Usal Redwood Forest
Improved Forest Management Project
CAR 730
Forest Project Design Document

For 2007 through 2014 Reporting Years and Initial Verification
Under the Climate Action Reserve's
Forest Project Protocol Version 3.2, August 31, 2010

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Purpose of This Document

This Forest Project Design Document (PDD) reports information about the Usal Redwood Forest Improved Forest Management Project required by the Climate Action Reserve's Forest Project Protocol Version 3.2, August 31, 2010. The information presented in this document is organized based on guidance from section 9.1.1 of the Forest Project Protocol.

This PDD has been submitted for verification as a draft document and is considered to be confidential until such time as the Usal Redwood Forest Project is registered with the Reserve. This document should not be distributed by the Reserve to any person other than the Verification Body until such time as the Project is registered.

The carbon stock estimates presented in this report have been submitted with the oversight of James D. Clark, California Registered Professional Forester #2528.

Signed: James D. Clark



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1. Introduction

Usal Redwood Forest Company, LLC ("URFC") manages the Usal Redwood Forest totaling approximately 49,571 acres; located in the Coast Range of Mendocino County. The Usal Redwood Forest is located approximately 25 miles due north of the city of Fort Bragg, primarily west of Highway 101. A vicinity map showing the location of the Usal Redwood Forest relative to local towns and highways is shown as Figure 1 on page 2.

URFC purchased approximately 50,526 acres in June of 2007. In October 2011, approximately 957 acres in the southwestern portion of the ownership were sold to the Save the Redwoods League resulting in the current configuration of the property. In conjunction with this sale in October 2011, a Conservation Easement was granted to The Conservation Fund through a grant from the California Wildlife Conservation Board. The Fund transferred this easement to CalFire in December 2014. The Usal Redwood Forest Project encompasses approximately 47,981 timbered acres of the larger property.

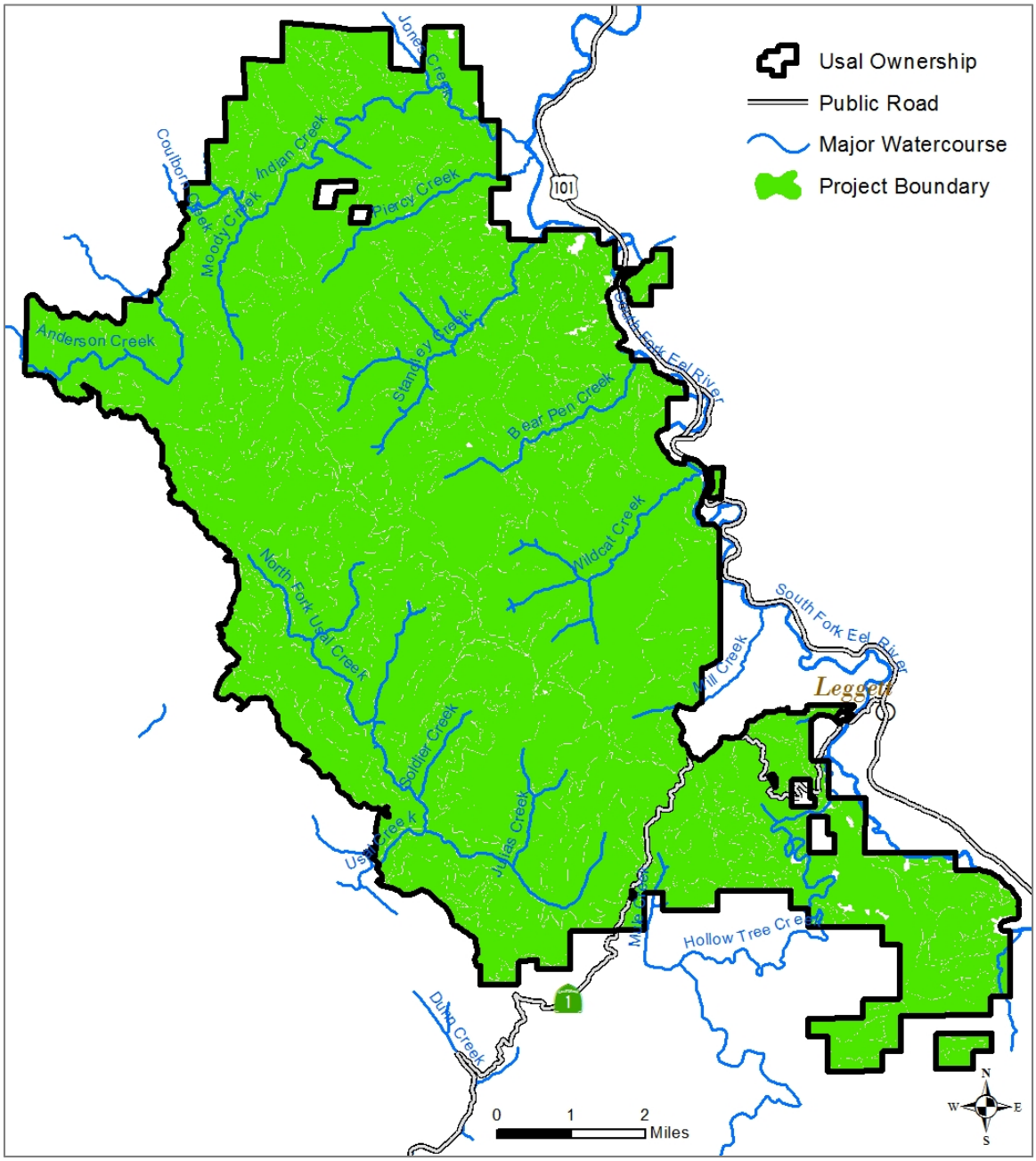
2. Project Information and Eligibility

The Usal Redwood Forest is generally characterized as moderate (site class III) to highly (site class II) productive timberland. Terrain is of moderate to steep slope. Elevation is from 40 feet to 2,500 feet above sea level. Primary conifer species are coastal redwood and Douglas-fir. The principal hardwood species is tanoak with a mixture of madrone, true oak, California laurel, and other California hardwoods.

The Usal Redwood Forest Improved Forest Management Project (the "Usal Redwood Forest") is comprised of 47,981.54 acres of timberland on the larger 49,571 acre ownership block. Located at the North end of Mendocino County approximately 25 miles due north of the city of Fort Bragg, the project encompasses the Usal Creek watershed and several tributaries to the South Fork of the Eel River. The Usal Redwood Forest is generally a well blocked out property that is 12 miles North/South by 10 miles East/West. The topographic map included in Attachment A shows the Project Area boundary, topography, roads, watercourses, and public land survey information.

The Usal Redwood Forest is not located on land that was part of a previously registered Forest Project.

Figure 1: Usal Redwood Forest Vicinity Map



2.1. Additionality

2.1.1. Legal Requirement Test

This project is not legally required. Among other reasons, the Usal Redwood Forest tract was acquired by URFC in 2007 with the expectation that their management regime would sequester carbon by increasing timber stocking and that they may be able to realize income from the sale of resulting carbon offset credits. URFC is a wholly-owned subsidiary of Redwood Forest Foundation, Inc. (RFFI), a non-profit organization comprised of timber, environmental, business and community leaders. RFFI is dedicated to acquiring, protecting, restoring and managing forestlands for the long-term benefit of the local community. The Usal Redwood Forest was purchased for the multiple and equally important purposes of establishing a community forest, generating jobs, protecting habitat, improving water quality, providing recreational opportunities for the community and ensuring the long-term sequestration of carbon.

2.2. Project start date and Initial Reporting Period

The Usal Redwood Forest has an initiation date of 6/13/2007 when the property was purchased by URFC. The initial reporting period for this Project is 6/13/2007 through 12/31/2014. For the purposes of allocating CRTs by vintage, the reporting period will be assumed to be seven and one half years in length.

2.2.1. Crediting Period and Minimum Time Commitment

Under Version 3.2 of the Protocol, the Project's crediting period will be 100 years in length, and the minimum time commitment will be 100 years following the issuance of any CRT for GHG reductions or removals achieved by the Project. The Usal Redwood Forest intends to convert the CRTs generated from the initial reporting period to ARB's Compliance Offset Program, and ultimately transition the Project to ARB's Compliance Offset Program.

2.3. Broadcast Fertilization

The Project does not employ broadcast fertilization.

2.4. Sustainable Harvesting Practices and Ongoing Management Activities

Upon the acquisition of the property, URFC changed the management goals for the property to that of a working community forest whereby the property's environmental attributes will be maintained and restored over time while providing economic benefits to the local community in terms of jobs, property taxes and forest products.

Commercial harvesting is planned within the Project Area; and since 2007 commercial harvest activity has taken place in 2012, 2013, and 2014. In October 2011, the conservation easement placed a restriction on the entire property limiting conifer harvest

volume removals to no more than 2.9% of total standing conifer inventory volume on an annual average basis over the length of each consecutive, non-overlapping 5-year period. The conservation easement also requires that the Usal Redwood Forest to be managed under a third party, forest management certification program, such as that of the Forest Stewardship Council (FSC) standards and to transition from even-age to uneven-age management over the life of one rotation; however, the easement allows for even-age silviculture to be employed to replace tanoak dominated stands with a more desirable and productive ecological condition of mixed conifers and hardwoods within 61 years of easement recordation.

At the Project's initiation on 6/13/2007 there were two approved Timber Harvest Plans (THPs) on the Project Area, 1-04-135MEN, and 1-06-058MEN. Commercial harvesting under these THPs was completed prior to the Project's initiation date by the previous landowner. The URFC is currently seeking FSC certification of the Usal Redwood Forest with SCS Global Services. This FSC certification is expected to be in place prior to the Project's registration with the Reserve.

Once obtained, FSC certification will be used to meet the sustainable long-term harvesting requirements per the Forest Project Protocol for future reporting periods. During the initial reporting period, harvesting on the Project Area has been limited to approximately 5,000 MBF since the Project's initiation in 2007. Growth during the same time is conservatively estimated to be 130,000 MBF. Silvicultural prescriptions associated with harvest have been limited to uneven-aged prescriptions and Special Prescriptions in the form of variable retention as defined by section 913.4 of the California Forest Practice Rules while also maintaining canopy cover averaging at least 40 percent across the entire forestland owned by the Forest Owner in the same Assessment Area covered by the Project Area. The Forest Owner owns no other forestland within the Assessment Area covered by the Project Area. As such, the Usal Redwood Forest Project has met the requirement for sustainable long-term harvesting for the initial reporting period by satisfying the third option under Section 3.10.1 of the Forest Project Protocol.

2.5. Natural Forest Management

The following is a description of how the Usal Redwood Forest meets (or will meet) the definition of "Natural Forest Management":

2.5.1. Native Species

The Usal Redwood Forest is characterized by a mix of redwood, Douglas-fir, true fir, tanoak, true oak, madrone, and other native hardwoods. Approximately 99.99% of the Project's biomass is in native species, and thus the Project meets the 95% criteria for carbon in native species. Regeneration activities proposed under the Project will utilize only native species.

2.5.2. Composition of Native Species

As of 12/31/2014, the Project Area is composed of approximately 26% redwood, 27% Douglas-fir, 0.10% other conifer (Grand fir, Western Hemlock, other conifer), 38% tanoak, 5% madrone, and 3% other hardwoods by basal area as shown in Table 1 below. URFC intends to manage the timber stands to reduce the hardwood component and increase the component of redwood. In no case will the composition of any one species exceed 60% on average across the Project Area.

Table 2.1: Project Level Species Composition by Basal Area

Species	Basal Area per Acre	Relative Percentage
Redwood	61.3	26.3%
Douglas-fir	63.9	27.4%
Grand Fir	0.1	0.0%
Western Hemlock	0.1	0.1%
Other Conifer	0.1	0.0%
Tan Oak	89.5	38.4%
Live Oak	2.3	1.0%
Pacific Madrone	11.8	5.1%
Bay Laurel	0.3	0.1%
Red Alder	1.7	0.7%
Bigleaf Maple	0.2	0.1%
Golden Chinkapin	0.9	0.4%
Willow Sp.	0.2	0.1%
Other Hardwood	0.8	0.3%
Total	**233.2**	**100.0%**

2.5.3. Distribution of Age Classes and Sustainable Management

URFC will demonstrate sustainable management through its pending FSC certification. FSC certification necessitates adherence to and verification of harvest levels that can be permanently sustained over time. In addition, the project proposes to employ variable retention and uneven-aged management which will maintain no more than 40% of the Project's forested acreage in ages less than 20 years at a watershed scale up to 10,000 acres. As of 12/31/2014, productive timberland acreage in ages less than 20 years amounts to approximately 4.0% of the project area, or approximately 1,910 acres.

Table 2.2: Project Age Class Distribution in 2014

CALWATER Watershed	IDNUM	Project Acreage	Project Acreage < 20 Years Old	% of Acreage < 20 Years
Bear Pen Creek	1111.320404	3,845	36	0.9%
Big Dann Creek	1111.320203	8		0.0%
Bridges Creek	1111.320405	61		0.0%
Cedar Creek	1111.320204	10		0.0%
Cottaneva Creek	1113.120101	120		0.0%
Jackass Creek	1113.110200	63	2	2.6%
Low Gap Creek	1111.320202	2,049		0.0%
Lower Hollow Tree Creek	1111.320302	3,850	297	7.7%
Lower Indian Creek	1111.320504	5,989	504	8.4%
Lower Usal Creek	1113.110101	5,286	3	0.1%
McCoy Creek	1111.320505	190		0.0%
Middle Hollow Tree Creek	1111.320301	549		0.0%
Mill Creek	1111.320401	1,859	23	1.3%
Piercy Creek	1111.320502	2,129	341	16.0%
Red Mountain Creek	1111.320403	0		0.0%
Standley Creek	1111.320501	5,046	34	0.7%
Upper Indian Creek	1111.320503	2,812	507	18.0%
Upper Sproul Creek	1111.320703	6		0.0%
Upper Usal Creek	1113.110102	9,971	124	1.2%
Wildcat Creek	1111.320402	4,138	40	1.0%
Grand Total		**47,982**	**1,910**	**4.0%**

As the Project Area is larger than 10,000 acres, the Project Area has been split by CALWATER planning watershed in order to determine compliance with the above requirement. As shown in Table 2.2 above, the Project is located within 20 CALWATER planning watersheds comprising the South Fork Eel River and Usal Creek watersheds with a relatively small area drained by Cottaneve and Jackass Creeks. Currently no more than 40% of the forested area in each watershed described above is less than 20 years in age.

2.5.4. Structural Elements

URFC does not actively remove lying dead wood as a part of its stand management activities. It is expected that the accumulation of lying dead wood will be commensurate with recruitment from standing dead trees. URFC is committed to maintaining and increasing, the number of standing dead trees within the Project Area as a component of its forest management objectives. URFC has not recently conducted any salvage operations, nor does it intend in the future to actively pursue aggressive salvage operations on its timberlands. URFC may conduct salvage harvesting in the future, but

with the goal of maintaining a component of standing dead trees in the post treatment stands.

In the case of the Usal Redwood Forest, the Project Area has not undergone any recent salvage harvesting. Therefore, all that must be demonstrated is that the greater of one metric ton of carbon per acre or 1% of standing live carbon stocks is present in standing dead wood, or that progress towards these targets is ongoing. The project currently contains an average of 1.24 Mg C per acre and 1.52% of standing live carbon stocks in standing dead wood.

2.6. Description of the Project Area

2.6.1. Existing land cover and land use

The Usal Redwood Forest is comprised of second- and third-growth redwood and Douglas-fir forest stands dominated by Tanoak in many areas. The Usal Redwood Forest is zoned Timber Production (TP).

2.6.2. Forest vegetation types

The following Wildlife Habitat Relationship (WHR) vegetation types occur on the Usal Redwood Forest:

RDW	REDWOOD
DFR	DOUGLAS FIR
AGS	ANNUAL GRASS
COW	COASTAL OAK WOODLAND
MHW	MONTANE HARDWOOD
CRC	CHAMISE-REDSHANK CHAPARRAL

The majority of the Project Area is classified as the DFR "Douglas Fir" type. Primary conifer species are Douglas-fir and Coastal Redwood. The principal hardwood species is Tanoak with a mixture of Madrone, oak (i.e. *Quercus)*, California laurel, and other California hardwoods. On most sites redwood would likely dominate if vegetation succession were allowed to proceed naturally.

2.6.3. Identifying the Project Area

The Project Area boundary is derived from the gross property acreage after removing non-timbered areas, slope instability areas that are not capable of growing a crop of trees, large watercourse channels, and road buffer acres. The Project Area is derived from a GIS stand layer which represents the most current depiction of the Usal Redwood Forest boundary. The final Project Area acreage is 47,981.54 acres .

2.6.4. Site Productivity

The Usal Redwood Forest is generally characterized as moderate (site class III) to highly (site class II) productive timberland. The determination of site index for the purposes of growth and yield modeling is described within the Modeling Plan (Attachment C).

2.6.5. Land pressure and climate zone

The Usal Redwood Forest as well as much of the surrounding land is utilized for timber production, recreation, agriculture and rural residential uses. Land pressures associated with these uses are typically conversion of timberland to home sites and fragmentation of larger blocks into smaller tracts. The Usal Redwood Forest ownership has been merged into a single parcel, cannot be subdivided and the residential development rights have been extinguished. Any industrial, commercial, or residential use of any kind is prohibited, except for permitted forest management and as otherwise permitted in the easement. Prior to recordation of the Conservation Easement, the Usal Redwood Forest's previous owner obtained Certificates of Compliance for the 92 separate legal parcels comprising the Project Area, thus allowing for the sale and development of these parcels to rural residential home and/or vineyard sites. Residential uses would involve the development of home sites while road use and human activity on the property would increase. Historically, increased human activity has resulted in the disruption and displacement of native plants and animals.

The Usal Redwood Forest area consists of both Maritime & Mediterranean climates influenced by the proximity to the Pacific Ocean and topography. Summers are warm and winters are mild and wet. The cooling pacific fog follows the path of the Eel River and Usal Creek onto the property where temperatures range from an average of low of 32 degrees F in January to an average high of 85 degrees F in August. Average annual rainfall for the property is approximately 60 inches per year.

3. Inventory Methodology

3.1. GHG Assessment Boundary

The Usal Redwood Forest Offset Project Boundary specifically includes the following GHG emission sources, sinks, and reservoirs (SSRs or Carbon Pools):

- IFM-1 Standing live carbon
- IFM-3 Standing dead carbon
- IFM-7 Carbon in in-use forest products
- IFM-8 Forest product carbon in landfills
- IFM-9 Biological emissions from site preparation activities
- IFM-14 Biological emissions from changes in harvesting on forestland outside the project area
- IFM-17 Biological emissions from decomposition of forest products

3.2. Inventory Design and Sampling Process

The Usal Redwood Forest inventory was conducted from January through the first week of March 2015 utilizing a random selection of plots located across eight timber stratum. Plot locations were determined from a random selection of plots from a 5 chain by 5 chain grid that uniformly covers the entire Project Area. The final inventory design resulted in the installation of 353 plots across the Project Area. A summary of the plot distribution by timber stratum and acreage is provided below in Table 3.1. The inventory methodology included as Attachment B provides a detailed description of the data collected as well as the structure of the cruise, including maps showing the cruise plot locations for the Usal Redwood Forest.

For operational purposes, the Usal Redwood Forest maintains a separate set of inventory data collected on a systematic grid across the entire URFC ownership without regard to timber stratification. The inventory is a stand based inventory of all stands at least 15 years of age, and includes data collected from 2000-2014. Using the cruise data from the operational inventory, a stratification methodology based on species composition and biomass density was assigned to each timber stand across the larger Project Area. The stratification methodology is described as a part of the larger inventory methodology in Attachment B.

Table 3.1: Strata and Plot Summary

Stratum	Acres	Plots
Conifer High	1,618.90	22
Conifer Medium High	8,686.23	78
Conifer Medium Low	12,860.67	90
Conifer Low	4,257.68	26
Hardwood High	2,151.85	20
Hardwood Medium High	7,560.21	52
Hardwood Medium Low	8,454.17	51
Hardwood Low	2,391.83	14
Total	**47,981.54**	**353**

3.3. Sampling Methodology

The inventory specifications utilized to conduct the current inventory are provided in Attachment B.

The inventory collected tree data on a series of nested fixed-area circular plots. Trees 10.6" DBH and larger were measured on a 10^{th} acre fixed radius plot, trees 3.6" DBH to 10.5" DBH were measured on a 50^{th} acre fixed area plot, and trees 1.0" DBH to 3.5" DBH were measured on a $1/100^{th}$ acre fixed area plot.

3.4. Data Management and Analytical System

Inventory data representing the current carbon stocks and the carbon stocks as of the Project commencement date is maintained in Access database files. These database files were developed from data gathered as a part of the 2015 inventory effort. The Access database files serve as the repository for inventory data and are accessed by the growth and yield model during growth and yield simulations.

The inventory databases are utilized to process the inventory data through the growth and yield model FORSEE, and analyze the modeling outputs. The calculation of volume, biomass and the ultimate conversion to carbon utilizes the inventory data and growth and yield output data and applies the volume formulas and biomass conversion factors described below in section 4.

3.5. Inventory Update Process

As timber management activities take place on the Usal Redwood Forest Project Area, or disturbance such as fire or mortality from extra-ordinary factors occurs, stands subject to harvest or disturbance will be recruised on the 5 chain by 5 chain grid. As additional timber stands are cruised each year, the plot data will be incorporated into the stratified inventory design. By 2026, the inventory design will be composed of plots that are no more than 12 years old. On this basis, URFC will maintain a forest inventory system that will meet the inventory specifications and requirements contained in Appendix A of the Forest Project Protocol, with plots which are no more than 12 years old.

Updating the Project's carbon stocks from year to year will involve the following steps:

1. Any newly installed inventory plots will be incorporated into the inventory estimate for the stratum in which they are located.
2. Existing inventory plots will be updated using FORSEE as described in the modeling plan.
3. Updating the forest inventory for harvests or disturbances that have occurred during the previous year through the installation of new plots, or adjustments to previous plot data.
4. Where necessary, the inventory update process may result in restratification of portions of the timber strata.
5. Inventory updates following harvest or disturbance will be re-measured within 12 months of the harvest or disturbance.
    a. Partial harvests, such as selections and thinnings are updated in two phases:
        i. Phase1: within one month of harvest completion, the inventory is depleted by modeling removals such that:
            1. The inventory forester selects one of the stands underlying the harvest unit to represent the new stand.
            2. The inventory plots from the selected stand are projected from time-of-cruise to time-of-harvest.
            3. Based on the forester's prescription for the harvest, plots are 'thinned' by removing trees from the projected tree lists.
            4. The 'thinned' plots are aggregated to estimate a stand-level inventory for the thinned stand.
            5. Based on the stand-level inventory estimate, the stand is evaluated against the stratification rules, and is assigned a strata.
            6. Any "active" plots within the harvested area are removed from the inventory database and are no longer used in the carbon stock calculations.
        ii. Phase 2: within one year of completion, the stand is resampled.

