$ = annual loss in LDW biomass through decay, for subregion i, year, t, (t d.m $ha^{-1}$ $yr^{-1}$)*

---

[15] Projecting ex-ante road and landing removals beyond a few years is difficult and complex. As described, $f_{PRJ,DAMAGE,i,t}$ functions as a proxy for estimating biomass impacts of all new roads and landings associated with annual harvesting in subregion, i. Project proponents can simulate $LBL_{PRJ,OTHER,i,t}$ directly, if appropriate models are available.

[16] $f_{PRJ,DAMAGE,i,t}$ may be zero or de minimis in cases where a subregion is already roaded.

*$LDW_{PRJ,IN,i,t}$ and $LDW_{PRJ,OUT,i,t}$ are summed across subregions.*

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

$$\begin{aligned}
LDW_{PRJ,IN,i,t} = {} & (LBL_{PRJ,NATURALi,t} - LBL_{PRJ,NATURALi,t} \bullet R_i) \bullet f_{PRJ,BLOWDOWN,i,t} + \\
& ((LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i) + \\
& (LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,OTHER,i,t} \bullet R_i)) \bullet f_{PRJ,BRANCH,i,t} + \\
& ((LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i) + \\
& (LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,OTHER,i,t} \bullet R_i)) \bullet \\
& (1 - f_{PRJ,BRANCH,i,t}) \bullet f_{PRJ,BUCKINGLOSS,i,t} + SNAG_{PRJ,,i,t} \bullet f_{PRJ,SNAGFALLDOWN,i,t} \quad (40)
\end{aligned}$$

*where:*

*$LBL_{PRJ,NATURALi,t}$, $LBL_{PRJ,FELLINGS,i,t,}$ and $LBL_{PRJ,OTHER,i,t}$ are as calculated in equations 35, 36, and 37, respectively.*

*$R_i$ is the root:shoot ratio in subregion, i (see equation 33b).*

*$f_{PRJ,BLOWDOWN,i,t}$ = the annual proportion of live aboveground tree biomass subject to blowdown in subregion, i, year, t (unitless; $0 \leq f_{PRJ,BLOWDOWN,i,t} \leq 1$). Ex ante estimates shall be derived preferably from regional reports in similar forest types.*

*$f_{PRJ,BRANCH,i,t}$ = the annual proportion of aboveground tree biomass comprised of branches $\geq$ 5 cm diameter in subregion, i (unitless; $0 \leq f_{PRJ,BRANCH,i,t} \leq 1$). Ex ante data are available from allometric equations and models (for example,* (Kurz & Apps, 2006) *for Canada;* (Smith, Miles, Vissage, & Pugh, 2004) *for the U.S.). In the event slash burning is undertaken, this parameter should be reduced accordingly to reflect the proportion of biomass remaining. Estimates should be obtained from expert opinion; as a default, assume 100% consumption.*

*$f_{PRJ,BUCKINGLOSS,i,t}$ = the annual proportion of the log bole biomass left on site after assessing and/or merchandizing the log bole for quality, in subregion, i (unitless; $0 \leq f_{PRJ,BUCKINGLOSS,i,t} \leq 1$). Preferably, data for this variable shall be based on regional and local comparative studies and experiential information derived from the local forest industry. Otherwise, an average default value of 21% can be used, based on US national summary statistics* (Smith, Miles, Vissage, & Pugh, 2004).

*$SNAG_{PRJ,i,t}$ = the total mass of the snag pool in subregion, i, year, t (see equation 42b).*

*$f_{PRJ,SNAGFALLDOWN,i,t}$ = the annual proportion of snag biomass in subregion, i, year, t, that falls over and thus is transferred to the LDW pool (unitless; $0 \leq f_{PRJ,SNAGFALLDOWN,i,t} \leq 1$). Ex ante estimates for this parameter can be derived from peer reviewed literature (for example,* (Parish, Antos, Ott, & Di Lucca, 2010) *and forest carbon accounting models that track the rates of input and losses from dead organic matter pools (for example,* (Kurz & et al, 2009).

$$LDW_{PRJ,OUT,i,t} = LDW_{PRJ,i,t} \bullet f_{PRJ,lwDECAY,i,t} \quad (41)$$

*where:*

*$LDW_{PRJ,i,t}$ = the total amount of lying deadwood mass in subregion i, year, t (see equation 39b).*
*$f_{PRJ,lwDECAY,i,t}$ = the annual proportional loss of lying dead biomass due to decay, in subregion i, year, t (unitless; ; $0 \leq f_{PRJ,lwDECAY,i,t} \leq 1$). A common approach to ex ante estimation of $f_{PRJ,lwDECAY,i,t}$ is to assume 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* (Harmon, et al., 1986)*. Other types of exponential models are available (reviewed in* (Harmon, et al., 1986)*) and may be more appropriate to particular forest types (to be described and justified by the project proponent, if used). Ex ante estimates for the decay parameter appropriate for the project should be derived from peer-reviewed literature (for example,* (Harmon, et al., 1986)*;* (Laiho & and Prescott, 2004)*;* (Harmon et al, 2008)*).*

*The change in standing dead wood (snag) carbon stock in year, t (t C $yr^{-1}$) is calculated as:*

$$\Delta C_{PRJ,SNAG,t} = \Sigma(SNAG_{PRJ,IN,i,t} - SNAG_{PRJ,OUT,i,t}) \bullet CF \quad (42a)$$

$$SNAG_{PRJ,i,t+1} = SNAG_{PRJ,i,t} + (SNAG_{PRJ,IN,i,t} - SNAG_{PRJ,OUT,i,t}) \quad (42b)$$

*where:*

*$SNAG_{PRJ,i,t}$ = The total mass of snags accumulated in subregion i at time t (t d.m.)*

*$SNAG_{PRJ,IN,i,t}$ = annual gain in snag biomass for subregion i, year, t (t d.m $ha^{-1}$ $yr^{-1}$). Snag biomass develops as a result of natural mortality. In cases where snags are created through management activities, these should be accounted for here.*

*$SNAG_{PRJ,OUT,i,t}$ = annual loss in snag biomass through decay, or falldown (i.e, transfer to the LDW pool)(t d.m $ha^{-1}$ $yr^{-1}$)*

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

*Note that $SNAG_{PRJ,IN,i,t}$ and $SNAG_{PRJ,OUT,i,t}$ are summed across subregions.*

$$SNAG_{PRJ,IN,i,t} = (LBL_{PRJ,NATURALi,t} - LBL_{PRJ,NATURALi,t} \bullet R_j) \bullet (1 - f_{PRJ,BLOWDOWN,i,t}) \quad (43)$$

*where:*

*$LBL_{PRJ,NATURALi,t}$ is as calculated in equation 35, and*

*$1 - f_{PRJ,BLOWDOWN,i,t}$ is the proportion of live tree aboveground biomass that dies in subregion, i, year, t, but remains as standing dead organic matter (i.e. snags) (unitless; $0 \leq f_{PRJ,BLOWDOWN,i,t} \leq 1$). Ex ante default estimates for this calculation can be derived from literature values (for example* (Harmon, et al.,

1986); (Runkle, 2000); (Harmon et al, 2008)) *and should be matched to the ecosystems that most closely characterize the project area.*

$$SNAG_{PRJ,OUT,i,t} = SNAG_{PRJ,i,t} \bullet f_{PRJ,SWDECAY,i,t} + SNAG_{PRJ,i,t} \bullet f_{PRJ,SNAGFALLDOWN,i,t} \quad (44)$$

*where:*

$SNAG_{PRJ,i,t}$ *= the total amount of snag mass in subregion i, year, t (see equation 42b).* $f_{PRJ,SWDECAY,i,t}$ *= the annual proportional loss of snag biomass due to decay, in subregion, i, year, t (unitless;* $0 \leq f_{PRJ,SWDECAY,i,t} \leq 1$*). As with lying dead wood, a common approach to estimating* $f_{PRJ,SWDECAY,i,t}$ *is to assume mass loss occurs in proportion to the amount of mass remaining in accordance with an a single exponential model (see equation 41). Ex ante estimates for this parameter can be derived from peer reviewed literature appropriate for the project site (for example, Vanderwel et al. 2006a) and forest carbon accounting models that track the rates of input and losses from dead organic matter pools for each forest type, productivity, and age-class (see, for example, Vanderwel et al., 2006b;* (Kurz & et al, 2009)*).*

$f_{PRJ,SNAGFALLDOWN,i,t}$ *= the annual proportion of snag biomass in subregion, i, that falls over and thus is transferred to the LDW pool (unitless;* $0 \leq f_{PRJ,SNAGFALLDOWN,i,t} \leq 1$*). See equation 40 for parameter estimates.*

*The annual change in DOM derived from dead belowground biomass (*$\Delta C_{PRJ,DBG,,t}$*; t C* $yr^{-1}$*) is calculated for each subregion as per equation 45a. Calculation of* $\Delta C_{PRJ,DBG,t}$ *is specific to a given subregion; each subregion must therefore be summed in order to calculate total annual loss across the project activity area.*

$$\Delta C_{PRJ,DBG,t} = = \Sigma(DBG_{PRJ,IN,i,t} - DBG_{PRJ,OUT,i,t}) \bullet CF \quad (45a)$$

$$DBG_{PRJ,i,t+1} = DBG_{PRJ,i,t} + (DBG_{PRJ,IN,i,t} - DBG_{PRJ,OUT,i,t}) \quad (45b)$$

*where:*

$DGB_{PRJ,i,t}$ *= The total quantity of dead belowground biomass accumulated in subregion i at time t (t d.m.).*

$DBG_{PRJ,IN,i,t}$ *= annual gain in dead belowground biomass for subregion i, year, t (t d.m* $ha^{-1}$ $yr^{-1}$*). Dead belowground biomass develops as a result of mortality through natural causes or through harvesting activities.*

$DBG_{PRJ,OUT,i,t}$ *= annual loss in dead belowground biomass through decay, (t d.m* $ha^{-1}$ $yr^{-1}$*)*

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

$$DBG_{PRJ,IN,i,t} = [(A_{PRJ,i} \bullet LB_{PRJ,i,t} \bullet R_i) \bullet (f_{PRJ,NATURAL,i,t} + f_{PRJ,HARVEST,i,t} + f_{PRJ,DAMAGE,i,t})] \quad (45c)$$

*where:*

$A_{PRJ,i}$ *= area (ha) of forest land in subregion, i;*

*$LB_{PRJ,i,t}$ = average live tree biomass (t d.m. $ha^{-1}$) in subregion, i, for year, t. $LB_{PRJ,i,t}$ is calculated for year, t, beginning with biomass estimates in year t=1 (the project start year) and with annual biomass increments ($G_{PRJ,i,t}$) added as per calculations in equation 33 a, b. This value is then multiplied by $A_{PRJ,i,}$ the area (ha) of forest land in subregion, i.*

*$R_i$ is the root:shoot ratio in subregion, i (see equation 33b).*

*$f_{PRJ,NATURAL,i,t}$ = the annual proportion of biomass that dies from natural mortality in subregion, i (unitless; $0 \leq f_{NATURALi} \leq 1$), year, t (see equation 35),*

*$f_{PRJ,HARVEST,i,t}$ = the proportion of biomass removed by harvesting from subregion, i, (unitless; $0 \leq f_{PRJ,HARVESTIi} \leq 1$), year, t (see equation 36),*

*$f_{PRJ,DAMAGE,i,t}$ = the proportion of additional biomass removed by for road and landing construction in subregion, i (unitless; $0 \leq f_{PRJ,DAMAGE,i,t} \leq 1$), year, t (see equation 37),*

$$DBG_{PRJ,OUT,i,t} = DBG_{PRJ,i,t} \bullet f_{PRJ,dgbDECAY,i,t} \quad (45d)$$

*where:*

*$DBG_{PRJ,i,t}$ = the total quantity of dead belowground in subregion i, year, t (equation 17b). $f_{PRJ,dgbDECAY,i,t}$ = the annual proportional loss of dead belowground biomass due to decay, in subregion i, year, t (unitless; $0 \leq f_{PRJ,lwDECAY,i,t} \leq 1$). The ex ante estimation of the decay of dead belowground biomass should be done using a similar single exponent decay function as that described above for lying deadwood biomass. Estimates for the decay parameter appropriate for specific project should be derived from peer-reviewed literature (see for example:* (Moore, Trofymow, Siltanen, Prescott, & CIDET, 2005)*;* (Melin, Petersson, & Nordfjell, 2009).

## Harvested Wood Products

All harvested wood products calculations are made within the Afognak Carbon Model; worksheet: Summary Tables and Figures (see references, Appendix 3), using key output data from the Landscape Summary Tool. Key assumptions used for the project in the Afognak Carbon Model spreadsheet are summarized Appendix 2, Table 1 and Appendix 2, Table 2 below. Additional assumptions and variables not described here are found in the Afognak Carbon Model spreadsheet.