The carbon stocks presented herein as of 12/31/2014 are based on the 2015 data as of the date the cruise data was recorded as described in the Modeling Plan.

4. Quantification Methodology

The calculation methodology for determining metric tonnes of carbon for the reported pools follows the guidance provided in Appendix A.3 of version 3.2 of the Forest Project Protocol.

IFM-1 Standing Live Carbon:

4.1. Above-ground Standing Live Carbon Pool

Above-ground standing live carbon in trees 1" DBH and larger was calculated using the appropriate biomass equation by species taken from the Forest Project Protocol page on CAR's website (http://www.climateactionreserve.org/how/protocols/forest/). The current biomass equation documentation provided by CAR is included as Attachment E . The equations referenced below are not reproduced here for the sake of minimizing redundancy. These equations are used to generate biomass estimates for the above-ground portion of standing live trees, and hard snags. These equations will be referred to as the "FIA equations" herein.

Each species can have as many as three FIA equations in order to calculate tree biomass. The FIA equations used by species are as follows:

Table 4.1: FIA Equations[1]

Species	Bole Cubic Ft Volume	Bark Biomass	Live Crown Biomass
Redwood	Equation 24	Equation 17	Equation 10
Douglas-fir	Equation 3	Equation 8	Equation 6
Grand fir	Equation 23	Equation 2	Equation 1
Western Hemlock	Equation 6	Equation 15	Equation 12
Other Conifer	Equation 17	Equation 21	Equation 17
Nutmeg	Equation 8	Equation 13	Equation 10
Tanoak	Equation 34	None	None
Pacific madrone	Equation 40	None	None
Live oak	Equation 42	None	None
California laurel	Equation 33	None	None
Red Alder	Equation 26	Equation 20	Equation 16
Golden chinkapin	Equation 32	None	None
Bigleaf maple	Equation 37	None	None
Willow	Equation 40		
Eucalyptus	Equation 31		
Other Hardwood	Equation 41	Equation 20	Equation 16

[1] Biomass and volume equations utilized herein are based on those equations that were in place at the time the Project was listed in 2010. These equations are listed as "Batch 1.0" on CAR's website.

Cubic foot volume is calculated as the volume of the total stem from ground to tip (includes the top and stump). Bole biomass is calculated by multiplying the cubic volume by the wood density, and then dividing by 2.204622 to calculate weight in kilograms (kg).

Tonnes of standing live biomass per sample plot are calculated as follows:

For equations that use total tree height in meters, tree height is calculated by multiplying the trees total height in feet by 0.3048. Trees per hectare are calculated by multiplying trees per acre by 2.471. Tree diameter at breast height ("DBH") in centimeters (cm) is calculated by multiplying its DBH by 2.54.

Bole Biomass:

The Cubic foot volume of each tree is calculated as the volume of the total stem from ground to tip (includes the top and stump). FIA refers to this value as CVTS. Bole biomass is calculated by multiplying the cubic volume by the wood density, and then dividing by 2.20462 to calculate weight in kilograms (kg). Above-ground biomass in kilograms (kg) per acre is calculated by multiplying the FIA calculated kg per tree by each tree's per acre value.

Bark and Live Branch Biomass:

The above referenced FIA equations produce biomass in kg for the various parts of the above-ground portion of each tree. Above-ground biomass in kilograms (kg) per acre is calculated by multiplying the FIA calculated kg per tree by each trees per acre value.

Missing Volume:

Total percent carbon defect of each tree is defined as the total percent cubic foot defect of a bole both inside and outside the board foot scaling cylinder from and including the stump to the tip. It is recorded as a percentage of missing portions of the entire bole. The total rebuilt heights of trees with broken tops were estimated by the cruisers and then used to estimate percent missing volume based on table 4-7 (Forest Data Collection Procedures and Standards included in Attachment B) which provided percent stem cubic volume by 16-foot log segment. The total percentage of the bole that is missing was multiplied by the total biomass (including various biomass components of the tree) as calculated above to calculate the net biomass of the tree. By applying this percent missing volume estimate to all portions of the tree, it is felt that the resulting net biomass value is conservative.

The net kg per acre value of each tree on the plot is summed to derive above-ground live biomass kg per acre for the plot. This value is used to calculate the respective below-ground live biomass component for the plot. Total standing live carbon values presented herein are for trees 1" DBH and larger.

4.2. Below-ground Live Carbon

This is calculated at the plot level using the model provided by Cairnes et. al. specified on page 110 of Appendix A of the protocol. The formula has as its input, above-ground live biomass in Mg per hectare, and outputs below-ground biomass in Mg per hectare. Total net above-ground live carbon in kg per acre for each plot is converted to Mg of biomass per hectare by multiplying by 2.471, and then dividing by 1000. After calculating the below ground component in Mg per hectare using the Cairnes model, the results are converted to kg per acre by multiplying by 1000 and dividing by 2.471.

4.3. Total Standing Live Carbon Pool

Total standing live biomass for each plot is the sum of the above-ground and below-ground live biomass kg per acre. Mg of carbon (Mg C) per acre per plot is then calculated by multiplying by 0.5 to estimate carbon biomass. Mg C per acre is converted to CO2- equivalent (C02-e) by multiplying by 3.664.

IFM-3 Standing Dead Carbon:

4.4. Standing Dead Above-ground Carbon Pool

Data on standing dead trees was collected as a part of the Usal Redwood Forest 2015 inventory. In general, the amount of carbon stored in a standing dead tree is based on the proportion of the tree remaining standing, and the condition of the tree, or its decay class. The standing dead carbon pool is for trees 5.0” DBH and larger, with a minimum height of 15'.

Standing dead trees from the inventory data are classified into six decay classes based on descriptions contained on page 12 of General Technical Report NRS-29 (Harmon et al, 2011). These decay classes are generally described as follows:

Class 0	Tree has recently died with leaves intact.
Class 1	All limbs and branches are present; the top of the crown is still present; all bark remains; sapwood is intact, with minimal decay; heartwood is sound and hard.
Class 2	There are few limbs and no fine branches; the top may be broken; a variable amount of bark remains; sapwood is sloughing with advanced decay; heartwood is sound at base but beginning to decay in the outer part of the upper bole.
Class 3	Only limb stubs exist; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay in upper bole and is beginning at the base.

Class 4 Few or no limb stubs remain; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay at the base and is sloughing in the upper bole.

Class 5 No evidence of branches remains; the top is broken; <20 percent of the bark remains; sapwood is gone; heartwood is sloughing throughout.

The inventory did not record a distinction between recently dead trees (class 0) and decaying but sound trees (class 1). As class 0 trees are not subject to a volume deduction due to rot, by ignoring them, the inventory classification system lends itself to making the class 1 snag biomass calculations more conservative.

Biomass for standing dead trees includes the bole and bark components calculated using the FIA biomass equations described above and following the same procedures as for live trees other than the manner in which missing volume is calculated.

As decay class already accounts for density degradation due to rot, total percent carbon defect only accounts for missing wood (pieces, chunks, slabs, hollows). Total percent carbon defect of each tree is recorded as a percentage of missing portions of the entire bole based on figure 4-5, figure 4-6, and table 4-7 (Forest Data Collection Procedures and Standards included in Attachment B), which provided illustrative guidance and percent stem cubic volume by 16-foot log segment, respectively. In contrast to live tree percent carbon defect, the actual heights of snags with broken tops were used instead of rebuilt heights to estimate percent carbon defect (i.e. missing volume). Cambell Global used FORSEE computation processes to reconstruct the total height of snags, which was used to derive the remaining percentage of the bole that is missing above the broken top. These percentages were summed and then multiplied by the total bole biomass as calculated above to calculate the net biomass of the bole.

Once the net biomass of each tree has been calculated, a relative density is applied by species and decay class. The relative density is in relation to the green density of sound wood, or the trees' wood density. Table 4.2 below lists the relative densities applied by species and decay class taken from Research Paper NRS-15 (Harmon et al, 2011).

Table 4.2: Relative Density by Species and Decay Class

Common Name	DC0	DC1	DC2	DC3	DC4	DC5
Douglas-fir Coastal	1	0.892	0.831	0.591	0.433	0.433
Grand fir	1	1.013	0.966	0.855	0.574	0.574
Other Coastal Conifers	1	0.990	0.980	0.830	0.598	0.598
Redwood	1	0.994	0.951	0.902	0.605	0.605
Western hemlock	1	1.040	1.080	0.848	0.525	0.525
Willow (spp)	1	0.982	0.793	0.618	0.525	0.525
Bigleaf maple	1	0.979	0.766	0.565	0.450	0.450
California-laurel	1	0.982	0.793	0.618	0.525	0.525
Golden chinkapin	1	0.982	0.793	0.618	0.525	0.525
Canyon live oak	1	1.02	0.841	0.705	0.591	0.591
Pacific madrone	1	0.982	0.793	0.618	0.525	0.525
Other Coastal Hardwoods	1	1.02	0.841	0.705	0.591	0.591
Red alder	1	1.030	0.903	0.535	0.393	0.393
Tanoak	1	0.982	0.793	0.618	0.525	0.525

4.5. Standing Dead Below-ground Carbon

This is calculated at the plot level using the model provided by Cairnes et. al. specified on page 110 of Appendix A of the protocol. The formula has as its input, above-ground biomass in Mg per hectare, and outputs below-ground biomass in Mg per hectare.

4.6. Total Standing Dead Carbon Pool

Total standing dead biomass for each plot is the sum of the above-ground and below-ground standing dead biomass Mg per acre. Mg of carbon (Mg C) per acre per plot is then calculated by multiplying by 0.5 to estimate carbon biomass. Mg C per acre is converted to CO2- equivalent by multiplying by 3.67.

IFM-6 Soil (if applicable):

Excluded because the conditions in Table 5.2 of the protocol that would require inclusion of this pool (site preparation involving deep ripping, furrowing, or plowing where soil disturbance exceeds 25 percent of the Project Area over the Project Life, or mechanical site preparation activities not conducted on contours) are not planned.

4.7. Wood Products Carbon Pools

Carbon in wood products is calculated based on the guidance provided in Appendix C of the Protocol. The following is a summary of the procedure employed:

IFM-7 Carbon in in-use forest products:

As no commercial wood products market for Tanoak or hardwood logs in general currently exists for hardwoods which could be harvested from the project area, wood products delivered to the mill in any period is calculated beginning with the cubic volume of harvested conifer trees 10" DBH and larger. Conifers smaller than 10" DBH are not included as they are too small to be delivered to the mill. The dry weight of wood products in pounds is calculated by multiplying the wood density in lbs/cubic foot by the cubic volume for each softwood species harvested based on the CVTS values derived from the FIA equations listed above. Bark and branch biomass are not included in the volume harvested. The wood densities utilized are those for the Douglas-fir forest type and are included in Table C.1 of Appendix C of the Protocol. The dry weight is multiplied by 0.5 to convert the weight to carbon weight only. The weight of carbon in lbs is divided by 2,204.6 to get the carbon weight in metric tonnes (Mg).

Mg of carbon is then multiplied by 0.675 to account for mill efficiencies, taken from the Forest Project Protocol page on CAR's website (http://www.climateactionreserve.org/how/protocols/forest/).

The resulting Mg carbon value after accounting for milling efficiencies is then passed to the wood products worksheets for calculating long-term in-use, and landfill wood products storage. For both in-use and landfill calculations, the wood products carbon is separated into product classes and multiplied by the respective 100-year average storage factor. The tables below list the assignment of wood products by class for the Northern California Coast Assessment Area per the most current Assessment Area Data File taken from the Forest Project Protocol page on CAR's website (http://www.climateactionreserve.org/how/protocols/forest/), as well as the 100-year average storage factors applied to each wood product class per table C.2 of Appendix C of the protocol.

Table 4.3 In-use Wood Products Factors

Wood Products by Class	
% Softwood Lumber	97.067%
% Hardwood lumber	0.002%
% Softwood Plywood	1.874%
% Oriented Strandboard	0.000%
% Non Structural Panels	0.244%
% Miscellaneous Products	0.095%
% Paper	0.718%

100-year Storage Rates Average Values from Appendix C, In-Use Table C.2	
Softwood Lumber	0.463
Hardwood lumber	0.250
Softwood Plywood	0.484
Oriented Strandboard	0.582
Non Structural Panels	0.380
Miscellaneous Products	0.176
Paper	0.058

Average carbon stored in in-use wood products is calculated using equation C.1. Carbon is converted to CO2-equivalent by multiplying by 3.67. This value is combined with IFM-8 using equation C.3 to represent $WP_{total, y}$ for the reportiong period.

$WP_{total, y}$ for the reporting period represents $AC_{wp,y}$ in equation 6.1. Average in-use wood products produced by the baseline analysis ($BC_{wp, y}$) are deducted from actual wood products produced each reporting period ($AC_{wp,y}$) in equation 6.1, and the resulting calculation is multiplied by 80% to account for the "Market Response".

IFM-8 Forest product carbon in landfills (if applicable):
Wood products delivered to the mill in any period is calculated beginning with the cubic volume of harvested conifer trees 10" DBH and larger. Conifers smaller than 10" DBH are not included as they are too small to be delivered to the mill. The dry weight of wood products in pounds is calculated by multiplying the wood density in lbs/cubic foot by the cubic volume for each softwood species harvested. The wood densities utilized are those for the Douglas-fir forest type and are included in Table C.1 of Appendix C of the Protocol. The dry weight is multiplied by 0.5 to convert the weight to carbon weight only. The weight of carbon in lbs is divided by 2,204.6 to get the carbon weight in metric tonnes (Mg).

Mg of carbon is then multiplied by 0.675 to account for mill efficiencies, taken from the Forest Project Protocol page on CAR's website (http://www.climateactionreserve.org/how/protocols/forest/).

The resulting Mg carbon value after accounting for milling efficiencies is then passed to the wood products worksheets for calculating long-term landfill wood products storage. The wood products carbon is separated into product classes and multiplied by the respective 100-year average storage factor. The tables below list the assignment of wood products by class per the most current Assessment Area Data File taken from the Forest Project Protocol page on CAR's website (http://www.climateactionreserve.org/how/protocols/forest/), as well as the 100-year average storage factors applied to each wood product class per table C.3 of Appendix C of the protocol.

Table 4.4 Landfill Wood Products Factors

Wood Products by Class	
% Softwood Lumber	97.067%
% Hardwood lumber	0.002%
% Softwood Plywood	1.874%
% Oriented Strandboard	0.000%
% Non Structural Panels	0.244%
% Miscellaneous Products	0.095%
% Paper	0.718%

100-year Storage Rates Average Values from Appendix C, In-Use Table C.2	
Softwood Lumber	0.298
Hardwood lumber	0.414
Softwood Plywood	0.287
Oriented Strandboard	0.233
Non Structural Panels	0.344
Miscellaneous Products	0.454
Paper	0.178

Average wood products carbon stored in landfills is calculated using equation C.2. Carbon is converted to CO2-equivalent by multiplying by 3.67. This value is combined with IFM-7 using equation C.3 to represent $WP_{total, y}$ for the reporting period.

$WP_{total, y}$ for the reporting period represents $AC_{wp,y}$ in equation 6.1. Average in-use wood products produced by the baseline analysis ($BC_{wp, y}$) are deducted from actual wood products produced each reporting period ($AC_{wp,y}$) in equation 6.1and the resulting calculation is multiplied by 80% to account for the "Market Response".

IFM-9 Biological emissions from site preparation activities :
As IFM-6, Soil carbon, is an excluded pool, no quantification of this source is required.

IFM-14 Biological emissions/removals from change in harvesting on forestland outside Project Area:

The Protocol refers to this carbon pool as Secondary Effects which are calculated using equation 6.10 of the Protocol. Secondary Effects associated with harvesting less than the average wood products produced by the baseline growth and yield analysis are calculated by subtracting the average carbon in harvested trees prior to delivery to a mill (PDM) generated by the baseline analysis from the actual carbon in harvested trees prior to delivery to a mill, and then multiplying the difference by 20%. As Secondary Effects are only calculated in years when actual wood products produced are less than the annual average under the baseline analysis, the resulting calculation is either zero, or a negative number.

The baseline modeling presented in the Modeling Plan (Attachment C) generates an average annual value for each of the above described wood products carbon pools. Actual wood products values for In-use, Landfill, and Prior to Delivery to the Mill ("PDM") are calculated based on a ratio between the average volume of wood delivered to the mill generated by the baseline analysis, and the average PDM value generated by the baseline analysis. Each reporting period, this ratio will be applied to the actual volume of wood delivered to a mill. On this basis, net wood products sequestered, as well as any Secondary Effects are calculated.

IFM-17 Biological emissions from decomposition of forest products:
This is quantified as a component of IFM-7 and IFM-8 as described above.

5. Modeling Plan

The Modeling Plan describes the construction of the growth and yield modeling framework, the methods employed to determine the Project's carbon stocks in 2007 and 2014, and how those stocks will be modeled forward. The Modeling Plan has been constructed per Appendix B of the Protocol, and is included as Attachment C to the PDD.

6. Summary of the carbon stock inventory for the Forest Project by each pool as of 6/13/2007 and 12/31/2014

6.1 Determining Actual Onsite Carbon Stocks

As of 12/31/2014, the Project area contains an average of 298.18 Mg CO_2e per acre of live carbon, and approximately 233 square feet of combined conifer and hardwood basal area per acre. Tree canopy cover averages approximately 75% across the Project area.

Tables 6.1 and 6.2 below provide a summary of carbon stocks for the Project Area by the reported pools.

Table 6.1: Carbon Stocks by Carbon Pool as of 6/13/2007

Carbon Pool	Source	Gross CO2e Tonnes per Acre	Total Gross CO2e Tonnes
Live Carbon Stocks	Sample Plots	240.98	11,562,519
Standing Dead Carbon Stocks	Sample Plots	5.14	246,613
Sum of CO2-eqivalent Tonnes from Required Pools		246.12	11,809,132

Table 6.2: Carbon Stocks by Carbon Pool as of 12/31/2014

Carbon Pool	Source	Gross CO2e Tonnes per Acre	Total Gross CO2e Tonnes
Live Carbon Stocks	Sample Plots	298.18	14,307,261
Standing Dead Carbon Stocks	Sample Plots	5.14	246,613
Sum of CO2-eqivalent Tonnes from Required Pools		303.32	14,553,874

6.2 Determining Actual Carbon in Harvested Wood Products

Harvesting has occurred in three years since the Project was initiated, 2012, 2013, and 2014. Table 6.3 presents the gross board foot harvest volumes for each year. These volumes are used in the attached Harvested Wood Products Calculation Worksheets included as Attachment G.

Table 6.3: Gross Harvest Volumes by Year

Year	Harvest Volume MBF Scribner Short Log Scale
2012	1,230.97
2013	1,287.48
2014	2,810.72

7. Inventory Confidence Statistics.

Stratified random sampling formulas taken from Shiver and Borders (1996) were used to calculate the sampling error for the Usal Redwood Forest as of December 31, 2014. A summary of the calculations are as follows:

Table 7.1 Inventory Confidence Calculation

Mean standing live and standing dead pools	82.65	Mg C per acre
SE of mean	2.09	Mg C per acre
SE of mean as %	2.52%	2.09 ÷ 82.65
Sampling Error at 90% CI	4.15%	(2.52%)*1.645
Confidence Deduction	0%	4.15% - 5.0%

8. Calculation of the Forest Project's Baseline Carbon Stocks

Legal constraints

Harvest on the Usal Redwood Forest is constrained by several factors. Firstly, the California Forest Practice Rules (FPR) create a minimum set of silvicultural standards below which harvest cannot occur.

Legal requirements include all laws, regulations, and legally-binding commitments applicable to the Project Area at the time of the project's initiation that could affect standing live carbon stocks. The Usal Redwood Forest is subject to the Z'berg- Nejedly Forest Practice Act of 1973 (FPA) and the corresponding Forest Practice Rules (FPR).

The rules that specifically effect the determination of baseline are those that include limits to silviculture activities. This includes the requirements for minimum basal area retention, rotation ages, harvest adjacency restrictions, watercourse buffer widths and sustained yield requirements.

The pertinent rules include but are not limited to the following:

- 14 CCR 913.11(c): Maximum Sustained Production of High Quality Timber Products;
- 913.2: minimum basal area retention standards for Unevenaged Regeneration Methods;
- 913.2 (a)(2)(B): Group selection harvest limitations;
- 913.2 (b)(6): Minimum post-harvest residual basal area retention standards for the Transition method;
- 913.3; minimum basal area retention standards for Intermediate Treatments;
- 913.4 (b): standards for rehabilitation of Understocked Areas;
- 913.1 (c): standards for Seed Tree Seed Step;
- 916.9: details harvest limitations for Watercourse and Lake Protection Zones around Class 1, 2 and 3 streams;
- 919.9: Northern Spotted Owl

The methods by which the Forest Practice Rule constraints listed above as well as other legally binding constraints are incorporated into the baseline harvest scenario are described in the modeling plan.

In addition to the legal constraints listed above, through an agreement with the California Wildlife Conservation Board (WCB), the impacts of the recorded conservation easement on the disposition of CRTs issued to the Usal Redwood Forest will be determined through an analysis of how the terms of the conservation easement constrain carbon stocks from the date the easement was recorded through the life of the Project. The terms of the conservation easement are not included as a legal constrain as a part of the baseline analysis included in the PDD. The disposition of the CRTs issued to the Project with regard to the terms of the conservation easement are subject to an agreement between RFFI and WCB.

Financial Constraints

In modeling the baseline for standing live carbon stocks, the Forest Owner must incorporate financial constraints that could affect baseline growth and harvesting scenarios. The Protocol provides two means by which the Forest Owner may demonstrate that the growth and harvesting regime assumed for the baseline is financially feasible. The first approach involves a financial analysis of the growth and harvesting

regime, while the second approach provides evidence that activities similar to the assumed baseline growth and harvest scenario have taken place on other properties within the Forest Project's Assessment Area within the past 15 years and that harvesting activities have taken place on sites comparable to the Project Area. The Usal Redwood Forest project will demonstrate financial feasibility using the first approach under section 6.2.1.3.

A financial analysis of the baseline harvesting regime that captures all relevant costs and returns, taking into account all legal, physical, and biological constraints is included as Attachment D. Cost and revenue variables included in the financial analysis are based on documented costs and returns for the Project Area, and on other properties in the Assessment Area. This financial analysis illustrates that the baseline harvest scenario is financially feasible.

8.1. Project Stocks in Comparison to Common Practice and the High Stocking Reference

The Project is located within the Northern California Coast Supersection per Appendix F of the Protocol. Within the larger Supersection, the Project is within the Coast Redwood/Douglas-fir Mixed Conifer Assessment Area. The Project Area is classified as both High and Low Site class within the Assessment Area. The Common Practice Indicator for the Coast Redwood/Douglas-fir Mixed Conifer Assessment Area is 188 Mg CO2-equivalent of above ground live carbon per acre for High Site and 166 Mg CO2-equivalent of above ground live carbon per acre for Low Site. The Project Area's above ground live carbon stocks were 195.35 Mg CO_2e as of the 6/13/2007 start date, and as such are above the Common Practice Indicator for both High and Low Site class categories. The Project Area is not subject to the High Stocking Reference (HSR) test as the Project stocks are above Common Practice.

Table 8.1: Usal Redwood Forest Common Practice

Supersection	Assessment Area	Site Class	Common Practice - Above Ground Carbon Mean (Metric Tonnes CO2e)	Acres
Northern California Coast	Coast Redwood Douglas-fir Mixed Conifer	High	188	2,755.66
	Coast Redwood Douglas-fir Mixed Conifer	Low	165	45,225.88
Weighted Average Common Practice Value			166.32	47,981.54

8.2. Minimum Baseline Level

The average baseline model results must not fall below a minimum baseline level (MBL). Because the Project's initial above-ground standing live carbon stocks were above Common Practice, the MBL is determined using Equation 6.5 in the Forest Project Protocol:

MBL = MAX (CP, MIN (ICS, CP+ICS-WCS))

Where,

MBL = Minimum baseline level (above-ground standing live carbon stocks)

CP = Common Practice (as determined above)

ICS = Initial above-ground standing live carbon stocks per acre within the Project Area (see Section 7 above)

WCS = The weighted average above-ground standing live carbon stocks per acre for all Forest Owner (and affiliate) landholdings within the same logical management unit (LMU) as the Project Area.

WCS is calculated using Equation 6.7:

$$If \ \left|1 - \frac{ECS}{ICS}\right| \leq 0.2, then \ WCS = ICS$$

$$If \ \left|1 - \frac{ECS}{ICS}\right| > 0.2, then \ WCS = \frac{ICS \times PA + ECS \times EA}{PA + EA}$$

Where,

WCS = Same as described above

ICS = Same as described above

PA = Size of the Project Area in acres

ECS = Above-ground standing live carbon stocks per acre within the LMU but excluding the Project Area (EA), as determined from existing inventory data

EA = Size of the LMU in acres, excluding the Project Area

A "logical management unit" or "LMU" is defined as all land that the Forest Owner and its affiliate(s) either own in fee or hold timber rights on, and which it or they manage as

an explicitly defined planning subunit. LMUs are generally characterized by having unique biological, geographical, and/or geological attributes, are generally delimited by watershed boundaries and/or elevational zones, and contain unique road networks.

The Usal Redwood Forest has been identified as one LMU, approximately 54 net acres of timberland for which URFC owns the timber rights on in the northwest quarter of section 15 T23N R17W are within the LMU but have been excluded from the Project Area.

The Usal Redwood Forest's variables are as follows:

CP = 166.32 Mg CO_2e per acre

ICS = 194.89 Mg CO_2e per acre

PA = 47,981.54 acres

ECS = 211.11 Mg CO_2e per acre[5]

EA = 54.97 acres

Based on the data above, the first if-then expression of equation 6.7 = 0.08, and is true, and:

WCS = ICS , or,

WCS = 194.89 MgCO_2e per acre

Equation 6.5 then becomes:

MBL = MAX (166.32, MIN (194.89, 166.32 + 194.89-194.89))

MBL = MAX (166.32, MIN (194.89, 166.32))

MBL = MAX (166.32, 166.32)

MBL = 166.32 MgCO_2e per acre

The averaged modeled baseline results, expressed as above-ground standing live carbon stocks per acre, must not fall below the MBL of 166.32 MgCO_2e per acre.

[5] ECS is calculated based on acres by stratum from the property subject to timber rights expanded to an average per acre value from the Project's current carbon stock estimates by stratum as of the Project Start date.

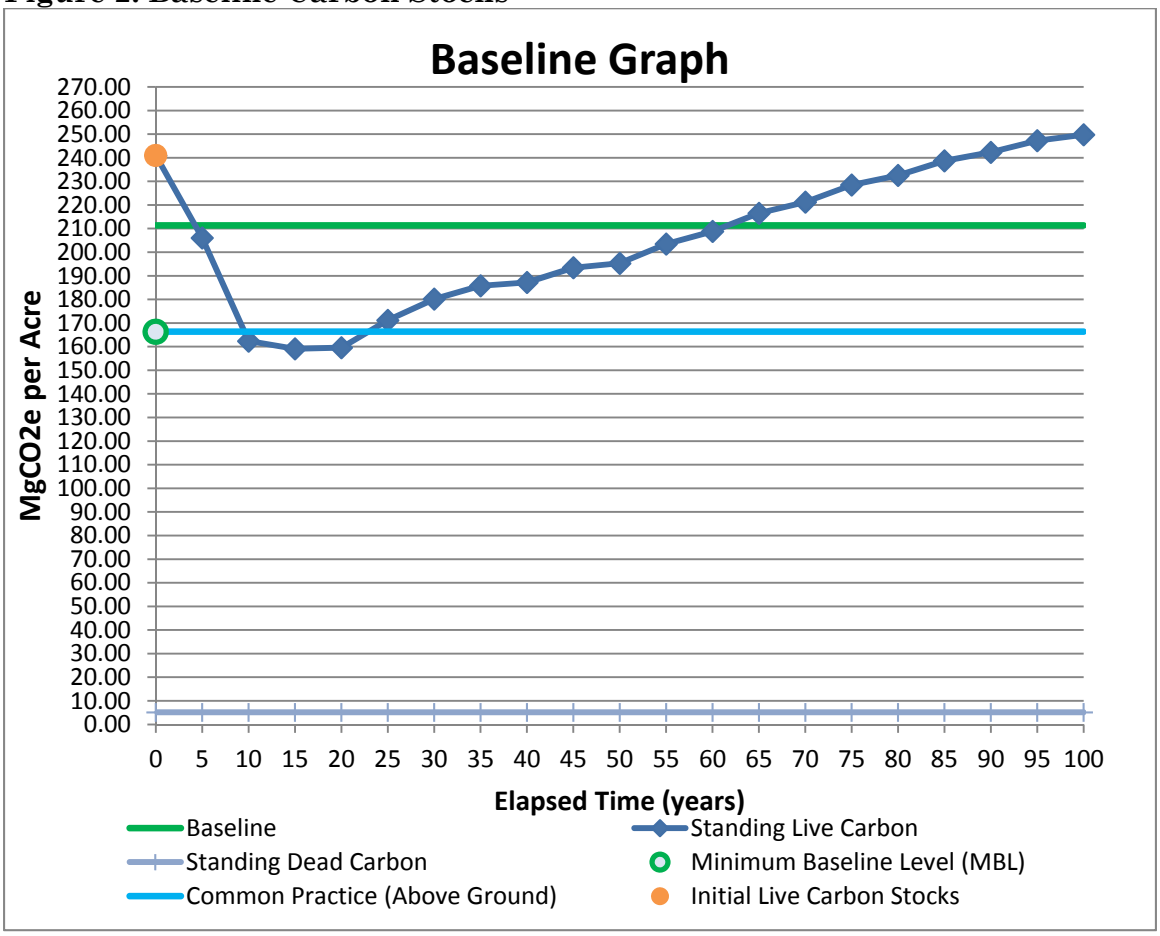
8.3. Calculated Baseline

The Modeling Plan included as Attachment C describes the methodology employed for the calculation of the Project's baseline. Table 8.2 below summarizes the above ground carbon stocks and the wood products calculations for the baseline analysis.

Table 8.2: Baseline Carbon Stocks ($MgCO_2e$ per Acre)

Elapsed Time	Standing Live Carbon Pool IFM-1	Standing Live Above Ground	Standing Live Below Ground	Standing Dead Carbon Pool IFM-3	Baseline
0	240.98	194.89	46.08	5.14	211.34
5	206.05	166.33	39.72	5.14	211.34
10	162.38	130.31	32.08	5.14	211.34
15	159.10	127.78	31.33	5.14	211.34
20	159.56	127.91	31.66	5.14	211.34
25	171.18	137.45	33.73	5.14	211.34
30	180.15	144.81	35.34	5.14	211.34
35	185.78	149.54	36.24	5.14	211.34
40	187.20	150.75	36.45	5.14	211.34
45	193.43	155.98	37.45	5.14	211.34
50	195.30	157.61	37.70	5.14	211.34
55	203.49	164.36	39.13	5.14	211.34
60	208.84	168.75	40.09	5.14	211.34
65	216.51	175.07	41.44	5.14	211.34
70	221.21	178.95	42.26	5.14	211.34
75	228.49	184.99	43.50	5.14	211.34
80	232.54	188.36	44.18	5.14	211.34
85	238.72	193.50	45.22	5.14	211.34
90	242.34	196.52	45.82	5.14	211.34
95	247.23	200.60	46.63	5.14	211.34
100	249.76	202.72	47.04	5.14	211.34
Average	206.20	166.53	39.67	5.14	211.34

Figure 2: Baseline Carbon Stocks



9. Description of how management activities for the Project have or will lead to increased carbon stocks in the Project Area compared to the baseline

The Usal Redwood Forest is a wholly owned subsidiary of the Redwood Forest Foundation and is managed as a community forest for multiple environmental, social and economic purposes. These purposes include restoration to historical reference ecological characteristics, restoration and maintenance of fish and wildlife habitat and improved water quality. Ensuring the long-term sequestration of carbon has been and continues to serve as a foundation for these and other management decisions.

The Foundation acquired the property in June 2007 and immediately made significant changes to management that have and will continue to sequester carbon. These include:

- Prohibiting forest subdivision or conversion;
- Creating management standards that precluded industrial harvest;
- Completing watershed restoration projects and

- Choosing to forgo any harvest during the recessionary period (2008-2012) as opposed to increasing harvest to meet economic objectives

In October 2011, the Foundation sold a conservation easement that included a primary silvicultural limitation on conifer harvest of 2.9% of inventory that will permanently guarantee carbon sequestration in perpetuity. The Foundation continues to also implement management practices that sequester additional carbon. For example, the Foundation's current silvicultural approach will continue to build forest inventory above and beyond the harvest limitations imposed by the easement. The Foundation is also seeking Forest Stewardship Council (FSC) certification with final approval likely by October 2015.

Finally, to achieve its goals as described above, the Usal Redwood Forest has developed a long range growth and harvest scenario that meets the terms of the recorded conservation easement while ensuring an economic return from the forest while at the same time increasing carbon stocks over time. This projected harvest scenario includes harvest levels significantly lower than those forecasted under the baseline harvest scenario described herein.

10. Calculation of the Project's reversal risk rating for purposes of determining contributions to the buffer pool

Table 10.1 below shows the calculation of the Project's reversal risk rating calculated on the bases of the guidelines in Appendix D of the Forest Project Protocol. The risk ratings shown below assume that the Project will not employ a Qualified Conservation Easement or Qualified Deed Restriction, and that the Forest Owner will select the version of the subordination clause in the PIA that requires a financial risk rating of 2%; however, as all tonnes and the Project are to be converted to ARB's offset program and compliance offset protocol, the 2% financial risk associated with the PIA is waived.

Table 10.1: Reversal Risk Rating:

Risk Category	PIA
Financial Failure	5%
Conversion	2%
Over-harvesting	2%
Social	2%
Wildfire	4%
Disease/Insect	3%
Other Catastrophic	3%
Total Buffer Pool Contribution	19.2%

The Project's reversal risk rating is calculated as follows:

100% - (((1-0.05)*(1-0.02)*(1-0.02)*(1-0.02)*(1-0.04)*(1-0.03)*(1-0.03)*100)) = 19.2%

11. Calculation of the Project's GHG Reductions from 6/13/2007 to 12/31/2014

The calculation of GHG reductions shown in the Forest Project Calculation Worksheet included as Attachment F is based on Equation 6.1of the Forest Project Protocol. Calculations proceed as follows:

1. Per section 9.3.3 of the Protocol, for a project's first reporting period where the reporting period covers more than two years, CRTs are assigned vintage according to the timing of GHG reductions. The assignment of CRTs to vintages 2007 through 2014 is calculated by determining the total change in carbon stocks from 6/13/2007 to 12/31/2014, and solving for the implied rate of carbon stock growth. The calculated growth rate is then used to estimate changes in carbon stocks over the initial reporting period. The Actual Onsite Stocks reported in the Forest Project Calculation Worksheet for 2007 are those at the end of 2007.
2. The increment in onsite carbon stocks is calculated after applying the Inventory Confidence Deduction of 0%.
3. Baseline carbon stocks are deducted from adjusted actual carbon stocks, resulting in a Total Quantified GHG Reduction/Removal for onsite stocks sequestered by the Project during a given year (vintage).
4. Average wood products—landfill and in-use—produced by the baseline[6] analysis are deducted from actual wood products produced during the period, and the resulting calculation is multiplied by 80% to account for the "Market Response". This represents the Total Quantified GHG Reduction/Removal for carbon stored in wood products.
5. Secondary Effects of harvesting less than the average wood products produced by the baseline growth and yield analysis are calculated by subtracting the average carbon in harvested trees prior to delivery to a mill (PDM) generated by the baseline analysis from the actual carbon in harvested trees prior to delivery to a mill, and then multiplying the difference by 20%. As Secondary Effects are only calculated in years when actual wood products produced are less than the annual average under the baseline analysis, the resulting calculation is either zero, or a negative number.
6. Total Net GHG Reductions/Removals are calculated by summing the total GHG reductions/removals for onsite stocks calculated in step 3, the total GHG reductions/removals for wood products calculated in step 4, and secondary effects calculated in step 5. The required buffer pool contribution is calculated by multiplying the Project's risk of reversal rating by the calculated total net GHG reductions/removals. The buffer pool contribution is subtracted from the total net GHG reductions/removals to arrive at the number of CRTs to be issued each year of the initial reporting period. CRTs are issued for whole tonnes of CO_2e sequestered by the Project.

[6] Wood products carbon stored in landfills is included as a deduction in years when actual wood products produced are less than the baseline average.

Equation 6.1: $\mathbf{QR_y = [(\Delta\ AC_{onsite} - \Delta\ BC_{onsite}) + (AC_{wp,\,y} - BC_{wp,\,y}) * 80\% + SE_y] * (1 - ACD) + N_{y-1}}$

Where,

QR_y	=	Quantified GHG reductions and removals for year y
$\Delta\ AC_{onsite}$	=	$(AC_{onsite}, y)(1 - CD_y) - (AC_{onsite}, y\text{-}1)(1 - CD_y\text{-}1)$ *Where*, $AC_{onsite,\,y}$ = Actual onsite carbon (CO_2e) as inventoried for year y $AC_{onsite,\,y\text{-}1}$ = Actual onsite carbon (CO_2e) as inventoried for year y-1 (if y is the first year of the project, then the value for AConsite, y-1 will be zero) CD_y = Appropriate confidence deduction for year y, as determined in Appendix A, Section A.4. CD_{y-1} = Appropriate confidence deduction for year y-1, as determined in Appendix A, Section A.4.
$\Delta\ BC_{onsite}$	=	$BC_{onsite,\,y} - BC_{onsite,\,y\text{-}1}$ *Where,* $BC_{onsite,\,y}$ = Baseline onsite carbon (CO_2e) as estimated for year y $BC_{onsite,\,y\text{-}1}$ = Baseline onsite carbon (CO_2e) as estimated for year y-1 (if y is the first year of the project, then the value for $BC_{onsite,\,y\text{-}1}$ will be zero)9
$AC_{wp,\,y}$	=	Actual carbon in wood products produced in year y that is projected to remain stored for at least 100 years (i.e. $WP_{total,\,y}$ derived for actual harvest volumes following the guidance in Appendix C)
$BC_{wp,y}$	=	Averaged annual baseline carbon in wood products that would have remained stored for at least 100 years (i.e. $WP_{total,\,y}$ derived for baseline harvest volumes following the guidance in Appendix C)
SE_y	=	Secondary Effect GHG emissions caused by the project activity in year y
ACD	=	Avoided Conversion Project discount factor. *(Not applicable to this Project)*
N_{y-1}	=	Any negative carryover from the prior year not due to a reversal.

The Forest Project Calculation Worksheet included as Attachment F shows the Project's calculated additionality for the reporting period 6/13/2007 to 12/31/2014 allocated to each vintage from 2007 through 2014. All values are in Mg CO_2e.

For vintages 2007 through 2014, the Usal Redwood Forest Improved Forest Management Project generates 3,918,782 CRTs and will be issued 3,166,372 CRTs after contributing CRTs to the Buffer Pool.

Table 11.1 Summary of CRTs by Vintage.

Vintage	GHG emission reductions/removals, before buffer pool deduction (CRTs)	Buffer Pool deduction (CRTs)	CRTs to be issued to the Forest Owner (CRTs)
2007	1,801,449	345,879	1,455,570
2008	270,507	51,938	218,569
2009	280,060	53,772	226,288
2010	289,883	55,658	234,225
2011	299,983	57,597	242,386
2012	313,477	60,188	253,289
2013	324,298	62,266	262,032
2014	339,125	65,112	274,013
Total	3,918,782	752,410	3,166,372

12. Attachments

Attachment A. Maps of the Project Area.

1. Topography with major watercourses including Township, Section and Range.
2. Orthophoto of Project Area.
3. Watershed Boundary Map.
4. Geodatabase containing Project GIS data.

Attachment B. Inventory Methodology and Strata Map.
Attachment C. Modeling Plan.
Attachment D. Financial Feasibility Analysis.
Attachment E. FIA biomass equation documentation.
Attachment F. Forest Project Calculation Worksheet (Provided by CAR)
Attachment G. Wood Products Calculation Worksheets (Provided by CAR)

ATTACHMENT A

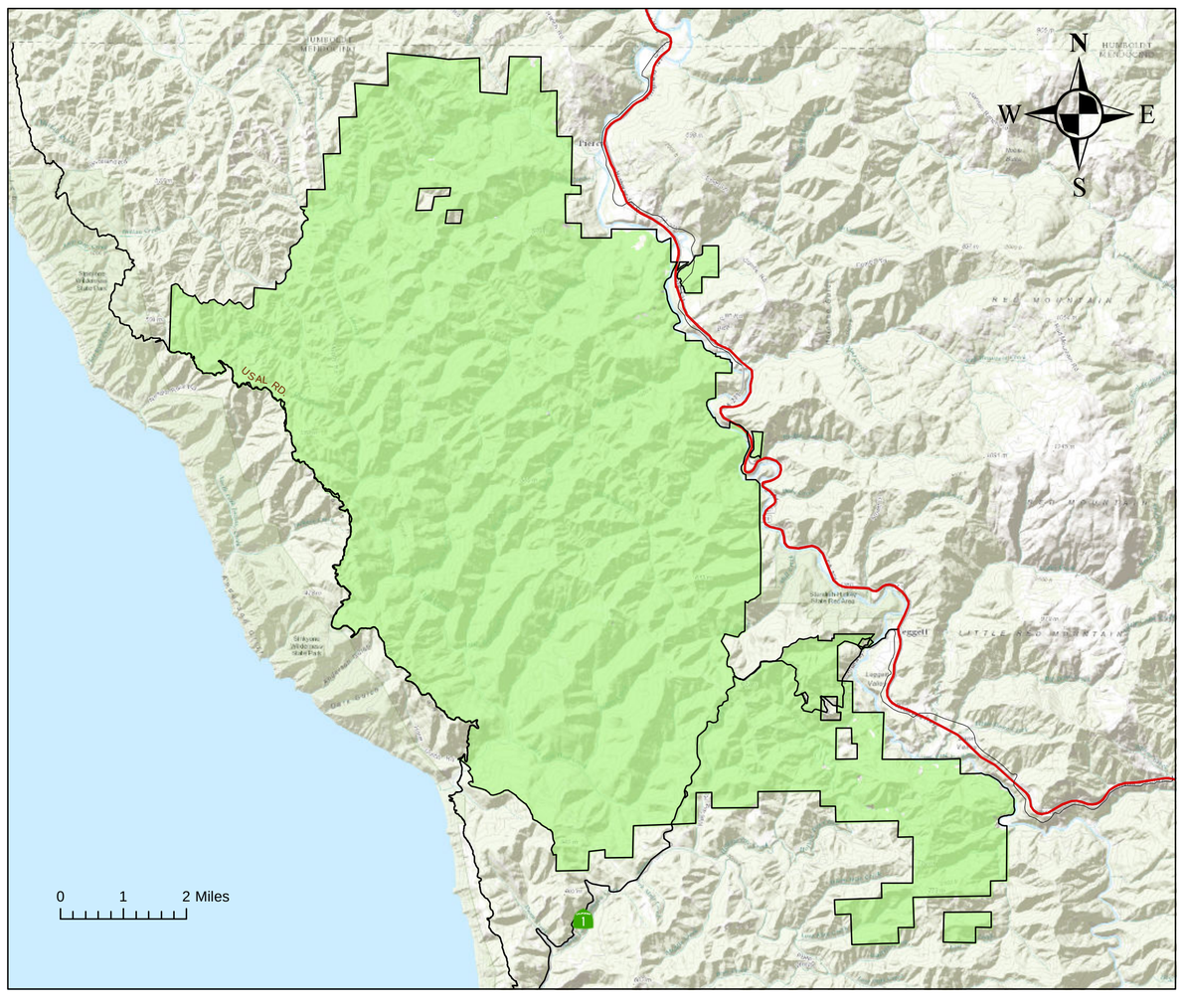
Usal Redwood Forest Topographic Map

Legend

- Usal Redwood Forest Company Ownership
- Usal Redwood Forest Project
- Public Road
- Permanent Road
- Seasonal Road
- Class I Watercourse
- Class II Watercourse
- Class III Watercourse

NCRM Inc.