*See Section 8.4 (equivalent baseline calculations) for various discussion and background on HWP calculations.*

*The annual change in the carbon stored in harvested wood products (HWP), $\Delta C_{PRJ,HWP,t}$, is calculated as:*

$$\Delta C_{PRJ,HWP,t} = \Delta C_{PRJ,PERMHWP1,t} + \Delta C_{PRJ,PERMHWP2,t} - \Delta C_{PRJ,EMITFOSSIL,t} \quad (46)$$

*$\Delta C_{PRJ,PERMHWP1,t}$ = the annual harvested carbon that remains in permanent storage after conversion to wood products during primary processing (t C $yr^{-1}$)*

$\Delta C_{PRJ,PERMHWP2,t}$ = *carbon that remains in permanent storage after accounting for secondary processing of the residue carbon (biomass) generated from primary processing (t C yr$^{-1}$)*

$\Delta C_{PRJ,EMITFOSSIL,t}$ = *fossil fuel emissions from harvesting (logging and log transport) and processing of the various wood products.*

### *Permanent carbon storage from primary processing ($\Delta C_{PRJ,PERMHWP1,t}$)*

*If harvesting is occurring in the project case, see section 8.3 for a discussion of key issues.*

$$\Delta C_{PRJ,PERMHWP1,t} = \Sigma[(LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i + LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,OTHER,i,t} \bullet R_i \bullet (1 - f_{PRJ,BRANCH,i,t}) \bullet (1 - f_{PRJBUCKINGLOSS,i,t})] \bullet \Sigma(RE_{PRJk} \bullet f_{PRJ,PERMHWPk}) \bullet CF \quad (47)$$

*where:*

$LBL_{PRJ,FELLINGS,i,t}$ = *annual removal of aboveground live tree biomass due to commercial felling in subregion, i; t d.m. yr$^{-1}$ (equation 36)*

$LBL_{PRJ,OTHER,i,t}$ = *annual removal of live tree biomass from incidental sources in subregion, i; t d.m. yr$^{-1}$ (equation 37)*

*1 - $f_{PRJ,BRANCH,i,t}$ the proportion of aboveground live tree biomass remaining after netting out branch biomass, in subregion i (unitless; $0 \leq f_{PRJ,BRANCH,i,t} \leq 1$)(see equation 40)*

*1 - $f_{PRJ,BUCKINGLOSS,i,t}$ = the proportion of the log bole remaining after processing for quality, in subregion, i (unitless; $0 \leq f_{PRJ,BUCKINGLOSS,i,t} \leq 1$) (equation 40)*

$RE_{PRJ,k}$ = *the recovery efficiency for each product type, k (unitless; $0 \leq RE_{PRJ,k} < 1$).*

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

$$RE_{PRJ,k} = f_{PRJ,PRODUCTk} \bullet f_{PRJ,PROCESSk} \quad (48)$$

*where:*

$f_{PRJ,PRODUCTk}$, *and* $f_{PRJ,PROCESSk}$, *are the respective fractions allocated to a given forest product type, k, and its associated processing efficiency (unitless; $0 \leq f_{PRJ,PRODUCTk}, f_{PRJ,PROCESSk} < 1$).*

*Bucking loss, product allocation, and primary processing efficiency estimates are project specific and may be derived from local or regional average harvesting operations and wood processing facilities when available. Alternatively, project proponents shall select local or regionally appropriate primary processing efficiencies for milling based on published data. One source of information is the CAR Forestry Protocol 3.2, Appendix C* (Climate Action Reserve, 2010)*; national and regional published sources are also available (see for example,* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*,* (Smith, Miles, Vissage, & Pugh, 2004)*, and references therein).*

$f_{PRJ,PERMHWPk}$ = *the fraction of biomass allocated to permanent storage after a 100-year time period, for each product type, k (unitless; $0 \leq f_{PRJ,PERMHWPk} < 1$). The simplest (i.e. default) approach is to use a first order decay function, of the following form* (Miner, 2006)*:*

***$f_{PRJ,PERMHWPk} = (1 / (1 + (Ln(2) / HL_k)))^Y$***  **(49)**

*where:*

*$HL_k$ is the half-life of a given product type, k (years), and Y is the elapsed time (i.e, 100 years). A number of other more complex decay functions are available (reviewed in* (Miner, 2006)*). Selection of any particular function other than the default should be justified in the PDD. If a first order function is employed, use* (IPCC, 2003a) *for default values unless national or sub-national values are available.*

### Secondary processing of the residue carbon (biomass) generated from primary processing ($\Delta C_{PRJ,PERMHWP2,t}$)

*See Section 8 for further discussion on residual manufacturing waste*

*The total residual biomass remaining in year t after primary product processing ($B_{PRJ,RESIDUAl,t}$; t d.m. $yr^{-1}$) is:*

$$B_{PRJRESIDUAl,t} = \Sigma[(LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i + LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,OTHER,i,t} \bullet R_i) \bullet (1 - f_{PRJ,BRANCH,i,t}) \bullet (1 - f_{PRJ,BUCKINGLOSS,i,t})] \bullet \Sigma(f_{PRJ,PRODUCTk} - RE_{PRJ,k}) \quad (50)$$

*where:*

*$RE_{PRJ,k}$ is as defined in equation 48; all other terms are defined in equation 47.*

*For purposes of secondary manufacturing, it is assumed that any residual biomass derived from paper production (i.e., black liquor) is combusted at 100% efficiency* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*, a conservative assumption. Hence, the final summation term in $B_{PRJ,RESIDUAl,t}$ is therefore calculated for all product types, except paper.*

*Let $f_{PRJ,BARK}$, $f_{PRJ,COARSE}$, and $f_{PRJ,FINE}$, be the proportions of bark, coarse, and fine residual biomass, respectively, (unitless; $0 \leq f_{PRJ,BARKt}$, $f_{PRJ,COARSEt}$, $f_{PRJ,FINEt} < 1$) that comprise $B_{PRJ,RESIDUAl,t}$. In addition, let $f_{PRJ,BARKUSE}$, $f_{PRJ,COARSEUSE}$, and $f_{PRJ,FINEUSE}$ be the proportions of each of these biomass categories that are allocated to secondary manufacturing (unitless; $0 \leq f_{PRJ,BARKUSE}$, $f_{PRJ,COARSEUSE}$, $f_{PRJ,FINEUSE} < 1$).*