0 0.5 1 2 3 4 Miles



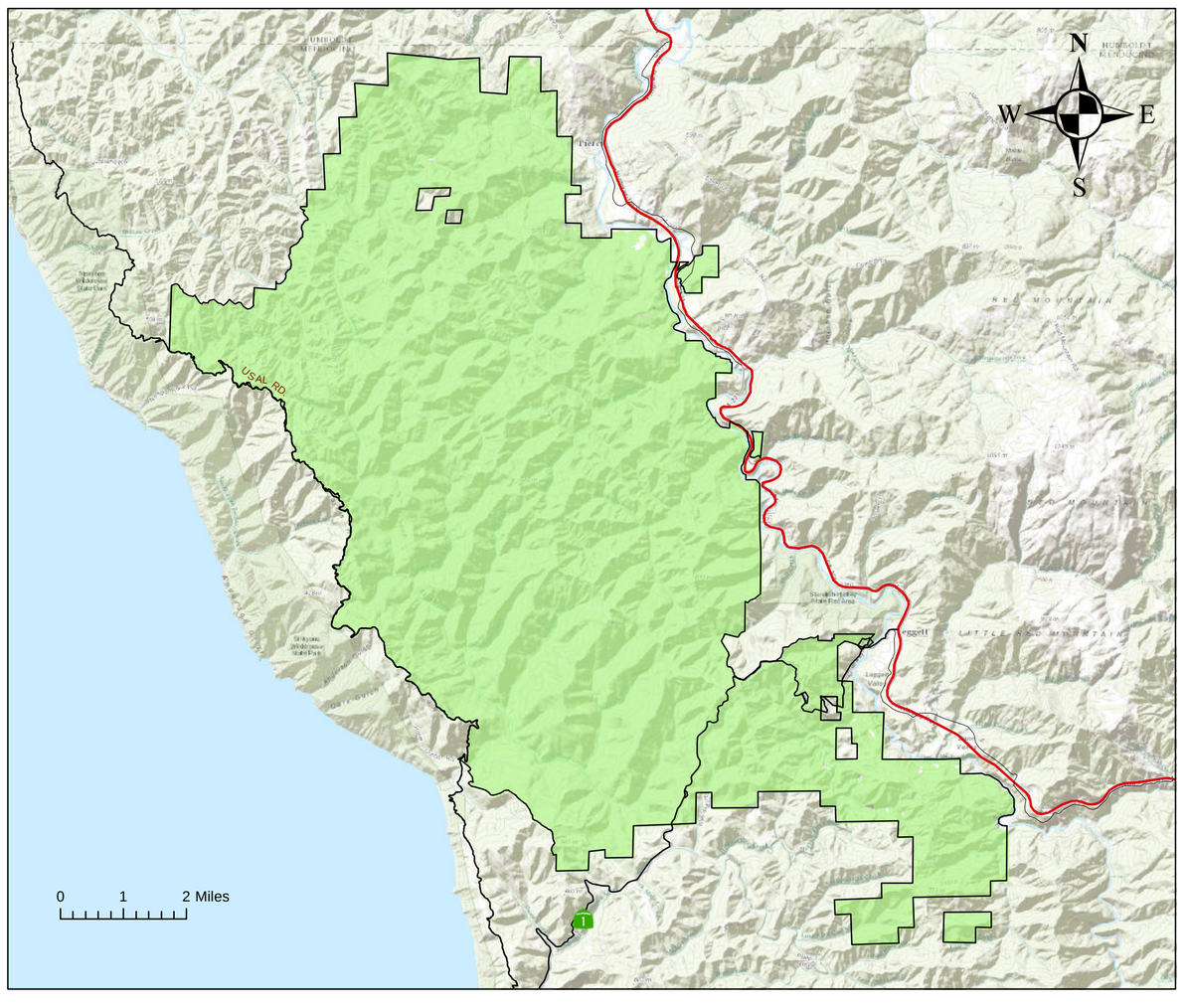
Usal Redwood Forest Orthophoto Map

Legend

- Usal Redwood Forest Company Ownership
- Usal Redwood Forest Project
- Public Road
- Permanent Road
- Seasonal Road
- Class I Watercourse
- Class II Watercourse
- Class III Watercourse

NCRM Inc.

0 0.5 1 2 3 4 Miles



Usal Redwood Forest
Watershed Boundary Map

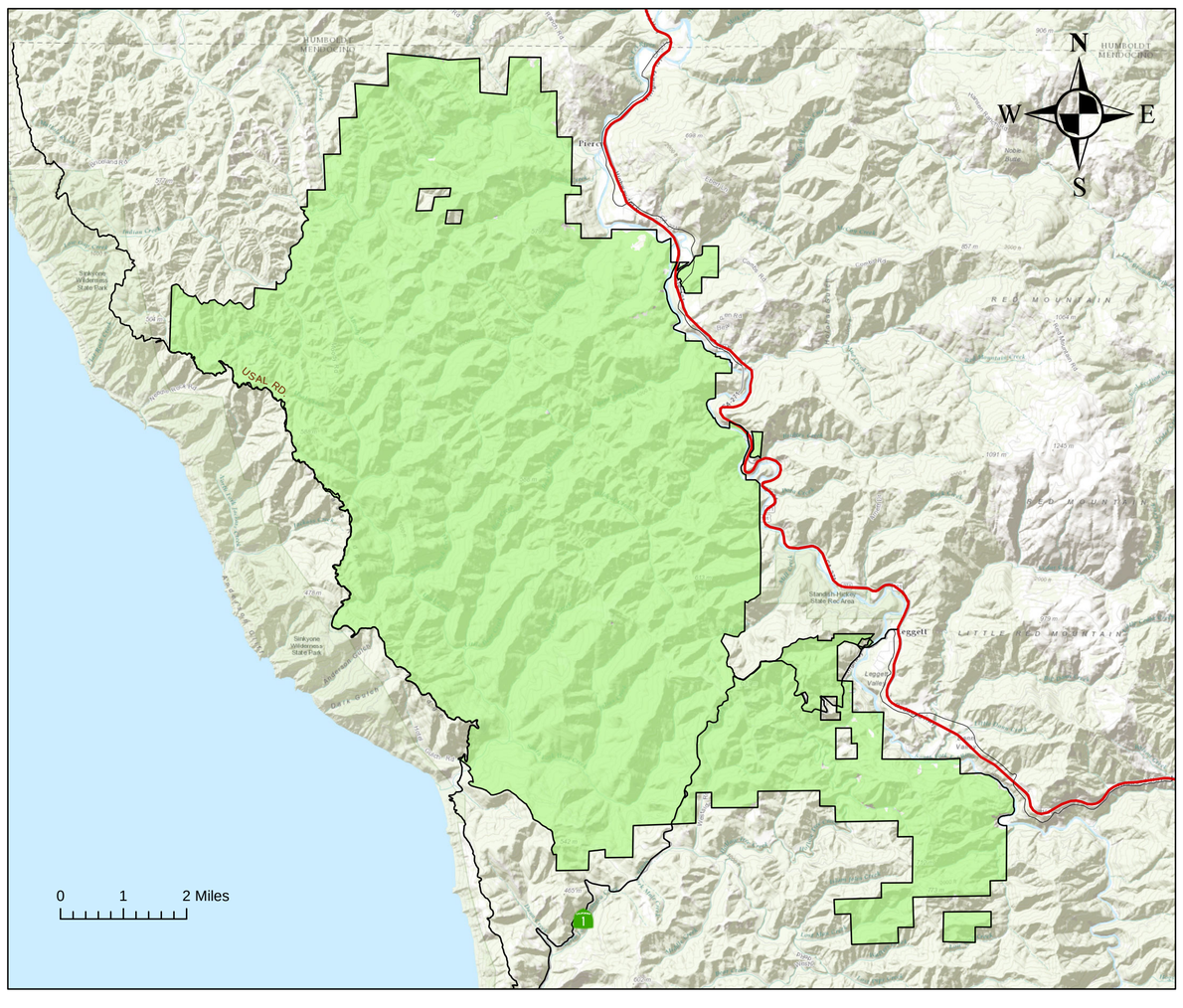
Upper Sproul Creek
Lower Indian Creek
McCoy Creek
Piercy
Upper Indian Creek
Piercy Creek
Standley Creek
Red Mountain Creek
Bear Pen Creek
Wildcat Creek
Bridges Creek
Jackass Creek
Upper Usal Creek
Mill Creek
Cedar Creek
101
Leggett
Big Dann Creek
Lower Usal Creek
Lower Hollow Tree Creek
Hales Grove
Low Gap Creek
Soldier Frank Point
Cottaneva Creek
Middle Hollow Tree Creek

Legend

- Usal Redwood Forest Company Ownership
- Usal Redwood Forest Project
- Watershed Boundary
- Public Road
- Watercourse

NCRM Inc.

0 0.5 1 2 3 4 Miles



ATTACHMENT B

USAL REDWOOD FOREST
INVENTORY METHODOLOGY

This document contains specifications for the collection of data in the field for the Usal Redwood Forest Inventory, as well as the data to be collected and the standards for data collection and processing. The Usal Redwood Forest includes approximately 47,979 acres of timberland characterized by Redwood, Douglas-fir, Tanoak and associated hardwood species. The Usal Redwood Forest Offset Project Boundary includes the following GHG emission sources, GHG sinks, and GHG reservoirs (SSRs or Carbon Pools) as defined in table 5.1 of the Forest Project Protocol Version 3.2, August 31, 2010:

IFM-1	Standing live carbon (carbon in all portions of living trees)
IFM-3	Standing dead carbon (carbon in all portions of standing dead trees)
IFM-7	Carbon in in-use forest products
IFM-8	Forest product carbon in landfills
IFM-9	Biological emissions from site preparation activities
IFM-14	Biological emissions/removals from changes in harvesting on forestlands outside the Project Area
IFM-17	Biological emissions from decomposition of forest products

The inventory data upon which the carbon stock estimates are based includes plot data collected in early 2015. The Usal Redwood Forest inventory was conducted from January through the first week of March 2015 utilizing a random selection of plots located across eight timber stratum. Plot locations were determined from a random selection of plots from a 5 chain by 5 chain grid that uniformly covers the entire Project Area. The final inventory design resulted in the installation of 353 plots across the Project Area.

The standard procedures for collecting field measurements are generally aimed at the collection of tree data pertaining to the quantification of the IFM-1 and IFM-3 carbon pools and are detailed in the enclosed Usal Redwood Forest Carbon Inventory Data Collection Procedures and Standards document. Carbon in carbon pools IFM7, IFM-8, IFM-9, IFM-14, and IFM-17 are calculated as described in Section 4 of the PDD.

Inventory Methodologies

The data collection procedures are described in detail in the attached Usal Redwood Forest Carbon Inventory Data Collection Procedures and Standards (Appendix B).

Calculation Methodologies

A description of the calculation methodologies used to determine metric tons per acre of each of the carbon pools listed above is included in Section 4 of the PDD and is included herein by reference. Included are the analytic methods and biomass equation references used to translate field measurements into volume and biomass carbon estimates.

Data Management Systems and Data Processing

The inventory data gathered by this inventory methodology is entered into an Access database. Plot data within the database was extensively sorted and queried to look for data entry errors. This process resulted in a final data set for cruise processing. The Access database serves as the repository for inventory data and is accessed by the growth and yield model during growth and yield simulations.

The inventory database is utilized to process the inventory data through the growth and yield model FORSEE, and analyze the modeling outputs. The calculation of volume, biomass and the ultimate conversion to carbon utilizes the inventory data and growth and yield output data and applies the volume formulas and biomass conversion factors described in section 4 of the PDD.

Stratification Methodology

For operational purposes, the Usal Redwood Forest maintains a separate set of inventory data collected on a systematic grid across the entire URFC ownership without regard to timber stratification. The inventory is a stand based inventory of all stands at least 15 years of age, and includes data collected from 2000-2014. Using the cruise data from this operational inventory, a stratification methodology based on species composition and biomass density was assigned to each timber stand across the larger Project Area. This inventory data was not used for the purpose of generating carbon stock estimates for the Project Area, and was only used for the purpose of informing proper inventory stratification as described below.

Campbell Global provided plot and GIS stand boundary data for the majority of the Usal Redwood Forest Project Area. There were 74 stands classified as "recent clearcuts" for which no inventory data had been collected. In order to supplement the inventory data, 10 of these uncruised stands were selected for sampling in 2014. This additional cruise data was collected under the direction of Campbell Global, and was incorporated into the final cruise database. Tree data had been grown forward to January 1, 2014 by Campbell Global. Using data from plots inventoried in all years and Campbell Global's FORSEE tables, basal area by species was calculated for all stands in FORSEE. Equivalent megagrams of carbon dioxide ($MgCO_2e$) per acre were then calculated for all stands using the FORSEE carbon calculation script. Based on these basal areas, stands were classified as hardwood or conifer dominated. Stands were then stratified into four strata in hardwood dominated stands and four strata in conifer dominated stands, based on $MgCO_2E$ per acre, from low to high. Stands were categorized into these strata such that there was the least possible variation in $MgCO_2E$ within each strata and the greatest possible variation in $MgCO_2e$ between each strata by using a tool in ArcGIS to establish natural breaks. A map of the strata is included as Appendix D. Table 1a below presents the results of the stratification.

Table 1: Strata and Plot Summary

Stand	Acres	Plots
Conifer High	1,618.90	22
Conifer Medium High	8,686.23	78
Conifer Medium Low	12,860.67	90
Conifer Low	4,257.68	26
Hardwood High	2,151.85	20
Hardwood Medium High	7,560.21	52
Hardwood Medium Low	8,454.17	51
Hardwood Low	2,391.83	14
Total	47,981.54	353

Some stands on the property were not inventoried and, therefore, not stratified using the process described above. Out of two stands of manageable brush, one was small and assigned to the strata of the stand surrounding it. The other, viewed in an aerial photograph and found to have very little timber, was included in an "OUT" strata, indicating that it would not be included in the Project Area. The remainder of the un-inventoried stands had slope stability issues or were recently clearcut. The clearcut stands were assigned to one of the eight strata based on aerial photo interpretation. All of the un-inventoried stands with slope stability issues were assigned to the "OUT" strata. Some stands inventoried by Campbell Global included areas off of the property. These areas were removed from the Project Area and were also assigned to the "OUT" strata.

Net acreage for each stand was calculated by geometry in ArcGIS. Road buffer width is based on road status and surface type. A description of the buffering assumptions provided by Campbell Global is included below as Appendix C. Polygons representing the road buffer have been removed from the strata in ARCGIS. The modeling plan describes the process for updating the inventory to the Project's commencement date in 2007, and the end of the initial reporting period in 2014.

Quality Assurance/Quality Control (QA/QC)

Procedures for ensuring quality control are explained in section 7 (Inspections) of the attached inventory methodology document.

Updating the Inventory

As timber management activities take place on the Usal Redwood Forest Project Area, or disturbance such as fire or mortality from extra-ordinary factors occurs, stands subject to harvest or disturbance will be recruised on the 5 chain by 5 chain grid. As additional timber stands are cruised each year, the plot data will be incorporated into the stratified inventory design. By 2026, the inventory design will be composed of plots that are no more than 12 years old. On this

basis, URFC will maintain a forest inventory system that will meet the inventory specifications and requirements contained in Appendix A of the Forest Project Protocol, with plots which are no more than 12 years old.

Updating the Project's carbon stocks from year to year will involve the following steps:

1. Any newly installed inventory plots will be incorporated into the inventory estimate for the stratum in which they are located.
2. Existing inventory plots will be updated using FORSEE as described in the modeling plan.
3. Updating the forest inventory for harvests or disturbances that have occurred during the previous year through the installation of new plots, or adjustments to previous plot data.
4. Where necessary, the inventory update process may result in restratification of portions of the timber strata.
5. Inventory updates following harvest or disturbance will be re-measured within 12 months of the harvest or disturbance.
    a. Partial harvests, such as selections and thinnings are updated in two phases:
        i. Phase1: within one month of harvest completion, the inventory is depleted by modeling removals such that:
            1. The inventory forester selects one of the stands underlying the harvest unit to represent the new stand.
            2. The inventory plots from the selected are projected from time-of-cruise to time-of-harvest.
            3. Based on the forester's prescription for the harvest, plots are 'thinned' by removing trees from the projected tree lists.
            4. The 'thinned' plots are aggregated to estimate a stand-level inventory for the thinned stand.
            5. Based on the stand-level inventory estimate, the stand is evaluated against the stratification rules, and is assigned a strata.
            6. Any "active" plots within the harvested area are removed from the inventory database and are no longer used in the carbon stock calculations.
        ii. Phase 2: within one year of completion, the stand is resampled.

Appendices:

A. Inventory Change Log
B. Usal Redwood Forest Carbon Inventory Data Collection Procedures and Standards (**Proprietary**)
C. Road Buffer Assumptions
D. Plot and Strata Map

Appendix A

Usal Redwood Forest Inventory Change Log

Date of Change	Note (changes made)

Appendix B

Usal Redwood Forest Carbon Inventory Data Collection Procedures and Standards (Proprietary)

Usal Redwood Forest

Carbon Inventory Data Collection Procedures and Standards

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1 CRUISE UNIT TYPING

The Usal Redwood Forest carbon inventory, cruise units are the stratum developed from the larger operational inventory.

2 PLOT ESTABLISHMENT

2-1 Plot Layout

Plot locations have been determined from a random selection of plots from a 5 chain by 5 chain grid that uniformly covers the entire Project Area. Maps of these randomly selected plots shall be provided to the contract cruisers. Contract cruisers shall establish the plots as mapped.

2-2 Navigating To Plot Centers

2-2.1 REFERENCE POINT (RP)

The goal of navigating is to place plot centers without bias at their mapped location within the cruise unit of sample (stratum). Follow these guidelines to accomplish the objective.

Cruisers will primarily use GPS units to navigate to and establish plot centers. To establish a GPS RP, stand in an opening not under canopy at least a chain from the intended plot center. Wait for good signal and report that accuracy is within a few feet, then use the GPS unit's "Go To" function to find the direction and distance to plot center. The cruiser shall then measure the distance to the plot center using a hand compass and steel tape, hip chain or electronic device. To avoid bias due to canopy and other factors, NEVER "chase signal" once the plot center above is reached by using distance and bearing indicated above.

2-2.2 NAVIGATION ROUTE DOCUMENTATION

Cruise Maps will be provided for Contractor to use for submitting Navigation Route Documentation. For each plot or group of plots cruised, Contractor shall notate on the Cruise Map:

1. Navigation routes with directional arrows.
2. Locations of plots exceeding a chain from their intended, mapped locations.
3. Cruiser initials.
4. Dates cruised.
5. Date submitted.

2-2.3 HAZARDOUS PLOT LOCATIONS

Plots may occur on hazardous landscapes such as but not limited to: streams, cliffs, and slides. If a plot is judged too unsafe to sample, contractor shall offset the plot 33 feet in a cardinal direction (North-East-South-West) that allows for the plot to stay in the same strata as previously mapped and the location is deemed safe to cruise.

The contractor is required to take a GPS point at the offset plot location and record the latitude and longitude in the plot notes.

2-3 Monuments

2-3.1 MONUMENT MATERIALS

The supplies used in the monumentation of Work are specified in Table 2-1 below.

Table 2-1
Material Specifications for Monuments

Item	Specification	Suggested Supplier
Flagging	Striped red and black vinyl flagging	Pacforest Supply Company http://www.pacforestsupply.com/
Flagging	White vinyl flagging	Pacforest Supply Company http://www.pacforestsupply.com/
Wire Stake Flag	Fluorescent-pink, 15” long wire stake flag having a 2 ½” x 3 ½” flag size	Pacforest Supply Company http://www.pacforestsupply.com/
Rebar plot center Stake	3/8” Rebar stake at least 16” in length with the top 6” painted.	Supplied by Company
Plot Tags	Model 1E34 3” X 4” write-on aluminum tag	Loma Industries http://www.lomaindustries.com/tags.htm

Nails	Aluminum siding plain shank style nail having a 0.128" diameter shank and a 3/8" diameter head	Forestry Suppliers http://forestry-suppliers.com/
Marker used when writing on flagging and wire stake flags	Wide-tip or bullet-tip, black permanent marker	No suggestion
Paint	white paint	Supplied by Company

2-3.2 REFERENCE POINT (RP) MONUMENTS

Three flags hung high, apart, and easily seen from a distance will monument RPs of navigation routes (one white flag, two red and black striped flags). Record on the white flag: (1) the plot number being navigated to; (2) the direction and distance to get there; (3) the cruiser doing the work, and (4) that day's date.

2-3.3 PLOT CENTER MONUMENTS

2-3.3.a Inventory Cruise Plot Center Monuments

Plot Center

Monument plot center with a wire stake flag and 3/8" rebar stake. The rebar stake shall be hammered into the ground such that at least 10" of the stake is below ground, and the top 6" of the plot stake shall be painted.

Flagging

By plot center, and preferably on either side, hang two black and red striped flags high, long, and apart in a way easily seen from a distance. In addition, do the following in these special circumstances.

Failed Inspection. Sometimes work fails inspection and plots must be re-visited for correction. When plots are re-visited for correction, hang high and long an additional flag listing the following information: "RW" (meaning rework); the cruiser doing the work, and that day's date.

Plot Tag

Find an object to attach a plot tag. Prefer choosing an object in the order shown below.

1. Live, healthy, sampled tree at least 6" DBH in size.
2. Largest, live, healthy, sampled tree at least 3.6" DBH in size.
3. Any live, healthy tree near plot center following the 1 and 2 size and preference guidelines above.
4. Any reasonable, nearby object that can be tagged (a snag, a stump, a log) (do not tag brush).

5. If nothing reasonable is present that a tag can be attached to using a nail, do not install a tag. Instead, write tag information on one of the hung flags.

Choose a spot on the object to attach the tag in a location that is (1) facing plot center and (2) preferably below stump height or close to the ground. Determine the direction (azimuth) and horizontal distance (to the nearest 1/10 foot) from the chosen spot of the tag to the plot center then scribe on the tag the information listed below.

1. Eight-digit grid plot number. Plot numbers are shown on cruise maps and begin with a "C".
2. Azimuth (True) and horizontal distance (format example 275d 4.7ft).
3. Cruise date.
4. Cruiser's initials.
5. Optional note (e.g. PC is on stump).

Using a nail, attach the tag at the chosen spot. Allow for growth by sinking the nail only deep enough to secure the tag. When done, the plot tag and stake install should look similar to Figures 2-3.

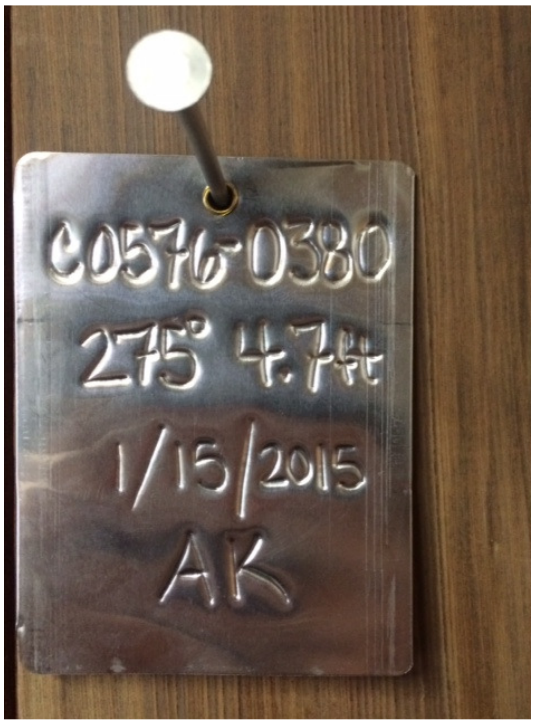


Figure 2-3 Plot Tag. *When attaching the plot tag, allow for growth by sinking the nail only deep enough to make the tag secure. The optional note is omitted from this example.*

3 PLOT SAMPLING PROCEDURES

3-1 Inventory Cruising

3-1.1 TREES SAMPLED

Trees that are sampled are described below.

1. Any live planted or seed-origin tree that has survived on-site at least 1.0" in diameter.
2. Any live stump sprout which is upright (not growing like a lateral branch) and is at least 1.0" in diameter.
3. Dead Trees which are at least 5.0" DBH and at least 15 feet tall.

Like dead trees, live trees have minimum DBH restrictions. See the "*3-1.2 Sample Design*" section below.

3-1.2 SAMPLE DESIGN

Nested, circular fixed area subplots are used when selecting trees. Nested means the different samples taken will all have a common plot (point) center.

Table 3-1
Sample Design for Nested Plot Sampling

Sample Design Code	Nested Subplot by DBH Range		
	Subplot 1 (1.0" – 3.5")	Subplot 2 (3.6" – 10.5")	Subplot 3 (>= 10.6")
1	1/100 Acre	1/50 Acre	1/10 Acre

3-1.3 ORDER OF TALLY

Follow these orders of tally instructions to speed inspections. Sample trees are recorded clockwise from north. Record any nested subplot 1 trees first, then record subplot 2 trees and finally subplot 3 trees. If trees are directly behind one another, start with the closest one from plot center and proceed outward. The contractor has the option to sample subplot 2 and 3 trees together if that process is easier for data collection.

3-1.4 SAMPLING EDGES OF CRUISE UNITS

Sometimes a plot center lands on or near a cruise unit border. Where trees on either side of the border area are clearly similar in size, stocking, spatial arrangement, and species composition (similar typing), tally all the trees within the nested subplots regardless of whether they lie within or outside the cruise unit. In simple words, sample a full plot.

When a nested subplot crosses over the cruise unit border and trees on either side of the border area are clearly not similar (typing is not the same), cruise trees using the walk-through method.

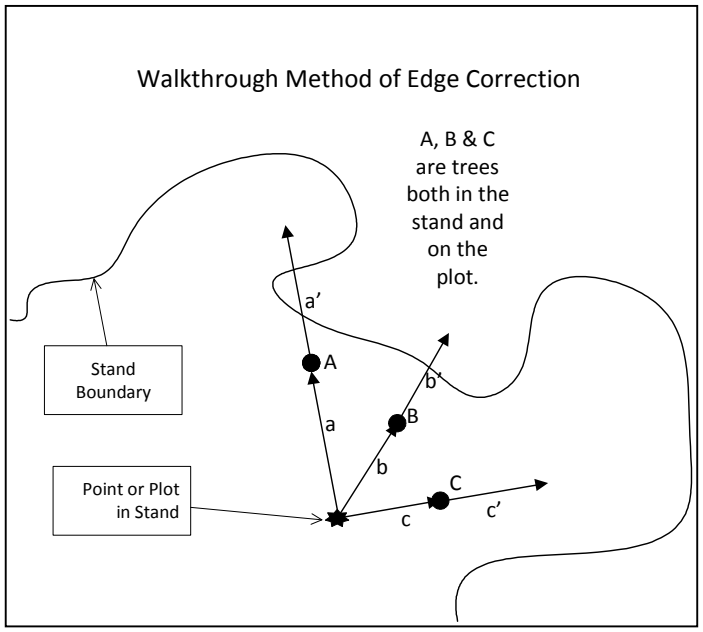
3-1.4.a Watercourses near a Cruise Unit Boundary

For stands whose boundary is a watercourse and a plot falls near the watercourse, cruise the plot as a normal plot so long as the plot coverage does not cross a property boundary.

3-1.4.b Walk-through Method

The walkthrough method has both the advantages of being unbiased in almost all cases and of accommodating uneven stand boundaries. The walkthrough method is simple to implement:

- Establish the point or plot where it falls, and record all 'in' trees within the stand.
- For each tree 'in' the point sample or on the fixed plot that falls between the point and the stand boundary, measure the horizontal distance from the point or plot center to the tree in question.
- Extend the line from the plot center through the tree by the same horizontal distance.
- If the end of the extended line is inside the stand, count the tree once. If the end of the extended line is outside the stand count the tree twice.



The accompanying figure illustrates the walkthrough method as described above. In this case trees A and C would be counted once and tree B will be counted twice.

3-1.4.c Roads

Cruise plots landing on unmapped (legacy) roads, abandoned roads, landings, and trails where they fall, for these components are a part of the unit of sample. Paved, rocked, or dirt roads as shown on the cruise maps are excluded from the Carbon Project Area, and as such are not sampled. Consider the road edges, defined as the top of the cut slope and where road grading ends on the fill slope, a cruise unit border.

Cruise plots having a plot center on the edge of a mapped, un-abandoned road (Figure 3-10). Get to the road edge to install plot center (see the edge definition above). Use an edge sampling method while ignoring trees located across the road.

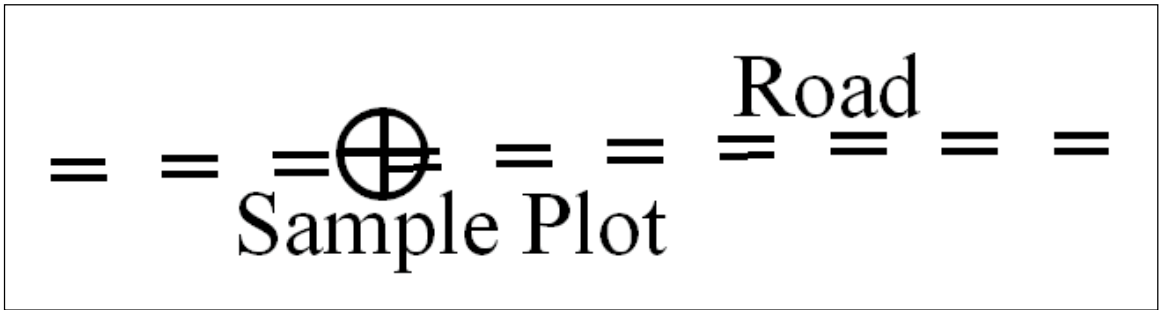


Figure 3-10 Non-Road Plot mapped on the edge of a road. *The plot center (the cross hairs of the sample plot) is on the mapped, un-abandoned, road-edge. Cruise the plot installing plot center at the road corridor edge defined as the top of the cut slope or where road grading ends on the fill slope.*

3-1.5 BORDERLINE CALLS

View trees whose boles of which have grown together as separate trees (do not group them together as one tree having fork damage). Likewise, view each fork emanating from a tree at or below breast height (BH) as a separate tree. BH is defined as the point on a tree's bole 4.5 feet distant from the ground line on the tree's uphill side, or, if a stump sprout, the point on a tree's bole 4.5 feet distant from the sprout's stump origin.

The sampling plane of fixed plots is ground line. Trees are tallied when their center or pith at ground line lies within (inside or on) the fixed plot circle. Where trees are growing off of stumps, the point of reference shall be the center of the tree where the tree is attached to the stump. Round computed fixed plot sizes to the nearest $1/100^{th}$ foot. Table 3-2 lists the horizontal fixed plot sizes used for inventory cruising.

Table 3-2
Fixed Plot Sizes used for Inventory Cruising

Fixed Plot Size in Acres	Horizontal Plot Radius in Feet
1/100	11.78
1/50	16.65
1/10	37.24

It is important to get a tree's borderline call right, for missing or adding trees will cause an inspection to fail. When the horizontal distance of a tree candidate to plot center must be computed for comparison to a given plots radius, prefer computing the distance using the slope correction formula shown in Figure 3-11. Slope correction tables may also be used.

Formula (Form 1) **s = h / cos(Ø)**

or

Formula (Form 2) **h = s [cos(Ø)]**

where

s = slope distance,
h = horizontal distance, and
Ø = angle in degrees

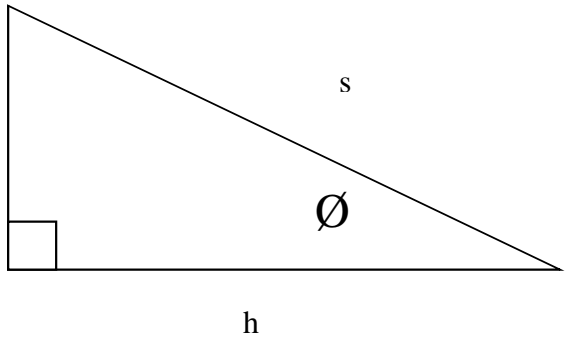
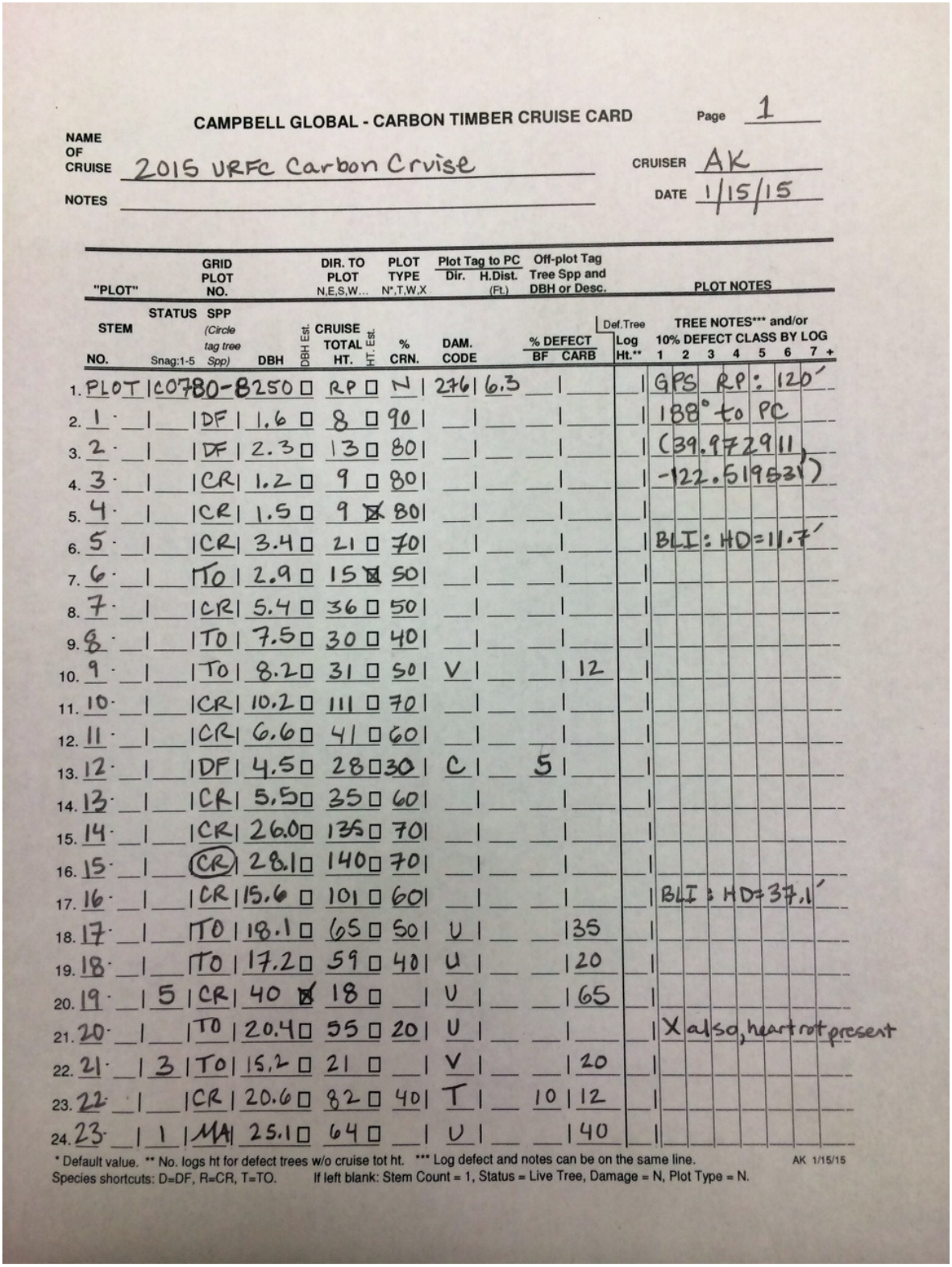


Figure 3-11 Horizontal Distance Formula. *Compute horizontal distance using the slope correction formula above.*

4 COLLECTED DATA

Figure 4-1 shows the cruise card with some sample data. Data recorded on the card are divided into the categories of "Stand", "Plot", and "Stem". The cell where each data is recorded is bounded by the columns of its column heading.



CAMPBELL GLOBAL - CARBON TIMBER CRUISE CARD Page 1

NAME OF CRUISE 2015 URFC Carbon Cruise CRUISER AK

NOTES DATE 1/15/15

"PLOT"	GRID PLOT NO.	DIR. TO PLOT N,E,S,W...	PLOT TYPE N*,T,W,X	Plot Tag to PC Dir.	Plot Tag to PC H.Dist. (Ft.)	Off-plot Tag Tree Spp and DBH or Desc.	PLOT NOTES
1	C0780-8250	RP	N	276	6.3		GPS RP: 120' 188° to PC (39.972911, -122.519531)

STEM NO.	STATUS Snag:1-5	SPP (Circle tag tree Spp)	DBH	DBH Est.	CRUISE TOTAL HT.	HT. Est.	% CRN.	DAM. CODE	% DEFECT BF	% DEFECT CARB	Def.Tree Log Ht.**	TREE NOTES*** and/or 10% DEFECT CLASS BY LOG 1 2 3 4 5 6 7+
2		DF	1.6		8		90					
3		DF	2.3		13		80					
4		CR	1.2		9		80					
5		CR	1.5		9	X	80					
6		CR	3.4		21		70					BLI: HD=11.7'
7		TO	2.9		15	X	50					
8		CR	5.4		36		50					
9		TO	7.5		30		40					
10		TO	8.2		31		50	V		12		
11		CR	10.2		111		70					
12		CR	6.6		41		60					
13		DF	4.5		28		30	C	5			
14		CR	5.5		35		60					
15		CR	26.0		135		70					
16		(CR)	28.1		140		70					
17		CR	15.6		101		60					BLI: HD=37.1'
18		TO	18.1		65		50	U		35		
19		TO	17.2		59		40	U		20		
20	5	CR	40	X	18			U		65		
21		TO	20.4		55		20	U				X also, heart rot present
22	3	TO	15.2		21			V		20		
23		CR	20.6		82		40	T	10	12		
24	1	MA	25.1		64			U		40		

* Default value. ** No. logs ht for defect trees w/o cruise tot ht. *** Log defect and notes can be on the same line. AK 1/15/15

Species shortcuts: D=DF, R=CR, T=TO. If left blank: Stem Count = 1, Status = Live Tree, Damage = N, Plot Type = N.

Figure 4-1 Cruise Card with sample data. *Campbell Global, Cruise Card*

4-1 Plot Data

The Plot data precedes the Stem data collected on a plot. The recorded information is defined below.

1. **"PLOT"**. Write "PLOT" to identify the information written to the right as Plot data.
2. **Plot No**. Record the cruise plot number. This number will be shown on the provided cruise maps.
3. **Direction to Plot**. Record the cardinal direction, bearing, or azimuth used while navigating to plot center. This will be the bearing and distance reported by the GPS unit, prefix the direction with a "G" for GPS then suffix the direction with a period followed by the distance traveled in feet. Syntax examples are listed below. The examples use a distance of 99 feet (1.5 chains) for routes starting from the GPS RP.
    a. Cardinal Direction. e.g. NE; GNE.99.
    b. Bearing. e.g. N45E; GN45E.99.
    c. Azimuth. e.g. 45, G45.99.
4. **Plot Type**. Following the order of prevailing entry listed in Table 4-1, enter the prevailing plot type code or description defining the plot sampled writing all remaining codes in Plot Notes. For example, a plot is a "Walkthrough" AND a "WLPZ" plot. Enter "T" or "Walkthrough" in Plot Type and "W" or "WLPZ" in Plot Notes.
5. **Plot Tag to PC**. These fields are applicable only to inventory cruising
    a. Direction. Record in degrees the bearing or azimuth (e.g. N20W, 340) from the plot tag to the plot center).
    b. Horizontal Distance. Record to tenths the horizontal distance from the point of attachment of the plot tag to the plot center.
6. **Off-plot Tag Description**. When the plot tag is not attached to a plot tree, record a description of the witness object that includes a reference to its size. Follow the syntax <*species*> & <*DBH*> OR <*object description*> & <*size*> (e.g. df9, crstump20in, log20ftlong36indiam). For witnesses that are also plot trees, see the "*4.2.1.c Species*" section.
7. **Plot Notes**. Enter pertinent notes about the plot. Separate notes by the semi-colon ";" delimiter (e.g. WLPZ; No Trees; on slide). Enclose critical notes in curly brackets (e.g. **{**bad typing, move plot to cruise unit 5132**}**).

Table 4-1
Plot Type Codes, Descriptions, and Definitions listed in Prevailing Order of Entry

Order of Prevailing Entry (Ascending)	Plot Type Code	Plot Type Description	Definition
1	T	Walkthrough	An edge sampling plot where some of the tallies may be doubled.
2	W	WLPZ	A plot falling within a Watercourse and Lake Protection Zone.
3	X	No Trees	A plot devoid of samples (can have off-plot site trees).
4	N	Normal	A plot not possessing any of the other plot types listed within the table. This is the default plot type. Leaving Plot Type empty (Null) defaults this value to Company systems. No need to ever record "Normal" in Plot Notes.

4-2 Stem Data

Stem data are a plot's sampled trees. The data immediately follows its Plot data. Kinds of data collected are divided into the categories of samples taken and subsamples taken.

4-2.1 SAMPLES TAKEN

The following data are collected for each tree on the plot.

1. **Stem No.** (Stem Number).
2. **Status.**
3. **Species.**
4. **DBH** (Diameter Breast Height).
5. **DBH Est.** (DBH Estimated).
6. **Total Height to Tip.**
7. **HT Est.** (Height Estimated).
8. **% Crown** (Percent Crown).
9. **Dam. Code** (Damage Code).
10. **% Total Defect – Carb.** (Carbon).
11. **Tree Notes.**

Instructions for their collection are given below.

4-2.1.a Stem

Stem Number is a tree's line (row) number of the plot; (see *3-1.3 Order of Tally*). The stem number is painted onto trees on the 1/50th acre and 1/10th acre plots with white paint facing plot center. No need to paint tree numbers on 1/100th acre subplot; simply paint a dot a DBH where diameter measurement was taken. See the "*4-2.1.d DBH (Diameter Breast Height)*" section for a definition of DBH.

4-2.1.b Status

A tree's status refers to whether or not it is live or dead. The default status code for a tree is to have a blank status code (indicates a live tree). Dead trees are ranked by their hard to soft decay class[i] (Table 4-3) and as such have a numeric status code entered.

For declining, live trees that have been girdled within the last three years of cruise, consider them dead even though they may still have green leaves. Record their status as "Snag Class 1". Trees with green leaves that were girdled longer than three years ago have survived the girdling and are recorded using a live status ranking.

Table 4-3
Dead Tree Status Codes, Descriptions, and Definitions

Code	Description	Description of Condition of Standing Dead Wood
1	Snag Class 1	All limbs and branches are present; the top of the crown is still present; all bark remains; sapwood is intact, with minimal decay; heartwood is sound and hard.
2	Snag Class 2	There are few limbs and no fi ne branches; the top may be broken; a variable amount of bark remains; sapwood is sloughing with advanced decay; heartwood is sound at base but beginning to decay in the outer part of the upper bole.
3	Snag Class 3	Only limb stubs exist; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay in upper bole and is beginning at the base.
4	Snag Class 4	Few or no limb stubs remain; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay at the base and is sloughing in the upper bole.
5	Snag Class 5	No evidence of branches remains; the top is broken; <20 percent of the bark remains; sapwood is gone;

		heartwood is sloughing throughout.

Table 4-4
Species Codes and Description

Species Code	Species
BM	Bigleaf Maple
CQ	Chinkapin
CR	Coastal Redwood
CY	Canyon Live Oak
DF	Douglas-fir
EU	Eucalyptus
GF	Grand Fir
MA	Madrone
MY	Oregon Myrtle
NM	Nutmeg
OC	Other Conifer
OH	Other Hardwood
RA	Red Alder
TO	Tanoak
WH	Western Hemlock
WI	Willow Species

4-2.1.c Species

Enter a species code listed in Table 4-4. If the tree has a plot tag, circle it (Figure 4-1).

4-2.1.d DBH (Diameter Breast Height)

DBH is a tree's diameter at Breast Height (BH). See the "*3-1.5 Borderline Calls*" section for a definition of BH. DBH is recorded to the nearest 1/10th inch. Read the diameter tape by truncating the digits to the right of tenths place. For example, a tree's DBH is 2.59 inches. Read 2.5 and write the 1/10th-inch DBH as 2.5. The point where DBH is measured shall be marked with a stripe of white paint at least 4" in length. Please see Appendix B for special instructions regarding DBH measurements.

4-2.1.e DBH Est. (DBH Estimated)

Check the box if DBH is not measured with a diameter tape, or calipers but estimated using some other means (eye, relaskop, etc.).

4-2.1.f Total Height to Tip

Total height is the total length of bole including the stump. The dominant stem is measured for trees having a fork. For leaning trees, the measurement is made along the lean. If a live tree or snag is broken only measure to the existing tip unless the tree has a recovered leader, do not attempt to measure to the reconstructed top. Trees with previously broken tops are considered recovered when a new leader (dead or alive) is 1/3 the diameter of the broken top at the point where the top was broken (not where the new leader originates from the trunk). Forked trees should be treated the same as unforked trees.

4-2.1.h % Crown (Percent Crown)

Percent crown is sampled on all live trees sampled for total height. It is defined by the equation:

$c = (b/t)\ 100$

where

c = % Crown,
b = length of the visually balanced crown (if sparse, also compact the crown), and
t = total height (height is rebuilt to tip for broken top trees).

Visually estimate the % crown. Enter the estimate as a code as shown in Table 4-5.