*The biomass allocated to secondary processing of bark, and coarse and fine residuals, in year, t (t d.m. $yr^{-1}$), is therefore:*

$$B_{PRJ,BARK,t} = B_{PRJ,RESIDUAl,t} \bullet f_{PRJ,BARK} \bullet f_{PRJ,BARKUSE} \quad (51a)$$

$$B_{PRJ,COARSE,t} = B_{PRJ,RESIDUAl,t} \bullet f_{PRJ,COARSE} \bullet f_{PRJ,COARSEUSE} \quad (51b)$$

$$B_{PRJ,FINE,t} = B_{PRJ,RESIDUAl,t} \bullet f_{PRJ,FINE} \bullet f_{PRJ,FINEUSE} \quad (51c)$$

*Default values are 26.5%, 42.9%, and 30.6%, for $f_{PRJ,BARK}$, $f_{PRJ,COARSE}$, and $f_{PRJ,FINE}$, respectively* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)*. Default values are 85%, and 42%, for $f_{PRJ,COARSEUSE}$, and $f_{PRJ,FINEUSE}$, respective* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005)). *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 is assumed to be 100% combusted, a conservative assumption. Local data should be used for all variables, if available.*

$B_{PRJ,COARSE,t}$ *and* $B_{PRJ,FINE,t}$ *must now be allocated to particular product classes in order to derive estimates of permanence from secondary manufacturing using the 100-year method* ($\Delta C_{PRJ,PERMHWP2,t}$).

$$\Delta C_{PRJ,PERMHWP2,t} = B_{PRJ,COARSE,t} \bullet f_{PRJ,PROCESSc} \bullet f_{PRJ,PERMHWPc} + B_{PRJ,FINE,t} \bullet f_{PRJ,PROCESSf} \bullet f_{PRJ,PERMHWPf} \qquad (52)$$

*Processing efficiencies* ($f_{PRJ,PROCESSc}$ *and* $f_{PRJ,PROCESSf}$) *in secondary manufacturing are typically much higher than primary manufacturing. Hence, a default value of 85 % can be used* (Perlack, Wright, Turhollow, Graham, Stodkes, & Erback, 2005). *With respect to calculating permanent storage, the default approach is to assume that* $B_{PRJ,COARSE,t}$ *has a half-life equivalent to sawnwood, and* $B_{PRJ,FINE,t}$ *has a half-life equivalent to non-structural panels. These values are then used in equation 20 to calculate the fraction of biomass allocated to permanent storage after a 100-year time period, for the coarse and fine material. Alternative half-lives (see* (Miner, 2006)*) can be used if justified from industry-specific information.*

## Fossil fuel emissions associated with logging, transport, and manufacture

*Annual fossil fuel emissions from harvesting and processing of the various wood products* ($C_{PRJ,EMITDIRECT,t}$) *are calculated as:*

$$C_{PRJ,EMITFOSSIL,t} = \Delta C_{PRJ,EMITHARVEST,t} + \Delta C_{PRJ,EMITMANUFACTURE,t} + \Delta C_{PRJ,EMITTRANSPORT,t} \qquad (53)$$

*Where*

$\Delta C_{PRJ,EMITHARVEST,t}$ *is the annual fossil fuel emissions associated with harvesting of raw material (t C yr*$^{-1}$*)*

$\Delta C_{PRJ,EMITMANUFACTURE,t}$ *is the annual fossil fuel emissions associated with the manufacturing of raw material (t C yr*$^{-1}$*)*

$\Delta C_{PRJ,EMITTRANSPORT,t}$ *is the annual fossil fuel emissions associated with the transport of raw material (t C yr*$^{-1}$*)*

*The simplest approach to calculating* $C_{PRJ,EMITFOSSIL,t}$ *is to use published or derived carbon emission intensity factors. In the case of harvesting,* $\Delta_{PRJ,}C_{EMITHARVEST,t}$*; t C yr*$^{-1}$*), can be calculated as:*

$$\Delta C_{PRJ,EMITHARVEST,t} = \Sigma[(LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i + LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,OTHER,i,t} \bullet R_i) \bullet (1 - f_{PRJ,BRANCH,i,t}) \bullet (1 - f_{PRJ,BUCKINGLOSS,i,t})] \bullet CF \bullet c_{HARVEST} \qquad (54a)$$

*where:*

$c_{HARVEST}$ *is the carbon emission intensity factor (t C emitted/t C raw material) associated with harvesting (see Appendix 2, Table 2); all other terms are as defined in equation 19.*

$\Delta C_{PRJ,EMITTRANSPORT,t}$ *must be calculated after consideration of the transport distance from harvest to processing facility, and the means of transportation. This term can be calculated as follows (after* (Heath, et al., 2010)*):*

$$\Delta C_{PRJ,EMITTRANSPORT,t} = \Sigma[(LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i + LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,OTHER,i,t} \bullet R_i) \bullet (1 - f_{PRJ,BRANCH,i,t}) \bullet (1 - f_{PRJ,BUCKINGLOSS,i,t})] \bullet CF \bullet \Sigma(f_{PRJ,TRANSPORTk} \bullet d_{TRANSPORTk} \bullet c_{TRANSPORTk}) \quad (54b)$$

*where:*

$f_{PRJ,TRANSPORTk}$ = *the fraction of raw material transported by transportation type, k. (unitless;* $0 \leq f_{PRJ,TRANSPORTk} < 1$*).*

$d_{TRANSPORTk}$ = *the distance transported by transportation type, k. (km);*

$c_{TRANSPORTk}$ *is the carbon emission intensity factor (kg C emitted/t C raw material) associated with transportation type; all other terms are as defined in equation 19.*

$$\Delta C_{PRJ,EMITMANUFACTURE,t} = \Sigma[(LBL_{PRJ,FELLINGS,i,t} - LBL_{PRJ,FELLINGS,i,t} \bullet R_i + LBL_{PRJ,OTHER,i,t} - LBL_{PRJ,OTHER,i,t} \bullet R_i) \bullet (1 - f_{PRJ,BRANCH,i,t}) \bullet (1 - f_{PRJ,BUCKINGLOSS,i,t})] \bullet \Sigma(f_{PRJ,PRODUCTk} \bullet c_{MANUFACTUREk}) \bullet CF \quad (55)$$

$c_{MANUFACTUREk}$ *is the carbon emission intensity factor (t C emitted/t C raw material) associated with manufacture of product type, k; all other terms are as defined in equation 19.*

(Heath, et al., 2010) (Heath, et al., 2010)Estimates for $c_{MANUFACTUREk}$ are provided in Appendix 2, Table 2.