Table 4-5
Percent Crown Codes

% Crown	
Code	% Crown
0	< 0
5	1 – 5
10	6 – 10
20	11 – 20
30	21 – 30
40	31 – 40
50	41 – 50
60	51 – 60

70	61 – 70
80	71 – 80
90	81 – 90
100	91 – 100

4-2.1.i Dam. Code (Damage Code)

For all live and dead trees and following the order of prevailing entry listed in Table 4-6 enter damage when present. Leaving the cell empty defaults the entry to "N" meaning "No Damage". The prevailing order of entry is based upon desirable wildlife features and favors listing cavity and agents leading to cavity first before considering other damages. For hardwoods, do not bother recording "Crook/Sweep" or "Fork" damage, for most local hardwood have these features. For this same reason, do not record broken top for hardwoods unless the top is completely sheared off. If a tree is subject to multiple damage codes insert the predominant code in the Damage Code field and write the additional damage codes in the Tree Notes.

Table 4-6
Damage Codes, Descriptions, and Definitions listed in Prevailing Order of Entry

Order of Prevailing Entry (Ascending)	Damage Code	Plot Type Description	Comments
1	U	Basal Cavity	
2	V	Cavity (not basal)	
3	X	Dead Top	
4	T	Broken Top	Generally not recorded for hardwoods.
7	N	No Damage	This is the default damage. Leaving damage empty (Null) defaults this value to Company systems.

Crack. Deduct 30% volume loss for each straight crack occurring by 16-foot log segment. 3 cracks cull a log. Cull a log having spiral crack.

Broken Top. Determine the percent volume loss of the log where the break occurs. Determine the percent volume loss of additional missing, 16-foot log segments above the break. Sum the values to determine the deduction.

Rot, Conks, Punk Knots. Follow the guidelines of Table 4-7 when estimating missing volume of 16-foot log segments for rot, conks, and punk knots.

4-2.1.k % Total Defect – Carb. (Carbon)

Total percent carbon defect is defined as the total percent cubic foot defect of a bole both inside and outside the board foot scaling cylinder from and including the stump to the tip. Record the estimate to the nearest whole percent for all live and dead trees (both conifers and hardwoods). There are differences between live trees and dead trees in how carbon defect is estimated; see below.

Carbon Defect for Live Trees. Using a rebuilt top if broken, record the total percent carbon defect due to missing portions of bole for live trees using Table 4-8 (conifers) or Table 4-9 (hardwoods) as a guide.

Damages affecting volume loss are basal cavity, cavity, heart rot, root rot, cracks, fire, mechanical, and broken tops. Damages *not* affecting volume loss are sweep, crook, fork, dead top, insects and browse.

Burnt and rotten wood are not as dense (lighter) and therefore have less carbon than solid wood. Because both carbon and biomass are sold by weight, when estimating loss due to rot or charcoal, imagine the airspace created (wood missing) if the defected wood were compressed to a solid composition. Defect according to how much airspace is produced.

Table 4-8
Conifer – Percent of Total Stem Volume Above Ground by 1/3 of Total Height (includes stump)

Total Height (ft)	% of Total Stem Cubic Volume		
	Bottom 1/3	Middle 1/3	Top 1/3
<= 4	Treat as 1 piece		
5 to 10	55%	40%	5%
11 to 20	65%	30%	5%
21 to 130	62%	30%	8%
Redwood >131	64%	29%	7%
Other Conifers > 131	66%	28%	6%

Table 4-9

Hardwood – Percent of Total Stem Volume Above Ground by 1/3 of Total Height (includes stump)

Total Height (ft)	% of Total Stem Cubic Volume		
	Bottom 1/3	Middle 1/3	Top 1/3
<= 20	Treat as 1 piece		
21 to 30	72%	23%	5%
>= 31 to 20	65%	30%	5%

Carbon Defect for Dead Trees. Considering the snag only to its actual height (only to the broken top if the tip is gone) as the entire piece (100% of the volume), in percent volume record an ocular, cubic-foot estimate of missing wood (pieces, chunks, slabs, hollows) to the actual height. Company systems will, based upon the actual height of the snag, determine whether the top is broken to compute a volume loss of the missing top.

Do not consider rot as defect as is done with live trees. Rot is quantified by the dead tree's status (see *Table 4-3*) that describes its density degradation from solid wood. Figures 4-5 and 4-6 are examples how to estimate carbon defect for dead trees.

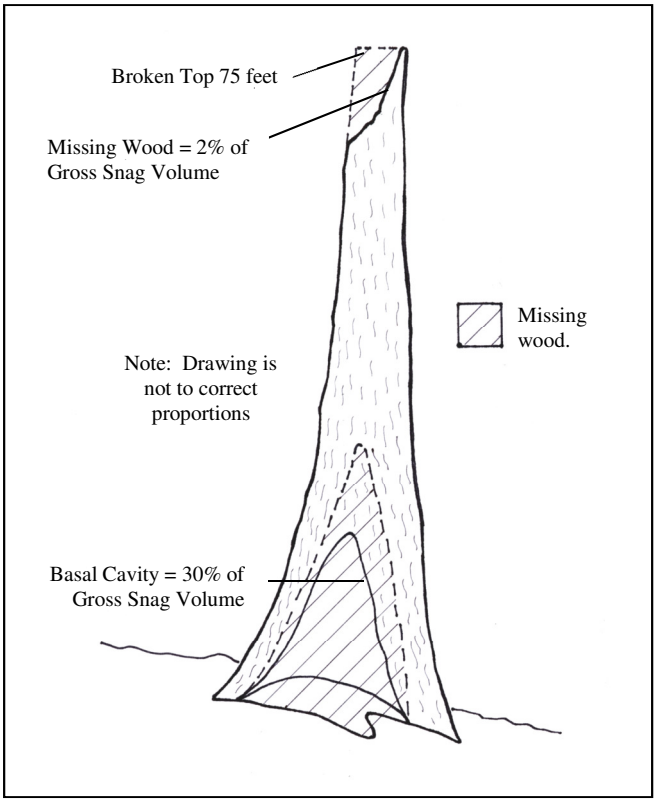


Figure 4-5 Snag Percent Carbon Defect Example 1. Snag Height = 75 feet; Defect = U (Basal Cavity); Carbon Percent Defect = 32%

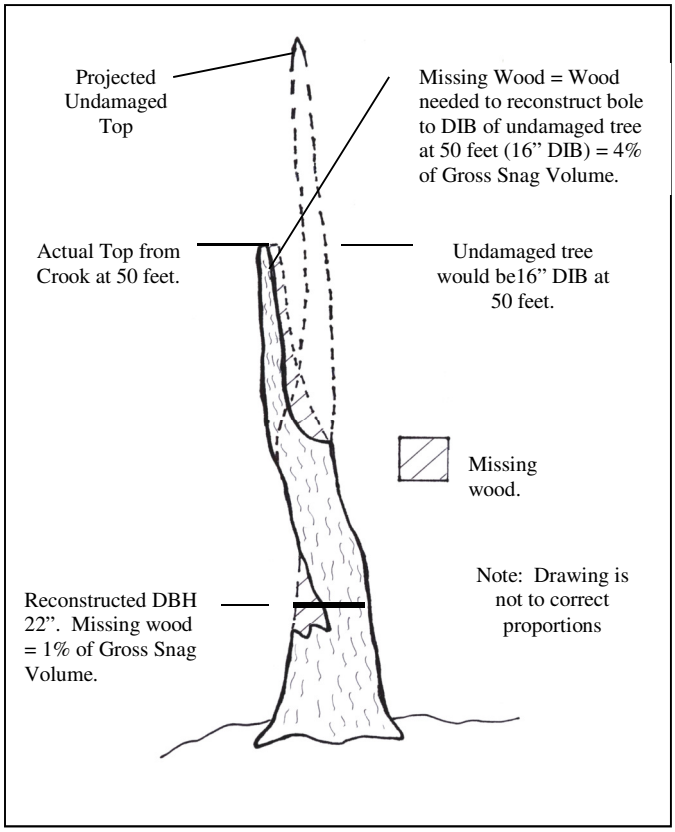


Figure 4-6 Snag Percent Carbon Defect Example 2. Snag Height = 50 feet; Defect = C (Crook); Carbon Percent Defect = 5% (4% + 1%).

4-2.1.l Tree Notes

Record any pertinent notes about the tree (if not recorded under *Dam. Code*) and borderline "IN/OUT" measurements. For these common notes, use the shorthand syntax listed below.

1. **bli**. Border Line In.
2. **blo *species DBH***. Border Line Out – Species Code – DBH to tenths (e.g. blo df 10.2).
3. **sd *feet***. Slope distance to hundredths from the tree's center to plot center (e.g. sd 25.32).
4. **hd *feet*** Horizontal distance to hundredths from the tree's center to plot center (e.g. hd 20.25).
5. ***x%***. Slope in percent used to compute horizontal distance from a tree's center to plot center (e.g. 25%).
6. **s**. Age estimated from a nearby stump ring count.
7. **w**. Age estimated from a whorl count.
8. **#x**. Stem Number (e.g. behind #6).

Separate groups of notes by the semi-colon ";" text delimiter. Following are examples of notes using the shorthand syntax.

1. bli; GROUND BEES AT BASE!
2. blo cr 26.9 hd 35.90; M
3. blo df 5.2 sd 10.62 35%; bear damage; behind #3

5 SUBMITTING WORK

Consultant shall submit completed Work at least bi-monthly to Company. The submitted Work shall be called a Block. A Block is comprised of (1) Work cruise data, (2) Work cruise maps, and (3) Data cards, if they were used for data collection. All Block items must be submitted for inspections to start and they must meet the work's submitted tolerances in Table 5-1.

Table 5-1
Work Submittal Tolerances

Work Submittals	
Item	**Tolerance**
Hand Writing, Printing, and Sketches	Legible and can be reproduced with a copy machine.
Electronic Data	Readable by Company computers and software.
Electronic/Paper Forms and Maps	All required forms and maps are submitted. All required fields are entered.
Company Provided Data	Correctly transferred to submitted forms.
Collected Data	Data content and syntax appear correct.

5-1 Work Cruise Data

There are three forms to Work cruise data:

1. Raw Data.
2. Inspection Data
3. Clean Data.

Consultant shall submit Raw Data and Clean Data to Company and may be required by Company to submit Inspection Data as explained below.

5-1.1 RAW DATA

Raw Data is the original cruise data as collected in the field on electronic, magnetic tape or paper media not altered or edited in any way.

When paper is the media, Company cruise unit data cards shall be used. See Figure 4-1 for an example. Cards will be supplied to the contractor by Company.

Company shall determine whether the submitted Raw Data qualifies to be considered as Inspection Data; (see *5-1.2 Inspection Data*). If the Raw Data does not qualify as Inspection Data, Contractor will be notified by Company and Contractor shall bring the data up to Inspection Data standards and submit Inspection Data.

5-1.2 INSPECTION DATA

Inspection Data is data that does not have any major problems that would prevent the data from being used for the inspection of Work. Inspection Data results from Raw Data. Its form must be electronically entered to the Excel workbook that is supplied by company OR, if agreed to by Company, entered to a different electronic format proposed by Consultant. Company shall use Inspection Data for inspections when making determinations of acceptable Work; (see 6 – *Inspections*). Hot Check Data is Inspection Data from the first day or two of cruising. If the data is being recorded onto paper data cards in the field, then the Hot Check Data may be submitted as the original data cards which will be returned to Contractor.

5-1.3 CLEAN DATA

Clean Data is data that is free of errors. Contractor is required to generate the Clean Data. Generally within four days of raw data submission, Company will process the data and notify the contractor of any deficiencies.. Generating Clean Data may include additional field work when submitted data is found to be deficient for reasons such as, but not limited to: (1) not meeting cruise targets or (2) incomplete data.

5-2 Work Cruise Maps, and Cruise Data Cards

Submit to Company:

1. Either the originals or legible copies of pertinent cruise maps showing all navigation route documentation; (see *2-2.2 Navigation Route Documentation*).
2. If the data was recorded onto paper cards in the field, submit copies of the cards. Company will make one copy of the cruise cards at no cost to the contractor if the originals are brought to the company office.

6 INSPECTIONS

Pursuant to the "*Inspection of Premises and* Work" section of the Agreement, Company reserves the right to inspect Blocks (see *5 – Submitting Work*) to determine compliance with the cruise procedures and standards. For reasons of efficiencies, Company may combine Blocks in the inspection process.

6-1 Conditions of Inspection

Standard. If Company chooses to inspect Blocks for compliance with procedures and standards, the Company representative or designee shall inspect. The Company representative's findings shall be the STANDARD and shall be conclusive for determining compliance to procedures and standards.

Failed Block. Consultant shall rework a failed Block until it complies with procedures and standards at no expense to Company. Issues causing rework shall be corrected across all failed plots of a Block or as directed by the Company representative.

Withholding Payment. A Block must be inspected to determine compliance if Company desires to withhold payment and require rework because Company believes the Block is not in compliance with procedures and standards.

The Inspection. When Company chooses to inspect, the inspection shall be done utilizing: (1) an office review and (2) a field review.

6-2 Inspection Procedures

Inspection consists of three parts:

1. Clean Data Inspection. Generally within four days of data submission, Company will process the submitted data and notify contractor….send the resulting. Contractor is responsible for cleaning the submitted data with edits to resolve problems. More than one round of data fixes may be required to completely clean the data. This may require one or more trips to the field by Contractor to collect the necessary data. Clean data as determined by Company constitutes passing the Clean Data Inspection.

2. Field Inspection. A field inspection will be carried out for an inspection block of 50 plots or all plots in a cruise, whichever is smaller. If data submissions are for less than a full field inspection block, Company has the right to accumulate submitted data and wait to inspect until a full field inspection block is available.

   The field review is a by-cruiser, random inspection of navigation, monumentation, plot location, and data collection. Work shall comply with the tolerances set forth in Table 6-1 and Table 6-2. Data measurements shall be scored using a Check Cruise Score Card. The inspection intensity of plots shall be: 10% for all cruisers. Company reserves the right to expand any inspection to

more than 10% for any reason. A score of 94% on the Inspection Scorecard and adherence to the cruise design constitutes passing the Field Inspection.

If the field review of any cruiser fails, the failed portion of the inspection batch shall be returned to the Contractor for rework.

3. Keypunch Inspection. If at any time Company suspects there are keypunch errors in any submitted data (not just the most recent data submission), Company can require Contractor to verify all keypunching. Keypunch errors are usually detected during Field Inspection. On rare occasions, keypunch errors are detected later when the data is being processed for the timberland inventory; this can be several months after the data was submitted. All data is assumed to provisionally pass the Keypunch Inspection. Final determination of passing the Keypunch Inspection occurs after all data has been submitted and is processed for the inventory.

Table 6-1
Navigation, Monumentation, and Data Collection Tolerances

Navigation and Monumentation		
Item		**Tolerance**
Plot Center Location		Plot centers are within the intended cruise unit, are reasonably close to their mapped location, and bias is not evident.
Flagging Monuments		Correctly hung and labeled most of the time. Referenced items may be located and identified despite labeling errors.
Plot Tag	Object	Correctly selected as stated in the procedures.
	Attachment	Correctly attached to the object as stated in the procedures.
	Horizontal Distance	Within +/- 3/10^{ths} foot most of the time.
	Direction to Plot Center	Within 2 ½ degrees most of the time.
	Label	Correctly labeled most of the time.
Data Collection		
Data Codes		Correct.
Data Measurements		Random sample of the Block's plots (10% sample) achieves a check cruise score of at least 94%.

Table 6-2
Check Cruise Score Card Tolerances

Check Cruise Score Card Tolerances	
Stem Count	1. No trees missing on 1/10th or 1/50th acre plots, and TPA within 30% tolerance for the 1/100th acre plot.
Diameter Breast Height (DBH)	Within +/- 2% for trees less than 24 inches DBH and within +/- 3% for larger trees.
Species	Correct
Total Height to Tip	Height samples within the lesser of +/- 10% or 10ft.
Status	Correct
Damage Code	Correctly chosen as stated in the procedures.
Percent Crown	Within +/- 1 Crown Code
Percent Total Defect (Carbon)	Within +/- 10%.

7 INVOICING

Submitted Block(s) (see *5 – Submitting Work*) forms the basis of payment and may be invoiced per the "*Compensation*" section of the Agreement. Invoices shall clearly show the information listed below.

1. Invoice number.
2. Consultant's business name.
3. Business address.
4. Business phone number.
5. Business fax number.
6. Business e-mail.
7. Company's name and address.
8. Agreement number.
9. Exhibit label.
10. Computer filenames of the Work cruise data.
11. A reasonable detail listing describing the items invoiced.
12. Dollars/item invoiced.
13. Total dollars charged.

7-1 Invoice Approval

Invoices for Submitted Plots. Company has two weeks to approve the invoice once plots pass the Clean Data Inspection, Field Data Inspection and Keypunch Inspection.

7-2 Invoice payment

Payment of invoices by Company generally occurs within two weeks of invoice approval.

APPENDIX A - HARVEST PLAN FLAGGING & PAINT COLORS WITH DEFINITIONS

As of May 14th, 2010

Table A-1. Flagging

Flagging Color/Combination	Meaning
Red 'PROPERTY LINE'	Property Line – Do NOT cross unless directed by RPF
Pink 'THP BOUNDARY'	Boundary of THP. – Don't fell trees outside except for safety.
Lime Glo 'SILVICULTURE'	Silviculture Boundary – may be coincident with WLPZ or Yarding Method.
Yellow/Black Stripe	Yarding Method Boundary.
Blue/White Stripe	Class I and II centerlines. *May not be flagged where obvious.*
Blue/White 'LAKE AND WATERCOURSE PROTECTION ZONE'	Watercourse and Lake Protection Zones, Canopy Retention Zones for Springs. May indicate silviculture boundary as well.
White w/Blue Polka Dots	Class III centerline. Triple flag denotes end of segment. May also serve as perimeter of a wet area.
White w/Blue Polka Dots with Solid Red	Wet Area Equipment Limitation Zone
Red	Tractor Stop Lines, Equipment Limitation Zones, Equipment Exclusion Zones.
Yellow 'SKID TRAIL'	Pre-flagged tractor road. Triple flag denotes end of trail.
Orange/White Stripe 'SPECIAL TREATMENT ZONE'	Special Treatment Zone for Wildlife Protection Zones, Archaeological Protection Zones, unstable areas, botanical protection areas.
Blue	Centerline of proposed roads. May also be present on existing roads which are very brushy.
Orange	Variety, primarily Logging road grades and Cable corridor roads
Blue and Orange hung together	Proposed and/or existing landing in brushy area. May also denote limits of use for existing WLPZ landings.
Orange/White or Green/White Stripe	Older inventory cruisers flagging, not THP related.
Pink/Black Stripe (may have Lime Glo)	Used by Wildlife Crews, not THP related.
Orange with White	Map Points, Instructions
Yellow with White	Road Maintenance Activities
Red with White	RPF message flagging.
White	Reconnaissance flagging, not THP related
Purple	Inventory or Aquatic Monitoring flags, not THP related.

Table A-2. Paint

Paint Color	Meaning
Blue	Harvest Tree, Labels
Orange	Retention Tree, Labels
Yellow	Property Line Blaze, Labels
RETAIN ANY TREE MARKED “NO” IN ANY COLOR PAINT	
CUT ANY TREE MARKED “CUT” IN ANY COLOR PAINT	

APPENDIX B – SPECIAL INSTRUCTIONS FOR DBH MEASUREMENTS

The attached special instructions for DBH measurement are taken from the FIA National Core Field Guide, Version 6.1 dated October, 2014 section 5.9.2. Not all instructions apply to the Usal Redwood Forest Carbon Inventory. For example, where the special instructions refer to multi-stemmed woodland species, no such species as defined in Appendix 3 of the Core Field Guide are found on the Usal Redwood Forest Project Area, and as such, references to multi-stemmed woodland species can be ignored.

5.9.2 DIAMETER AT BREAST HEIGHT (DBH)
Unless one of the following special situations is encountered, measure DBH at 4.5 feet above the ground line on the uphill side of the tree. Round each measurement down to the last 0.1 inch. For example, a reading of 3.68 inches is recorded as 3.6 inches.

Special DBH situations:

1. Forked tree: In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less. Forks originate at the point on the bole where the piths intersect. Forked trees are handled differently depending on whether the fork originates below 1.0 foot, between 1.0 and 4.5 feet, or above 4.5 feet.

   - Trees forked below 1.0 foot. Trees forked below 1.0 foot are treated as distinctly separate trees (fig. 23). Distances and azimuths are measured individually to the center of each stem where it splits from the stump (fig. 26 A-C). DBH is measured for each stem at 4.5 feet above the ground. When stems originate from pith intersections below 1 foot, it is possible for some stems to be within the limiting distance of the microplot or subplot, and others to be beyond the limiting distance. If stems originating from forks that occur below 1.0 foot fork again between 1.0 and 4.5 feet (fig. 26-E), the rules in the next paragraph apply.

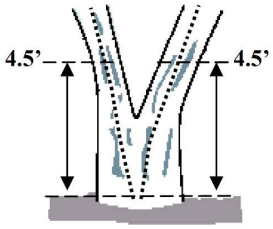


Figure 23. Forked below 1.0 ft.

   - Trees forked between 1.0 foot and 4.5 feet. Trees forked between 1.0 foot and 4.5 feet are also counted as separate trees (fig. 24), but only one distance and azimuth (to the central stump) is recorded for each stem (fig. 26 D-F). Although a single azimuth and distance applies to all, multiple stems should be recorded as they occur in clockwise order (from front to back when one stem is directly in front of another). The DBH of each fork is measured at a point 3.5 feet above the pith intersection. When forks originate from pith intersections between 1.0 and 4.5 feet, the limiting distance is the same for all forks--they are either all on, or all off the plot.

     Multiple forks are possible if they all originate from approximately the same point on the main stem. In such cases, measure DBH on all stems at 3.5 feet above the common pith intersection (fig. 26-F).

     Once a stem is tallied as a fork that originated from a pith intersection between 1.0 and 4.5 feet, do not recognize any additional forks that may occur on that stem. Measure the diameter of such stems just below the base of stem separation as shown in figure 26-E (i.e., do not move the point of diameter the entire 3.5 feet above the first fork).

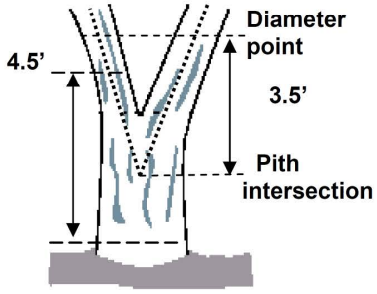


Figure 24. Forked between 1.0-4.5 ft.

- Trees forked at or above 4.5 feet. Trees forked at or above 4.5 feet count as one single tree (fig. 25). If a fork occurs at or immediately above 4.5 feet, measure diameter below the fork just beneath any swelling that would inflate DBH.