***Note: Equations and calculations for Leakage, Gross Emissions Reductions, Net Emissions Reductions, and Project VCU's are covered in the main document in detail.***

# Appendix 3 - Supporting Data files

The following table includes the key data files used in the PDD. The Afognak Carbon Model is included as part of the PDD. The remaining files were provided to auditors as evidence documentation.

**Table 18 - List of supporting data files used in the creation of the Afognak project description document.**

| Description | Filename | Format | Date |
|---|---|---|---|
| Spatial inventory data for the Afognak landbase. Used to support the landscape-scale modeling with the Landscape Summary Tool | Afognak Nov 29.mdb | Microsoft Access Database with shapefile | 11/29/2011 |
| Stand-level carbon database for each analysis unit generated from FORECAST for use in the Landscape Summary Tool | Afognak FORECAST attribute curves.xlsx | MS Excel | 01/23/2012 |
| Example of the use of the allometric biomass equations (Standish et al. 1985) to generate biomass data from growth and yield data | TIPSY Ss 20 output with Standish equations v1.1.xls | MS Excel | 03/11/2010 |
| Spreadsheet model used to calculate storage and emissions from harvested wood products and to calculate to project VCUs from model output on emissions considering leakage, uncertainty, and buffers etc.. | Afognak Carbon Model v2.1.xlsx | MS Excel | 01/23/2012 |
| FORECAST Calibration data set with AU run details | Afognak sitka v8.57.fds | FORECAST<br><br>Dataset file | 01/09/2012 |
| Afognak monitoring plot data with uncertainty factor calculation | Afognak plot data & UF Jan. 2012 | MS Excel | 01/23/2012 |
| Landscape Summary Tool with output | Afognak LST April 20, 2012.xlsx | MS Excel | 01/23/2012 |
| Excel version of FORECAST calibration dataset used for sitka spruce showing the use of BEFs from Li et al. 2003 and as modified by Lehtonen et al. 2004. | Sitka Spruce Dataset Afognak v1.1.xlsx | MS Excel | 01/23/2012 |
| Google earth file containing the project bounary | Afognak_Project_Boundary.kml | KML | 04/03/2012 |

# Appendix 4. Support For Assumed Retention Levels And Harvesting Rates

## *I. Assumptions With Respect To The Spatial Extent of Harvesting and/or Levels Of Retention:*

In the baseline analysis presented in Section 4.1, the assumption is made that 5% of mature forest area will be retained within the baseline harvest area that is not designated as higher and better use (HBU). Further, the assumption is made that within the HBU area 15% of mature forest area will be retained. It should be clarified that there is additional mature forest retained in the baseline scenario due to the establishment of legal stream buffers and areas left out of the harvest plan created for the Shuyak and Uganik parcels as part of the appraisal process (See Section 4.1).

In fact, the total retention of mature forest within the project area in the baseline scenario is **14.2%** (Table 7). This figure, the result of the combined retention assumptions, is the one that should be evaluated.

The retention assumptions described above (including mature forest areas excluded from the baseline harvest area) were based upon: 1) the harvest plan created for the Shuyak and Uganik areas as part of the appraisal process, 2) visual assessments of past harvesting on Afognak island, and 3) the legal requirements for retention on private lands.

### *1. Shuyak and Uganik timber appraisal harvest plan*

As part of the timber appraisal process a harvest plan was created for the Shuyak and Uganik parcels (Forest and Land Management, Inc. , 2008). For the purpose of the baseline scenario, this harvest plan was projected across the remaining parcels where a spatial harvest plan was not included in the appraisal. To estimate the amount of mature forest that would be left behind after harvest (after exclusion of non-productive, stream buffers, etc.), we analyzed the amount of actual retention in the Uganik and Shuyak parcels. The total retention of mature forest area in the Shuyak parcel (not including the areas designated HBU) was 10.5%. If both the Uganik and Shuyak parcels are considered together, a total of 24% is retained. This increase is due to the fact that the Uganik parcel has areas of streams with buffers and non-productive land dispersed throughout which are unique to the Uganik parcel (in comparison to the other project parcels), and which lead to the exclusion of a higher percentage of mature forest from the harvest plan (see Figure A1).

However, the Shuyak parcel (10.5% retention) is more representative of the other parcels within the project area in terms of the type of terrain and the level of fragmentation of both the remaining mature forest and the total pre-harvest (prior to 1999 harvest) productive land (Table A1 and Figure A1). This was confirmed during on site fieldwork which covered extensive areas of the Waterfall, Paul's Lake, Shuyak, and Uganik parcels in October 2011, wherein the Uganik parcel was observed to have a significantly higher level of open and marshy areas, and a major stream with related terrain. This is also evident in visual observation of orthophotos, where the level of openings and forest fragmentation is obvious in the Uganik parcel, and limited in the Waterfall, Paul's Lake, and Laura Lake parcels.

To confirm these observations, we looked at the level of forest fragmentation and the density of streams, which are key determinants with respect to the amount of mature forest likely to be left behind during harvest operations due to stream buffers, operability around larger stream terrain, and operational accessibility and the economics to reach isolated mature timber patches (particularly across wet openings). To evaluate the level of fragmentation in the pre-harvest landscape within the project area, polygons of pre-harvest productive forest area were created using a dissolve function in ARCGIS to remove the borders of the polygons harvested prior to 1999, and analysis done to compare the level of fragmentation and density of streams between parcels. The spatial distribution of existing mature forest and of total pre-harvest productive land was considerably more fragmented in the Uganik parcel in comparison to the the Shuyak, Waterfall, and Laura Lake/Paul's Lake parcels, respectively (Table A1). The average polygon size of mature forest and the perimeter to total area ratio provide good measures of fragmentation (i.e. smaller polygon sizes indicate more fragmentation, and higher perimeter to area ratio also indicates more fragmentation). Further, the Uganik parcel has a significantly greater density of streams (or mature forest area affected by stream buffers) relative to the other parcels as indicated the proportion of the productive area that falls within stream buffers.