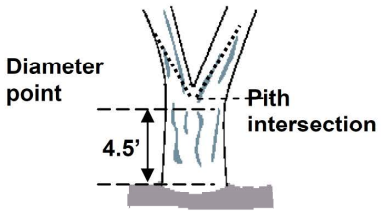


Figure 25. One tree.

2. Stump sprouts: Stump sprouts originate between ground level and 4.5 feet on the boles of trees that have died or been cut. Stump sprouts are handled the same as forked trees, with the exception that stump sprouts are not required to be 1/3 the diameter of the dead bole. Stump sprouts originating below 1.0 foot are measured at 4.5 feet from ground line. Stump sprouts originating between 1.0 foot and 4.5 feet are measured at 3.5 feet above their point of occurrence. As with forks, rules for measuring distance and azimuth depend on whether the sprouts originate above or below 1.0 foot. For multi-stemmed woodland species, treat all new sprouts as part of the same new tree.

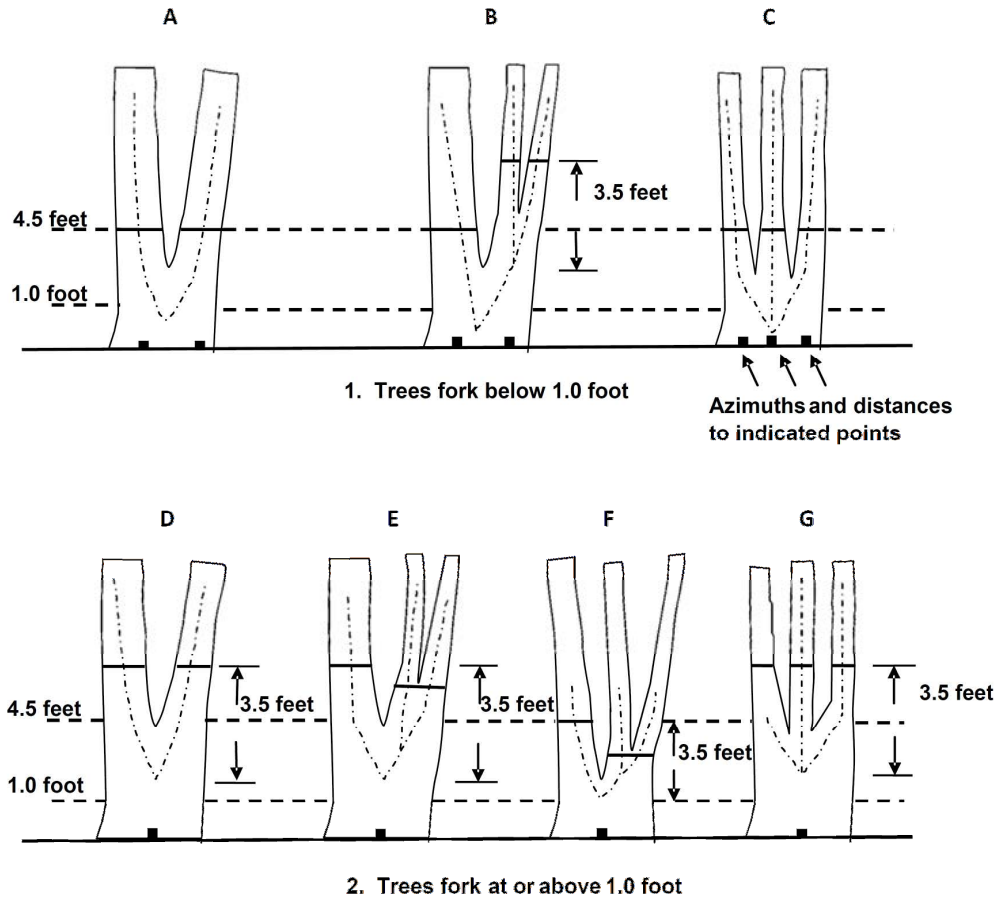


Figure 26. Summary of where to measure DBH, distance, and azimuth on forked trees.

3. Tree with butt-swell or bottleneck: Measure these trees 1.5 feet above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 feet or more above the ground (fig. 27).

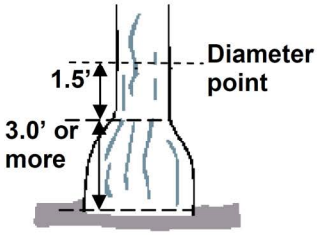


Figure 27. Bottleneck tree.

4. Tree with irregularities at DBH: On trees with swellings (fig. 28), bumps, depressions, and branches (fig. 29) at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

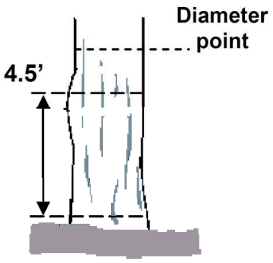


Figure 28. Tree with swelling.

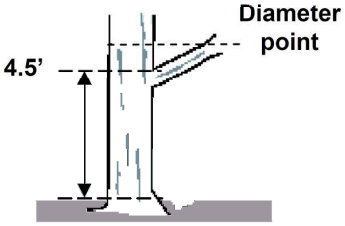


Figure 29. Tree with branch.

5. Tree on slope: Measure diameter at 4.5 feet from the ground along the bole on the uphill side of the tree (fig. 30).

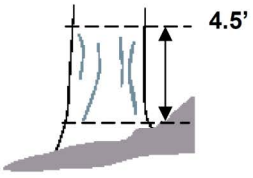


Figure 30. Tree on a slope.

6. Leaning tree: Measure diameter at 4.5 feet from the ground along the bole. The 4.5-foot distance is measured along the underside face of the bole (fig. 31).

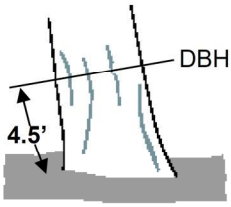


Figure 31. Leaning tree.

8. Independent trees that grow together: If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each, set the "DIAMETER CHECK" code to 1, and explain the situation in the notes.

   In this situation use the "half-DBH" method. Take a half tree diameter by estimating two point opposite each other on the stem at the DBH point. Measure the distance between the two marks and double the measurement to determine DBH. Either paint the location of the two marks, or set an aluminum nail at each point. Make a note that the DBH was measured using the "half-DBH" method.

9. Missing wood or bark: Do not reconstruct the DBH of a tree that is missing wood or bark at the point of measurement. Record the diameter, to the nearest 0.1 inch, of the wood and bark that is still attached to the tree (fig. 32). If a tree has a localized abnormality (gouge, depression, etc.) at the point of DBH, apply the procedure described for trees with irregularities at DBH (figs. 28 and 29).

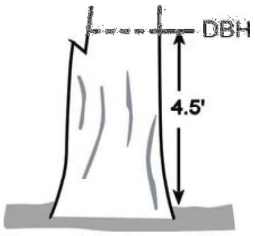


Figure 32. Tree with part of stem missing.

10. Live windthrown tree: Measure from the top of the root collar along the length to 4.5 feet (fig. 33).

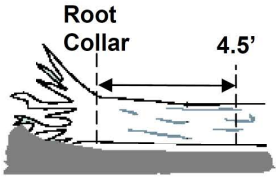


Figure 33. Tree on the ground.

11. Down live tree with tree-form branches growing vertical from main bole: When a down live tree, touching the ground, has vertical (less than 45 degrees from vertical) tree-like branches coming off the main bole, first determine whether or not the pith of the main bole (averaged along the first log of the tree) is above or below the duff layer.

    - If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (fig. 34).

    - If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 feet from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 feet above the pith intersection for both the main bole and the tree-like branch.

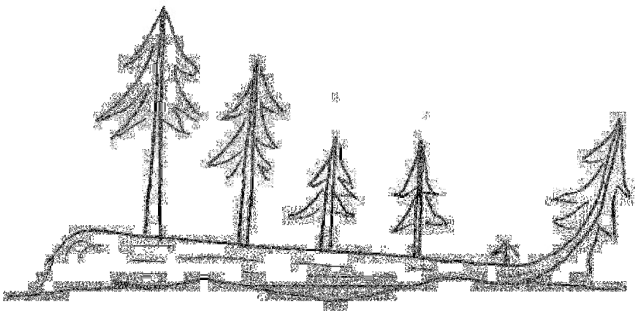


Figure 34. Down tree above duff.

- If the intersection between the main down bole and the tree-like branch occurs beyond the 4.5 feet point from the stump along the main bole, treat that branch as part of the main down bole.

- If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH and length measurements from the ground, not necessarily from the top of the down bole (fig. 35). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

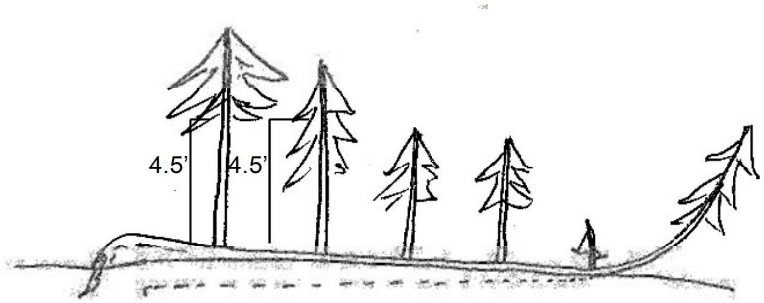


Figure 35. Down tree below duff.

12. Tree with curved bole (pistol butt tree): Measure along the bole on the uphill side (upper surface) of the tree (fig. 36).

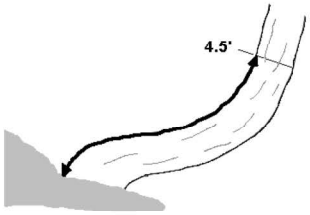


Figure 36. Tree with curved bole (pistol butt tree).

REFERENCES

[i] Harmon, Mark E.; Woodall, Christopher W.; Fasth, Becky; Sexton, Jay; Yatkov, Misha. 2011. Differences between standing and downed dead tree wood density reduction factors: A comparison across decay classes and tree species. Res. Pap. NRS-15. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 40 p.

List of Tools Used:

Tools typically used to measure heights, diameters and plots include: compass, 75-foot loggers tape (with DBH), clinometer, Releskop, laser range finder, GPS, and calculator.

Appendix C

Road Buffer Assumptions

The Road buffer algorithm uses the WIDTH_SURFACE field in the road layer to buffer the roads for our analytic road buffer layer in SDE. The value is assumed to be the entire width of the treeless surface, so the value is halved.

If no value exists in the WIDTH_SURFACE field, an assumption of width will be applied based on the ROAD_TYPE attribute. If there isn't information for road type, the SURFACE field is used.

Assumptions for all northwest properties are:

Road Type	Width
Highway/State/County/City	50
Mainline	40
Mainline (dirt)	24
Secondary/Spur	24
Paved	40
Rocked	30
Dirt	24

Things that *do not* get buffered, based on the ROAD_TYPE and STATUS field:
ROAD_TYPE: 4WD, Trail
STATUS: Unknown, Legacy, Abandoned

Appendix D

Plot and Strata Map

Usal Redwood Forest Plot and Strata Map

Legend

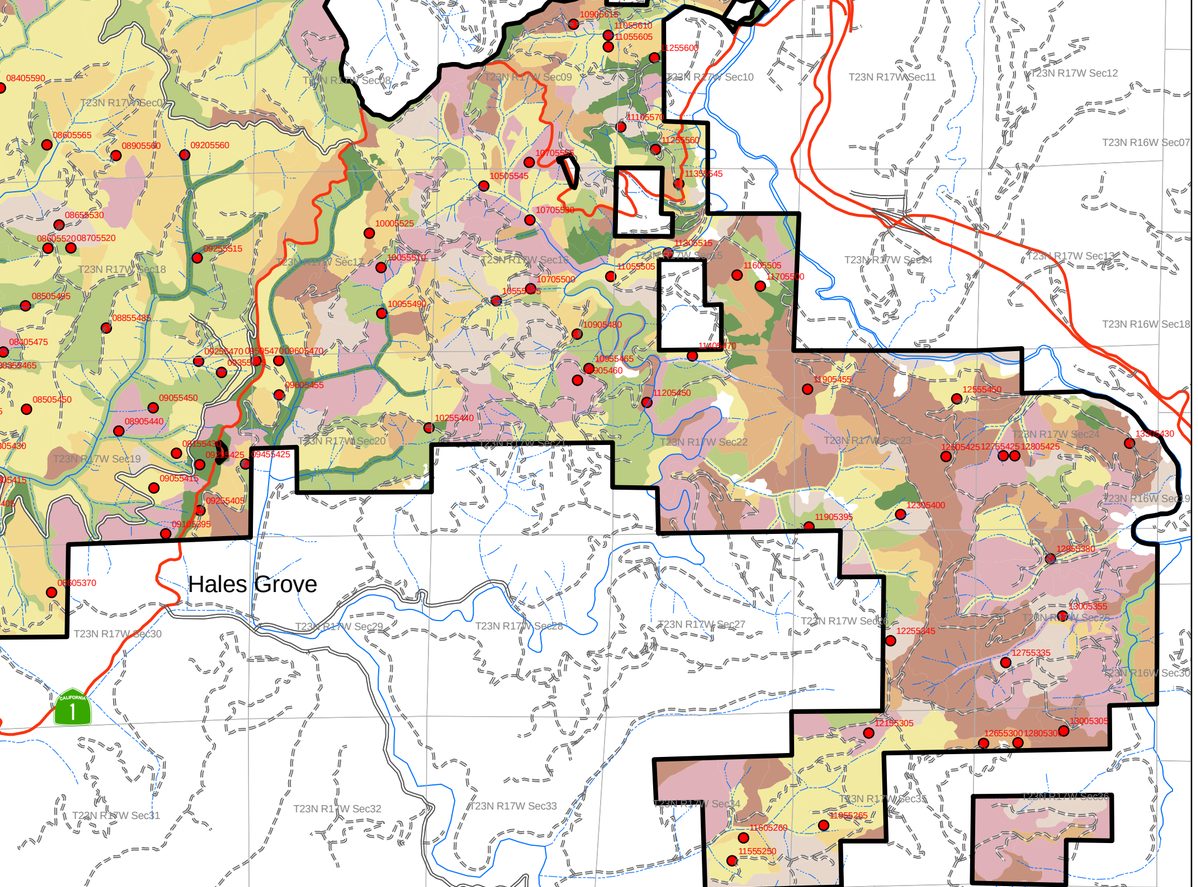
- Usal Redwood Forest Company Ownership
- Inventory Plot
- Permanent Road
- Seasonal Road
- Public Road
- Class I Watercourse
- Class II Watercourse
- Class III Watercourse

Strata

- Conifer High
- Conifer Medium High
- Conifer Medium Low
- Conifer Low
- Hardwood High
- Hardwood Medium High
- Hardwood Medium Low
- Hardwood Low

NCRM Inc.

0 0.5 1 2 3 4 Miles



ATTACHMENT C

Usal Redwood Forest Modeling Plan

By Jim Clark, RPF #2528

September 17, 2015

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Growth and Yield Modeling:

The growth and yield modeling described in this modeling plan is performed using the FORSEE model and the AllCA_ResLib resource library, and is based on the following:

Plot Data:

The modeling presented in this document is based on the Usal Redwood Forest inventory, conducted in January and February of 2015 utilizing a random selection of plots located across eight timber stratum. Plot locations were determined from a random selection of plots from a 5 chain by 5 chain grid that uniformly covers the entire Project Area. The final inventory design resulted in the installation of 353 plots across the Project Area. The inventory methodology included as Attachment B to the PDD provides a detailed description of the data collected as well as the structure of the cruise, including maps showing the cruise plot locations for the Usal Redwood Forest.

Updating the Inventory:

The inventory methodology included as Attachment B to the PDD provides a detailed description of the method of maintaining an up to date inventory for the Usal Redwood Forest.

Volume Calculations:

Conifer board foot volume calculations presented in Table 5a below utilize the standard FORSEE volume equations. Reported volumes are in board feet Scribner Scale for all conifers 8.5 inches DBH and larger. The FIA volume and biomass equations described in the PDD are used for the calculation of all carbon stock values presented below.

Biomass Calculations:

Biomass calculations utilized in the modeling are described in detail in the PDD. The PDD lists all of the species specific volume and biomass equations utilized which are in compliance with the Forest Project Protocol.

Adjusting the Inventory Data to 6/13/2007 and 12/31/2014:

The PDD and Inventory Methodology describe the method by which a stratified inventory was constructed for the purpose of identifying timber strata. The cruise data generated by the 2015 inventory has been used to represent the Project's carbon stocks as of 12/31/2014. The database was compiled and grown forward five years to 12/31/2019. The differences in DBHs and heights between 12/31/2019 and 12/31/2014 were then divided by five and multiplied by 7.5, resulting in a seven and a half year growth increment for each tree. These seven and a half year growth increments in DBH and height were subtracted from each tree in the 12/31/2014 database. TPA of trees with a DBH less than 1" or heights less than 4 feet after the increment adjustment were adjusted to zero, resulting in a database representing the start date of the project, or approximately June 13, 2007. For the purposes of calculating additionality for vintages 2007 through 2015, the reporting period will be considered to be seven and a half years in length.

Harvesting has occurred in three years since the Project was initiated, 2012, 2013, and 2014. In order to estimate the carbon stocks as of the project start date, in addition to adjusting the inventory data backwards seven and a half years, the harvests conducted in 2012 through 2014 must be accounted for. The process of accounting for those harvests and making appropriate adjustments is described in Exhibit A.

Missing Volume:

The inventory data upon which the baseline growth and yield analysis is based gathered data on missing volume from trees with broken tops, or from trees that included defects that reduced the tree's net carbon value. FORSEE outputs all growth and yield results in terms of gross volume or biomass. The carbon stock values presented in the PDD as of the project commencement date, and the end of the initial reporting period are net of the missing volume recorded in the inventory data. In order to represent this missing volume in the baseline analysis, the average percentage of missing standing live carbon stocks as of the Project start date are used to reduce the baseline growth and yield output from FORSEE.

Ingrowth:

Ingrowth in FORSEE is handled through the sprouting of species such as tanoak, madrone, black oak and white oak, and the addition of regeneration to bring the stand up to a minimum Forest Practice point count. The sprouting function in FORSEE (FSE.fsprout) was set to sprout 20% of sprouting species, as well as bringing the point count to specific point count levels per acre using the FORSEE point count regeneration function (FSE.fRegen_PtCount). Redwood was not included in sprouting species because the FORSEE point count regeneration function was used to moderate ingrowth.

Site Index:

Douglas-fir and/or redwood site trees are sampled as a part of the Usal Redwood Forest Operational Inventory each inventory for stands at least 30 years old. Douglas-fir is often preferred in mixed stands because of the sureness of counting rings. From the sample, site index is computed for Douglas-fir and redwood following the guidance set forth in "Wensel, L. and Krumland, B. 1986. A Site Index System for Redwood and Douglas-fir in California's North Coast Forest, Hilgardia Vol 54 Number 8, November 1986."

The stand data maintained within the GIS with the exception of the "recent clearcut" stands are assigned a 50-year Douglas-fir site index (DFSI). To calculate the DFSI for each stratum, each stand was weighted by the ratio of its net acreage to the total net acreage of the strata. These stand weights were multiplied by the stands' average DFSIs, then summed to calculate the weighted average Douglas-fir site indices for each stratum. Stands without DFSI values were assigned the average DFSI for the stratum in which they are located. A table of strata and DFSI was constructed as an input to FORSEE and is included as Table 3a below.

Table 3a: Average Douglas-fir Site Index by Stand

Stratum	DFSI
Conifer Low	106
Conifer Medium Low	108
Conifer Medium High	114
Conifer High	116
Hardwood Low	104
Hardwood Medium Low	103
Hardwood Medium High	102
Hardwood High	101

FORSEE adapts missing site tree estimators from the CRYPTOS/CACTOS research notes and the recent site publication of Krumland and Eng (2005- CDF California Forestry Report No. 4) Missing site index estimation uses the qualifying 'control' species, in this case Douglas-fir, with the most site index sample observations as the independent variable in either ratio or simple linear regression estimators.

For the purpose of modeling silvicultural prescriptions as part of the baseline analysis, the entire Project Area is treated as site class III as defined in the California Forest Practice Rules.

Project Acreage:

The Usal Redwood Forest Improved Forest Management Project is comprised of 47,981.54 acres of timberland. The topographic map included in Attachment A of the PDD shows the Project Area boundary. Attachment E also includes GIS data in the form of a geodatabase that includes the Project Area boundary.

Baseline Modeling:

The baseline modeling utilizes the above-described June 13, 2007 dataset, and an unevenaged management harvesting strategy employing selection, transition, commercial thinning, and rehabilitation of understocked stands combined with small group openings not exceeding 2.5 acres in size. Portions of the Usal Redwood Forest timber stands are dominated by hardwoods species, or are in an understocked condition. The baseline modeling assumes an aggressive treatment of hardwood species in order to release existing conifer regeneration, and convert areas dominated by hardwoods to conifer occupation. This reduction is accomplished through rehabilitation and hardwood release treatments.

At the Project's initiation on 6/13/2007 there were two approved Timber Harvest Plans (THPs) on the Project Area, 1-04-135MEN, and 1-06-058MEN. Commercial harvesting under these THPs was completed prior to the Project's initiation date by the previous landowner.

- THP 1-04-135MEN had a final completion filed on October 4, 2006. This final completion was rescinded following a completion inspection where some map point work was found to be inadequate. The map point work was completed in 2007 and the final completion re-submitted with the 2007 date. No harvesting occurred in 2007.
- THP 1-06-058MEN had all timber harvesting completed in 2006 as well. There was a partial completion filed in December 2006 which indicated that the only work remaining to do was the treatment of hardwoods to meet stocking requirements in the THP. The treatment of hardwoods was done in 2007 and no harvesting of timber occurred.

Baseline Harvest Strategy:

The baseline harvest strategy relies on the application of a series of harvest regimes across the Project Area timber stands. The regimes are modeled at the plot level and the growth and yield data is converted to stand level data. This group-selection harvest strategy allows for the harvest in small groups of a portion of the property located outside of WLPZs and no-harvest reserve areas within an 80-year period. Table 3b below describes the harvest regimes applied across the Usal Redwood Forest timber stands. The final baseline growth and yield analysis is determined by applying a percentage of each regime to each timber stand type.

The silvicultural prescriptions incorporated into the regimes are designed to best accommodate local timber stand conditions, while complying with the Forest Practice Rules as well as all other legal requirements. To accomplish

this, a harvest strategy has been developed that evaluates each plot's stocking status in square feet of basal area per acre and point count stocking. Tables 4a-4c below illustrate the silviculture decision matrix upon which the growth and yield modeling is based. Harvesting under selection and transition, utilizes a BDq harvest strategy.