Table A1. Measures of fragmentation of productive land and stream density within the different parcels included within the project area.

| Parcel # | Name | Mature Forest Avg. poly. Area (ha) | Mature Forest Perimeter to Area Ratio | Mature Forest Area in Stream buffers (ha) | Mature Forest Area in Stream buffers (% of total area) | Total Pre-harvest Productive Area (ha) | Pre-harvest Productive Area Perimeter to Area Ratio |
|---|---|---|---|---|---|---|---|
| 1 | Waterfall | 20.1 | 0.016 | 5.5 | 0.9% | 795.8 | 0.013 |
| 2 | Shuyak | 6.8 | 0.023 | 4.3 | 1.0% | 558.8 | 0.015 |
| 3 | Uganik | 3.6 | 0.039 | 19.6 | 5.2% | 536.0 | 0.019 |
| 5 | Laura Lake and Paul's Lake | 64.2 | 0.007 | 3.6 | 0.4% | 834.0 | 0.007 |

Consistent with on the ground observations and visual orthophoto observation, Table A1 demostrates the Shuyak property is more similar to the Waterfall, Laura Lake, and Paul's Lake parcels for projecting mature forest retention levels, in comparison to the Uganik parcel. Therefore the project's projected baseline scenario retention of 14.2% is a reasonable, or conservative assumption when compared against the most comparable data from the Shuyak parcel (10.4%).

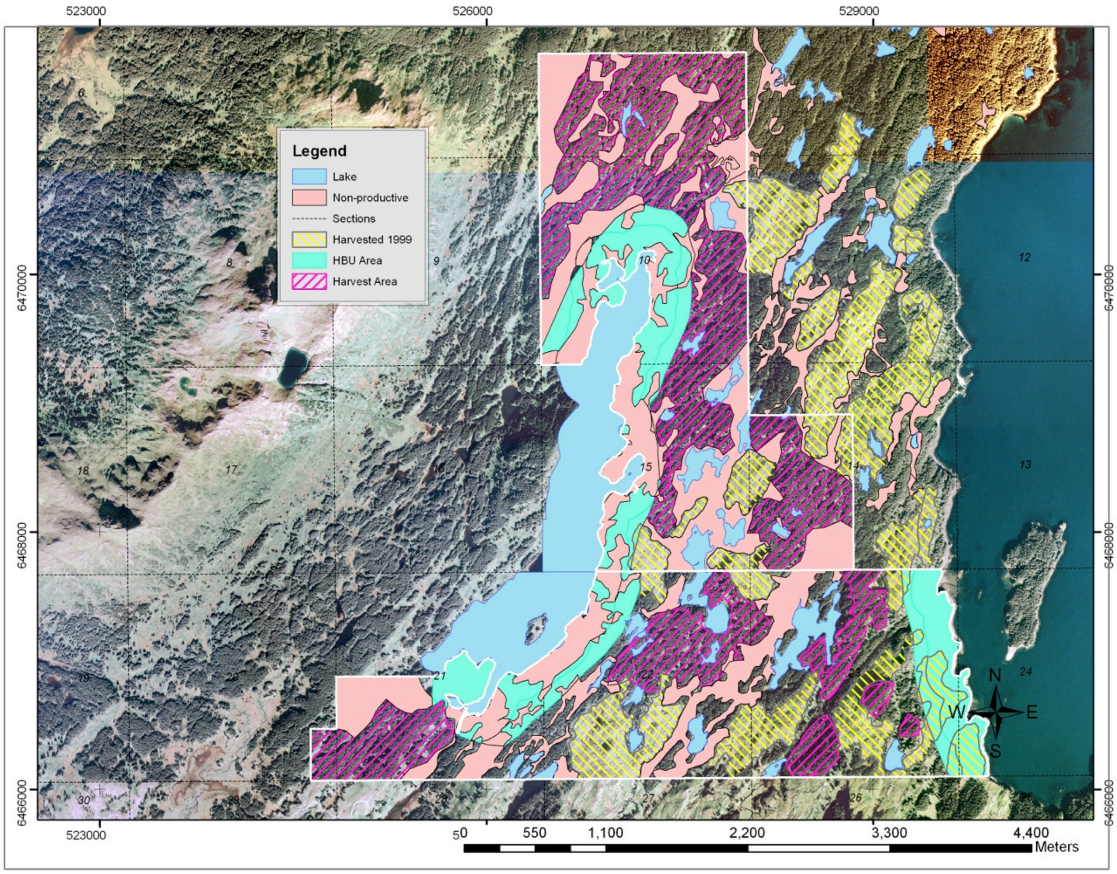



Figure A1. A map showing the timber appraisal harvest plan for the Shuyak and Uganik parcels within the project area. The upper parcel is the Shuyak parcel and the lower is the Uganik parcel. The additional areas of the Uganik and Shuyak parcels located on Delphin Point are not shown here. Note the extent of the previous and projected harvesting (yellow and pink hash-marked areas) in the upper Shuyak parcel.

### *2. Visual assessments of past harvesting on Afognak Island*

There are multiple logging areas across Afognak Island that show examples of past harvesting trends. The following examples demonstrate visual evidence of the extent of logging across the landbase and the typical practices relating to tree retention within cut areas.

**Example 1:** Figure A2 shows evidence of a two-pass harvest approach used in an area near Gretchen Lake on Afognak Island located to the southeast of the project area. Here, areas of recent clearcut harvesting (within ~0-3 years) appear as brown in color while areas of past clearcut harvesting (within ~5-10 years) appear as light green. Areas of retention of mature forest appear as dark green (it is possible these are slated for future harvest or even were in the process of being harvested when the Google Earth image was taken, but to be conservative, we have assumed the remaining forest areas are to be permanently retained).

This example was selected due to the clear property boundary lines on the North and East and ocean on the South/Southeast making it possible to visualize a relatively defined area with distinct boundaries to show the extend of harvesting. The area has clearly had the majority of the mature timber removed (as would be expected in the baseline scenario), with the exception of the few noted remaining mature forest areas. We believe this area is reasonably visually representative of the harvesting occurring across the areas of relative continuous forest (i.e. similar to the Waterfall, Laura Lake, and Paul's Lake parcels) once all harvesting is removed. By comparison, some of the surrounding area has a harvest pattern similar to one of the two "passes" seen in this example, which indicates the second harvest is not yet complete in all areas (also corroborated by areas flown over and observed on site during the audit visit).

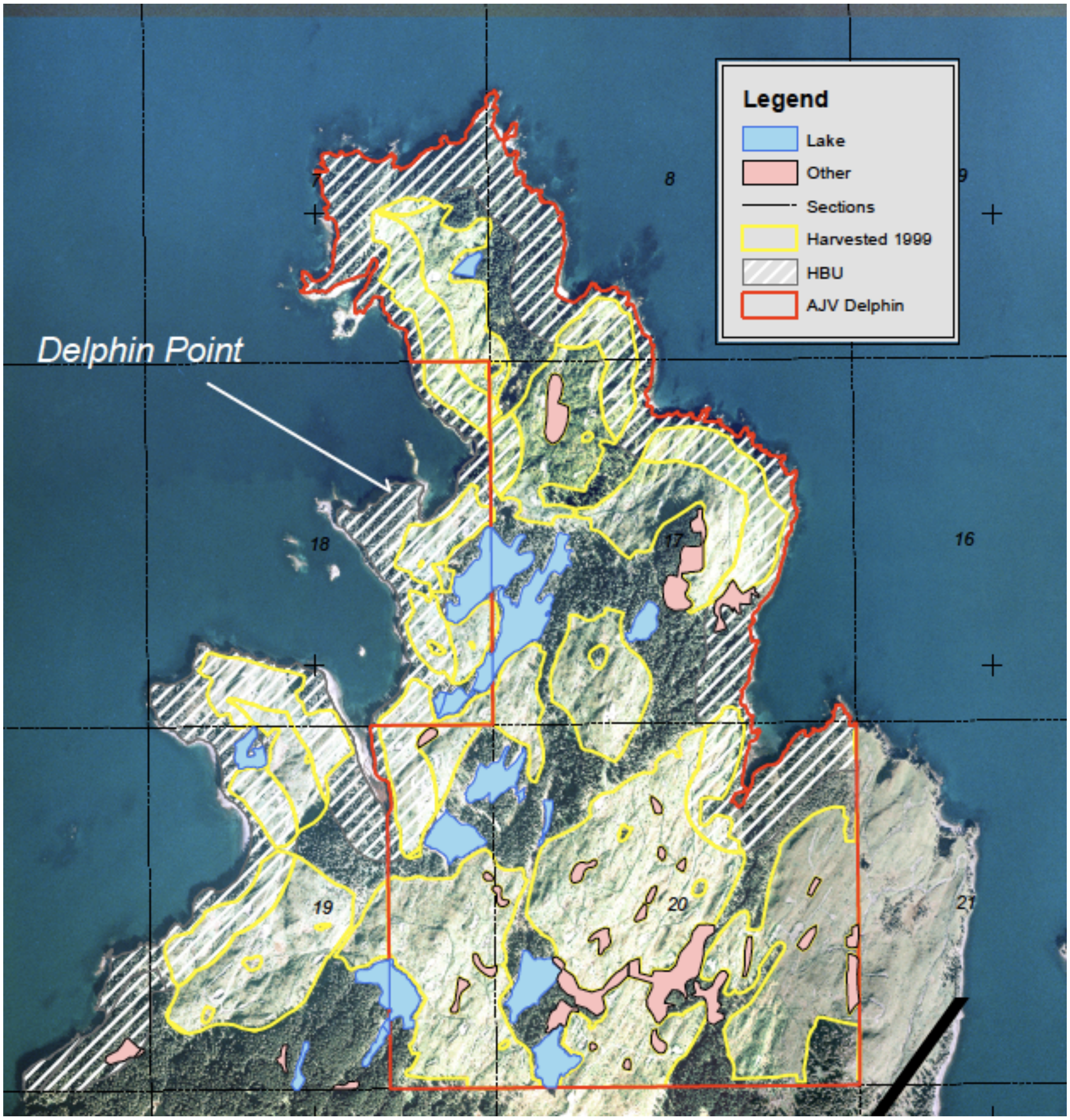
In this example, after the 2-pass harvesting, we occularly estimate that less than 15% (likely <10%) of the mature forest remains with much of the retention appearing to potentially be within stream buffers. This example provides adjacent area evidence of the that the 14.2% retention employed in the baseline scenario is reasonable.

The visual assessment approach was also used to determine that clearcut harvesting has been occurring in areas defined as higher and better use (HBU) in the Shuyak and Uganik timber appraisal documents. For example, Figure A3, shows several areas of clearcut harvesting within areas defined as HBU land on Delphin Point in lands directly to the east of the project parcels in that area. The 15% retention assumption in HBU areas within the baseline scenario was increased from the 5% used elsewhere as a conservative measure.


Figure A2. Example of the method of two-pass cutting on private forest land on Afognak Island near Gretchen Lake located southeast of the project area (from Google Earth). Areas of recent clearcut harvesting (within past 3 years) appear as brown in color while areas of past clearcut harvesting (within 10-15 years) appear as light green. Areas with retention of mature forest appear as dark green.

**Example 2**: The Delphin Point area (which includes the two small parcels from Uganik and Shuyak, but mainly areas outside the project area) is another example of the extent of logging spatially on the landbase. In this case, the example clearly demonstrates extensive areas cutover, and multiple examples of harvesting to the shoreline and within what the PD describes as the HBU buffer areas.

We have not measured or estimated the retained timber area because it is not clear what portion of the remaining mature forest area would have been slated for future harvest versus retained on the areas outside the project parcels; however as an example the timbered area in the very southwest corner would clearly have been logged (and in fact, the adjacent land directly to the south has been clearcut to the property line since this image was taken).




FigureA3. A map of Delphin Point on Afognak Island showing evidence of past clearcut harvesting in areas designated as HBU during the appraisal process. The area in highlighted in red, adjacent to the project area on the left, is not part of the project area. Harvesting in Section 21 (bottom right) also shows clear cuts right to the coastal boundary.

**Example 3**: The following photographs provide further visual evidence of the typical practices within a harvested cutblock on Afognak.

FigureA4 –

Approximately 2010 clearcut on the south end of Delphin Point. The photo is taken looking south while standing on the south property line on the small Shuyak parcel, and demonstrates the typical current clearcut practices. Note the size of the cutblock, limited tree retention. Although not clearly evident, note the small lake is not buffered, and this cut went virtually to the shoreline cliffs to every reachable tree. Photo: Mike Vitt

FigureA5 – older (10-15 years old) clearcutting within the larger Shuyak/Uganik parcels.  Note the extend of harvesting across the landscape.  The mature patch in the upper left is expected to be harvested in the appraisal harvest plan.  Also note the sparce natural regeneration and heavy shrub and grass competition.  Photo: Mike Vitt

Figure A6 – Another example demonstrating the typical extent of logging, limited stream buffers, and harvesting to or close to the ocean shoreline, in full compliance with the legal requirements on Alaska private lands. Photo: Mike Vitt.

***3. Legal requirements***

The only legal requirements in terms of retention on private land in this area is the protection of buffers around anadromous fish bearing streams. At least 50ft (~15m) of buffer area is required in Kodiak Island Borough according to Alaska riparian management zone regulations (U.S. Corps of Engineers, 2002) are also restrictions harvesting with respect to eagle nests, such that 100m buffer zones are required around active nests (US Fish and Wildlife Service, 2007). See Figures A4-A6 above for visual examples of typical harvests.

These legal limitations, extrapolated to the project landbase, amount to substantially less than the 14.2% mature forest retention assumed for the baseline scenario. Thus, the retention assumptions are conservative with respect to the legal requirements for harvesting on private land.

## II. Assumptions With Respect To Rate Of Harvest

In the baseline scenario described in Section 4.1 harvesting is projected to occur over a 10-year timeframe within the period of 2006-2016. This assumption is based upon: 1) financial and operational constraints, 2) the expiration date of timber rights in the project area, 3) information with respect to past harvesting, and 4) opinions of regional experts. Further information is provided in 5) to provide an overview of the state of the regional forest industry (and the over-arching practices leading to it) at the time of the project start.

### *1. Financial and operational constraints*

Harvesting activities in remote locations such as Afognak have high fixed costs for mobilization and operational logistics that strongly incentivize operators to maximize harvest volumes (to reduce the overall delivered unit cost (i.e. $/m$^3$ or $/mbf), and therefore improve profitability). Unlike "land-based" logging that is connected to road infrastructure and relatively proximal to residential and industrial resources, the Afognak properties are strictly water-access. Therefore, there are relatively high costs to mobilize equipment (via barges), supplies (via barge), and staff to the site (i.e. via barge or float plane). Floating or land based camp operations would have to be brought in and operated. The delivery of logs would require both loading and trucking capacity, log sort operations, booming ground operations, and then coordination with a large, high volume ocean-going log barge for transport to Asia.

Logistics and costs related to mobilization and remote operations, combined with large volume ocean transport strongly influence these operations to maximize their harvest volume over the shortest number of mobilizations possible. In other words, the objective is to be as efficient as possible by reducing the number of "entries" required and maximizing the volume removed each entry to offset these high fixed costs. This is supported by project implementing partner 3GreenTree's experiences managing remote logging operations in coastal British Columbia, and accounts of harvesting on Afognak Island during the 1990s (Hunt, 2010), and indicates that the baseline scenario should reflect a relatively compressed harvest schedule (minimum # of entries, maximum volume per entry). This combines with the other rate of harvest indicators outlined in this section to inform the development of the baseline scenario for the project.

### *2. Timeline on the expiration of timber rights prior to the carbon project*

Prior to the development of the carbon project, the original transactions involved the Native Corporations retaining the harvesting rights for the period of 9/24/2000 – 11/16/2013 on the Paul's Lake Tract A and Laura Lake Tract B (the other properties were sold 'fee-simple' without additional timber rights agreements). This type of agreement strongly implies the 13-year timeframe under which the Native Corporations intended to harvest the remaining timber volume from the initial properties, and provides the clear incentive to do so. In fact, we can speculate that this timeframe was likely substantially longer than actually necessary to remove the timber value, to provide leeway for operational sequencing, unexpected market conditions or other delays (the corporations would have lost any timber value remaining or any related compensation at the expiration of this agreement, and hence would have been strongly dis-incentivized to leave any timber value at risk of expiration). At the time these timber rights were effectively extinguished in the later acquisition agreements (2005), no harvest had yet occurred on these Paul's Lake and Laura Lake properties (harvesting was occurring on the other properties subject to the agreements formed in 2005, potentially indicating they were moving towards these properties progressively, perhaps in preparation for meeting the timeline of the timber rights agreements). The timeline on these timber rights was combined with the other corroborating data (items 1, 3, and 4 in this section) outlined in this section of Appendix 4 to guide the development of the timeframe/rate of harvest in the baseline scenario for the project (effectively a 11 year harvest period: 2006-2016, inclusive).

***3. Descriptions of past harvesting***

An account of activities that occurred leading up to the conservation planning that occurred following the Exxon Valdex accident in 1989 (Hunt, 2010) describes the harvesting on Afognak Island by the different native corporations as occurring primarily over a decade between 1991 and 2000. Hunt (Hunt, 2010) reports that during that period the average annual timber cut from Afognak Island ranged from 50 to 60 million board feet. Considering the average volumes in the project area as determined from the timber appraisal are ~560 $m^3$ $ha^{-1}$, and that these areas a representative of Afognak Island in general, the annual area cut would have ranged from 208-250 ha per year. This is consistent with the assumption of 198.6 ha harvested per year in the baseline scenario.

***4. Opinions of regional experts***

Clare Doig, a consulting forester from the region with extensive forestry experience on Afognak Island and the surrounding region (Clare Doig of Forest & Land Management Inc. – also the party responsible for the timber appraisals) expected that the land would have been logged in 8 years (Clare Doig, personal communication), based on similar rationale as described in Item 1 above. Mr. Doig further reiterated an estimate of 1,000-1,200 acres per year (with annual fluctuations due to market conditions) as his estimate of the average rate of harvest on Afognak Island (email correspondence between Clare Doig and 3GreenTree – March 7, 2012). In addition, Winrock (Winrock International, 2002) reported, in an initial assessment of the carbon project for the property, that a representative from regional US Fish Wildlife Service expected the harvesting would occur over a 12-year period. These assessments further informed (and are consistent with) the rate of harvest assumption in the baseline scenario.

5. Other Reference to Typical Landscape Scale Harvesting:

In the timber appraisal undertaken by Clare Doig (Forest and Land Management, Inc. , 2008), the following discussion of the current state of harvesting operators on Afognak Island:

"Between 1997 and 2007 several private timberland owners throughout Alaska ended harvesting activities because their standing timber inventories were exhausted. Among the Southeast Alaska producers exiting the log export business were Atikon Forest Products, Klukwan, Inc., Shaan Seet, Inc., Klawock Heenya Corporation, and Rayonier, Inc. At Icy Bay on the Gulf Coast, Citifor, Inc. and Wasser & Winters also ended their operations. The net result of this decrease in harvest activity has been a steady decline in spruce log exports from Southeast and Coastal Alaska. During this same period, Afognak Island operators Koncor Forest Products (KFP) and Afognak Native Corporation (ANC) also elected to cease their harvesting operations. Unusually, however, KFP and ANC retained significant volumes of standing timber when they ended active operations, and have since engaged in a series of stumpage sales to the current operator, Trans-Pac

Alaska LLC."

This timber appraisal background information is further corroborating evidence about the state of the forest industry in the region that indicates a typical practice of essentially liquidating existing timber stocks (to the point of wrapping up operations once stocks are depleted), and that the remaining operators expected to continue liquidating standing timber volumes using outside operators.  Although anecdotal in nature, it adds further support ing information that the rate and extent of harvesting baseline scenario is not inconsistent with common regional operating practices.