The "Bdq" formula is commonly used to describe the stand structure of uneven-aged forest stands and has been described extensively in the scientific literature. BDq refers to the stand structure with, in order of relative importance: B, the residual basal area; D, the maximum retained diameter class; and q, the ratio of the number of trees in adjacent (one inch) diameter classes.

Table 3b: Harvest Regime Descriptions

Regime	Harvest Scenario Description
R1	This regime applies the silvicultural parameters outlined in tables 4a and 4b below. Simulates group selection by assigning plots to be group-selected in a given decade.
R9	No-harvest prescription applied to NSO activity centers, and NSO core areas.
R10	WLPZ harvest / NSO Nesting/Roosting prescription. Performs selection harvest every decade while retaining a minimum of 150 square feet of conifer and hardwood basal area per acre, and 60% canopy.
R2	NSO Low Quality Foraging Habitat prescription. Performs selection harvest every decade while retaining a minimum of 85 square feet of conifer and hardwood basal area per acre, and 40%-100% canopy.

General Harvest Constraints:

Harvest on the Usal Redwood Forest is constrained by several factors. Firstly, the California Forest Practice Rules (FPR) create a minimum set of silvicultural standards below which harvest cannot occur.

Legal requirements include all laws, regulations, and legally-binding commitments applicable to the Project Area at the time of the project's initiation that could affect standing live carbon stocks. The Usal Forest is subject to the Z'berg- Nejedly Forest Practice Act of 1973 (FPA) and the corresponding Forest Practice Rules (FPR). As the Project was initiated in

2007, the Forest Practice Rules in place in 2007 are applicable to the baseline analysis.

The rules that specifically effect the determination of baseline are those that include limits to silviculture activities. This includes the requirements for minimum basal area retention, rotation ages, harvest adjacency restrictions, watercourse buffer widths and sustained yield requirements.

The pertinent rules include the following:

- 14 CCR 913.11(c): Maximum Sustained Production of High Quality Timber Products;
- 14 CCR 913.2: Minimum basal area retention standards for Unevenaged Regeneration Methods;
- 14 CCR 913.2 (a)(2)(B): Group selection harvest limitations;
- 14 CCR 913.2 (b)(6): Minimum post-harvest residual basal area retention standards for the Transition method;
- 14 CCR 913.3 (a): Commercial thinning;
- 14 CCR 913.4 (b): standards for rehabilitation of Understocked Areas;
- 14 CCR 913.1 (c): standards for Seed Tree Seed Step;
- 14 CCR 916.5 Procedure for Determining Watercourse and Lake Protection Zone (WLPZ) Widths and Protective Measures;
- 14 CCR 919.9: Northern Spotted Owl
- 14 CCR 912.7(b): Resource Conservation Standards for Minimum Stocking

The methods by which the Forest Practice Rule constraints listed above as well as other legally binding constraints are incorporated into the baseline harvest scenario are described in the following sections.

Constraints Analysis:

Characterization:

Timber harvesting was modeled over 100 years for the baseline scenario, taking legal constraints, financial feasibility, and physical limitations into consideration while maintaining average live above-ground carbon stocks above the minimum baseline level. Forest stand development was projected using a combination of uneven-aged systems to create multi-aged conditions depending on the arrangement of treatment types over space and time. Forest stands were subject to treatment types based primarily on their forest structure and site attributes as it relates to the California Forest Practice Rules, e.g. Timber Site III vs. Timber Site IV or designated northern spotted owl (NSO) habitat vs. non-designated NSO habitat.

Baseline Legal Constraints:

Constraints that affect land-use specific to forest management activities have been incorporated into the carbon modeling. For this project, legal constraints have the greatest effect on timber harvesting levels, as opposed to what is financially feasible or physically possible. These legal constraints dictate what types of silvicultural activities (treatment types) are allowed, and where (spatial) and when (temporal) they are allowed, that is, there are different legal constraints for different locations of the project area. There are three general constraint types that determine what treatments are operable for any given area: 1) Timber Site; 2) NSO designated habitat; and 3) Water and Lake Protection Zones. Each constraint, and how it is applied in the modeling, is described below by constraint class.

Northern Spotted Owl:

Twenty-three NSO activity centers are located with 0.7 miles of the Usal Redwood Forest Project Area. Activity center locations are taken from GIS data provided by Campbell Global in comparison to activity center locations stored in the CNDDB system. If is felt that the activity center locations maintained by Campbell Global are more accurate than those within the CNDDB system.

Harvest activity is restricted using the following parameters taken from guidance from the US Fish and Wildlife Service "Northern Spotted Owl Take Avoidance Analysis and Guidance For California Coast Forest District" ("Attachment A"), March 15, 2011.

<u>These restrictions are summarized as follows:</u>

Within the 0.7 mile radius (985 acres) of each Activity Center:

1) Retain habitat to maximize attributes desirable for NSO.

2) Retain at least 500 acres of suitable (Nesting /Roosting/Foraging) NSO habitat, post-harvest, as follows:

    a) Retain 200 acres of Nesting/Roosting habitat within a 0.7 mile radius of the Activity Center consisting of:
        i) 100 acres of the 200 acres of Nesting /Roosting habitat retained should be contiguous, or contiguous as possible with the Activity Center.

ii) An Additional 100 acres of Nesting/Roosting habitat within the 0.7 mile radius:
    1) If the second 100 acres of Nesting/Roosting habitat is also contiguous with the Activity Center, or within the same drainage, operations should retain a minimum of 66% of the pre-harvest basal area per acre of trees at least 11" DBH.
    2) If the remaining 100 acres of Nesting/Roosting habitat is not contiguous with the Activity Center, retain at least Nesting/Roosting habitat.

b) Retain at least 300 acres of Suitable NSO habitat, post-harvest, of at least Foraging quality.

3) Remove no more than 1/3 of the remaining suitable habitat in excess of 500 acres within 0.7 miles of an Activity Center during the life of timber operations.

NSO Habitat Definitions:

Activity Center (AC): Area of concentrated activity of either a pair of NSO or a single territorial NSO, represented by a mapped location (e.g., usually a nest tree) that occurs within, but not necessarily in the exact center of, the "Core Area," defined below.

Core Area: 100 acres of the 200 acres of Nesting/Roosting habitat retained within a 0.7 mile radius contiguous with the Activity Center. If 100 acres of contiguous Nesting/Roosting is not available, then the highest quality habitat available shall be included.

Foraging Habitat: Habitat that contains ≥40% canopy cover of trees that are ≥ 11" DBH (diameter at breast height), and have a basal area ≥75 square feet per acre of trees ≥ 11" DBH. Trees may be conifer or hardwood.

Nesting/Roosting Habitat: Forested habitat that supports successful nesting and associated roosting behavior by NSO. Habitat with ≥60% canopy cover of trees that are ≥ 11" DBH, and have a basal area ≥ 100 square feet per acre of trees ≥ 11" DBH. Trees may be conifer or hardwood.

Regimes R2, and R10 have been designed to retain the required basal area and tree sizes as described in tables 4a-4c below for each respective NSO habitat type description. A GIS buffer analysis around the NSO activity

centers was conducted to ensure that the required acreage of each type of NSO habitat was retained in the required quantity.

Within 1000 feet of each AC, no harvest was modeled and stratum acreage within this 1000' buffer distance are assigned to the R9 regime. Within a 0.7 mile radius of the AC, acreage was assigned to either the R2 or R10 regime while considering historical NSO habitat classification data provided by Campbell Global. Areas classified as the R10 regime were selected from stands in proximity to the 1000' AC buffer that were also attributed as Nest/Roost habitat in the NSO habitat GIS layer. Areas selected as the R2 regime were primarily attributed as foraging habitat in the NSO habitat GIS layer. Stands classified as WLPZ buffer within the 0.7 mile buffer were not included in the assignment of R2/R10 regimes, but were spatially considered in the selection of stands to be harvested under either the R2 or R10 regime. In general, areas designated as WLPZ were adjacent to stands selected as the R2 or R10 regime.

Stand acres assigned to the R10 regime within the 0.7 mile AC buffer are treated as no harvest as a part of the final NSO harvest constraint analysis. This is felt to be conservative given the fact that some level of harvest is allowed within stands designated as NSO Nest/Roost habitat as long as sufficient acreage is retained.

Application of the above listed harvest restrictions associated with NSO activity centers resulted in the application of certain amounts of each timber strata being assigned to regimes R9, R10, and R2. Table 3c below includes a summary of acres by strata included in each of the above listed regimes.

Harvesting WLPZ Areas:

Utilizing the Usal Redwood Forest GIS the acreage associated with class I and II WLPZs was determined primarily from existing stands identified adjacent to class I and II watercourses. The buffering used to delineate these stands was based on a 150' buffer or larger for class I watercourses, and either a 100' or 75' buffer for class II watercourses. These buffer distances are consistent with Table I from 14 CCR 916.5 and 916.9 of the Forest Practice Rules. The resulting buffering analysis resulted in 5,704.67 acres located within class I or class II WLPZs. This represents approximately 11.9% of the net timbered acreage of the Project Area. These WLPZ acres are harvested using the R10 selection silvicultural prescription. Harvest levels within the WLPZ are designed to meet FPR standards for shade canopy retention. FPR requirements for the retention of the largest trees, and restrictions on harvests within the channel zone are addressed by adhering to 14 CCR 916.9 of the Forest Practice Rules.

Adjustment to Baseline due to Title Restriction:

An approximate 195.5 acre portion of the property described as "Township 23 North, Range 17 West, Section 36, SW ¼; NW ¼ SE ¼," is subject to a title restriction that limits access to the described area. To account for this restriction, acreages on the Project Area within the constrained area were summarized by strata and amount to 190.1 acres. This 190.1 acre portion of the Project Area is subject to the "no-harvest" prescription in the baseline analysis.

Table 3c: Acres by Regime following NSO, and WLPZ Buffer Analysis

Stand	Acres	R9	R10	R2	Constrained Acres
Conifer High	1618.90	414.33	541.53	120.51	1076.37
Conifer Medium High	8686.23	912.78	2314.86	601.19	3828.82
Conifer Medium Low	12860.67	862.50	1790.24	785.53	3438.28
Conifer Low	4257.68	33.44	182.39	185.65	401.48
Hardwood High	2151.85	404.38	35.20	245.67	685.25
Hardwood Medium High	7560.21	742.60	183.23	822.47	1748.30
Hardwood Medium Low	8454.17	769.07	362.97	584.23	1716.28
Hardwood Low	2391.83	82.11	100.69	61.19	243.98
Total	**47981.54**	**4221.21**	**5511.11**	**3406.45**	**13138.77**

Table 3d: Procedures for Determining Watercourse and Lake Protection Zone Widths and Protective Measures[1]								
Pursuant to 14 CCR 916.5								
Water Class Characteristics or Key Indicator Beneficial Use	1) Domestic supplies, including springs, on site and/or within 100 feet downstream of the operations area and/or 2) Fish always or seasonally present onsite, includes habitat to sustain fish migration and spawning.		1) Fish always or seasonally present offsite within 1000 feet downstream and/or 2) Aquatic habitat for nonfish aquatic species. 3) Excludes Class III waters that are tributary to Class I waters.		No aquatic life present, watercourse showing evidence of being capable of sediment transport to Class I and II waters under normal high water flow conditions after completion of timber operations.		Man-made watercourses, usually downstream, established domestic, agricultural, hydroelectric supply or other beneficial use.	
Water Class	Class I		Class II		Class III		Class IV	
Slope Class (%)	Width Feet	Protection Measure	Width Feet	Protection Measure	Width Feet [see 916.4(c)] [see 936.4(c)] [see 956.4(c)]	Protection Measure	Width Feet [see 916.4(c)] [see 936.4(c)] [see 956.4(c)]	Protection Measure
<30	75	BDG	50	BEI	See CFH		See CFI	
30-50	100	BDG	75	BEI	See CFH		See CFI	
>50	150[2]	ADG	100[3]	BEI	See CFH		See CFI	

1 - See Section 916.5(e) for letter designations application to this table.
2 – Subtract 50 feet width for cable yarding operations.
3 – Subtract 25 feet width for cable yarding operations.

Unevenaged Silviculture:

All forest stands in the project area are subject to retention standards for uneven-aged silviculture based on their "Timber Site" or site class. Forest stands in the project area of this constraint class must follow these terms at a minimum:

All forest stands where uneven-aged silviculture is applied shall maintain the minimum basal area retention thresholds of 125 square feet per acre for Site I stands and 75 square feet per acre for Site II and III stands and 50 square feet per acre for Site IV and V stands for selection silviculture, and 50 square feet per acre for transition silviculture for Site II and III stands.

Selection:

14 CCR 913.2: Minimum basal area retention standards for Unevenaged Regeneration Methods:

Unevenaged management is utilized to establish and maintain an unevenaged stand structure. Unevenaged management attributes include the establishment and/or maintenance of a multi-aged,

balanced stand structure, promotion of growth on leave trees throughout a broad range of diameter classes, and encouragement of natural reproduction.

a) Selection Under the selection regeneration method, the trees are removed individually or in small groups sized from .25 acres to 2.5 acres.

1) Trees to be harvested or trees to be retained shall be marked by or under the supervision of the RPF prior to felling operations. When openings greater than .25 acres will be created, the boundaries of the small group(s) may be designated in lieu of marking individual trees within the small group areas. A sample area must be marked prior to a preharvest inspection for evaluation. The sample area shall include at least 10% of the harvest area up to a maximum of 20 acres per stand type which is representative of the range of conditions present in the area.

2) Post harvest stand stocking levels shall be stated in the THP. The level of residual stocking shall be consistent with maximum sustained production of high quality timber products. In no case shall stocking be reduced below the following standards:

A. Selection System.

1. On Site I lands at least 125 square feet per acre of basal area shall be retained.

2. On Site II and III lands at least 75 square feet per acre of basal area shall be retained.

3. On Site IV and V lands at least 50 square feet per acre of basal area shall be retained.

4. Unless the plan submitter demonstrates how the proposed harvest will achieve MSP pursuant to 14 CCR § 913.11 (a) or (b), the residual stand shall contain sufficient trees to meet at least the basal area, size, and phenotypic quality of tree requirement specified under the seed tree method.

B. Group Selection.

1. At least 80% of the stocked plots must meet the Basal Area stocking standards of 14 CCR 913.2(a)(2)(A).

2. Not more than 20% of the stocked plots may meet stocking standards utilizing the 300

point count standard with trees that are at least 10 (ten) years old.

3. An RPF or supervised designee may offset up to 8 plots per 40 plots where those plot centers are initially placed within small group clearings created during the current harvest. Unless substantially damaged by fire, the RPF or supervised designee shall not exclude small group clearings created by previous timber harvesting from the stocking survey.
4. Unless the plan submitter demonstrates how the proposed harvest will achieve MSP pursuant to 14 CCR 913.11 (a) or (b), the residual stand shall contain sufficient trees to meet at least the basal area, size, and phenotypic quality of tree requirements specified under the seed tree method.

3) Within any THP, small group clearings under the selection method shall be separated by a logical logging area.

4) Following completion of timber operations (including site preparation) not more than 20 percent of the THP area harvested by this method shall be covered by small group clearings.

Transition:

14 CCR 913.2: Minimum basal area retention standards for Unevenaged Regeneration Methods:

b) Transition. The transition method may be used to develop an unevenaged stand from a stand that currently has an unbalanced irregular or evenaged structure. The transition method involves the removal of trees individually or in small groups from irregular or evenaged stands to create a balanced stand structure and to obtain natural reproduction.

1) Area for determination of preharvest seed tree retention levels shall be no greater than 20 acres in size.

2) This method is to be used to increase stocking and improve the balance of age classes so as to allow the residual stand to be managed by the selection regeneration method. This method shall not be used more than two times for a stand. The RPF shall

delineate areas previously treated by the transition method on the plan map.

3) Stands suitable for the transition method contain adequate quantity and quality of seed producing trees to provide adequate regeneration for new age classes. Stands suitable for this method shall have no more than 50 sq. ft. of basal area greater than the selection basal area standards.

4) Trees to be harvested or trees to be retained shall be marked by or under the supervision of a RPF before felling operations. A sample area must be marked before the preharvest inspection for evaluation. The sample area shall include at least 10% of the harvest area up to a maximum of 20 acres per stand type which is representative of the range of conditions present.

5) Immediately following the completion of timber operations, the minimum basal area standards in 14 CCR 932.7(b)(2) shall be met.

6) The post harvested residual stand shall contain at least 15 square feet of basal area per acre of seed trees at least 12 inches dbh or greater for timber sites I, II or III; or 12 square feet of basal area per acre of seed trees 12 inches dbh or greater for timber sites IV or V. Unless obviously stocked, these basal area requirements will be determined from sampling averaged across each harvested area required in 14 CCR § 933.2(b)(1). Unless the plan submitter demonstrates how the proposed harvest will achieve MSP pursuant to 14 CCR § 933.11(a) or (b) [953.11(a) or (b)], where present in the preharvest stand, disease free, undamaged seed trees 18 inches dbh or greater shall be retained post harvest until the stand exceeds the minimum seed tree requirements of 14 CCR § 933.1(c)(1)(A). The seed trees shall be full crown, capable of seed production and representative of the best phenotypes available in the present stand.

7) Following completion of timber operations (including site preparation) not more than 20 percent of the Plan area harvested by this method shall be occupied by small group clearings.

14 CCR 912.7: Resource Conservation Standards for Minimum Stocking:

The following resource conservation standards constitute minimum acceptable stocking in the Coast Forest District after timber operations have been completed.

b) An area on which timber operations have taken place shall be classified as acceptably stocked if either of the standards set forth in (1) or (2) below are met within five (5) years after completion of timber operations unless otherwise specified in the rules.

2) The average residual basal area measured in stems 1 inch or larger in diameter, is at least 85 square ft. per acre on Site I lands, and 50 square ft. per acre on lands of Site II classification or lower. Site classification shall be determined by the RPF who prepared the plan.

Commercial Thinning:

14 CCR 913.3: Intermediate Treatments:

a) Commercial thinning. Commercial thinning is the removal of trees in a young-growth stand to maintain or increase average stand diameter of the residual crop trees, promote timber growth, and/or improve forest health. The residual stand shall consist primarily of healthy and vigorous dominant and codominant trees from the preharvest stand.

1) Post harvest stand stocking levels shall be stated in the THP. The level of residual stocking shall be consistent with maximum sustained production of high quality timber products. Generally stands will develop stand structures with considerably higher levels of basal area than provided in these minimum standards as stand age increases. In no case shall stocking be reduced below the following standards:

A. Where the preharvest dominant and codominant crown canopy is occupied primarily by trees greater than 14 in. DBH:

1. On Site I lands, at least 125 sq. ft. per acre of basal area shall be left.

2. On Site II and III lands, at least 100 sq. ft. per acre of basal area shall be left.

3. On Site IV lands, at least 75 sq. ft. per acre of basal area shall be left.
4. On Site V lands, at least 50 sq. ft. per acre of basal area shall be left.

B. Where the preharvest dominant and codominant crown canopy is occupied primarily by trees less than 14 in. DBH, a minimum of 100 trees per acre over 4 in. DBH shall be retained for site I, II and III. For site IV and V - 75 trees per acre over 4 in. dbh shall be retained.

Rehabilitation of Understocked Areas:

14 CCR 913.3: Special Prescriptions:

The following special harvesting methods are appropriate under certain conditions:.

b) Rehabilitation of Understocked Area Prescription. For the purposes of restoring and enhancing the productivity of commercial timberlands which do not meet the stocking standards defined in 14 CCR 912.7 prior to any timber operations on such lands, an area may be harvested provided it is restocked in accordance with Subsections (l) or (2). To facilitate restocking, a regeneration plan must be included in the THP. The regeneration plan shall include site preparation, method of regeneration, and other information appropriate to evaluate the plan.

1) If the area meets the standards of 14 CCR 912.7 within five years of completion of timber operations, the area shall be considered acceptably stocked, or shall be considered acceptably stocked if it contains at least 10 planted countable trees for each tree harvested on sites I, II, and III, and 5 planted countable trees for each tree harvested on site IV and V.

2) On understocked timberlands where no countable conifer trees are to be harvested and the broadleaf species are not designated for management, the area shall be planted to equal or exceed the stocking standards of 14 CCR 912.7(b)(1) [932.7(b)(1), 952.7(b)(1)] and shall be considered acceptably stocked if within five years of completion of timber

operations it contains at least an average point count of 150 of Group A species on all site classifications.

This overall constraint is emulated in the baseline by setting a minimum basal area target for uneven-aged stands when they are treated. Approximately 6% of the Project Area is harvested as small groups each decade of the 100-year baseline analysis period during the second period on.

MSP:

All forest stands and baseline activities in the project area are subject to the Maximum Sustained Production (MSP) of High Quality Timber Products section of the California Forest Practice Rules. It is assumed in the baseline model that MSP is achieved pursuant to 14 CCR 913.11(c)(2) and (3), paraphrased below:

2) For uneven-aged management, complying with the seed tree retention standards, meeting minimum stocking and basal area standards for the selected silvicultural methods as contained in the Forest Practice Rules only with group A species, and protecting the soil, air, fish and wildlife, water resources and other public trust resources through the application of these rules.

3) For intermediate treatments and special prescriptions, complying with the stocking requirements of the individual treatment or prescription.

This overall constraint is emulated in the baseline by requiring that selection and transition harvests retain at least 15 square feet of conifer basal area in trees 18" DBH or larger, and that rehabilitation and commercial thinning harvests meet the minimum stocking standards of the Forest Practice Rules.

Hardwood Harvest:

The Usal Redwood Forest's hardwood reduction program calls for the manipulation of hardwood stocking levels through, manual or mechanical treatments or commercial harvest, or basal herbicide treatments as appropriate. Understocked portions of the Project Area were modeled as a rehabilitation harvest per 14 CCR 913.4(b).

Baseline Harvest Summary:

Treatment types, or silviculture systems, were applied to forest stands in the baseline model such that they followed the silvicultural method objectives in Article 3 of the Forest Practice Rules and as additionally described in this section. Specifically, these treatments included selection, transition, commercial thinning, and rehabilitation of understocked stands. Treatments were selected and scheduled in the baseline based on legal constraint(s) and stocking.

The arrangement of these treatments over time and space create timber product value in both yields and appreciation and provide NSO habitat that is in line with the baseline scenario characterization and legal constraints. The application of the silvicultural regimes described below at the landscape level, yield an acceptable return on investment for the forest owner while maintaining compliance with the California Forest Practice Rules and NSO Take Avoidance protection measures. Overall, the baseline regime reflects maximum sustained productivity and a harvest and growth pattern that indefinitely serves multiple management objectives.

Standing Dead:

The standing dead carbon pool represents approximately 1.72% of the total carbon found on the Project Area, and is above the one metric ton test in the structural elements evaluation criteria under section 3.8.2 (Table 3.2) of the protocol. The standing dead carbon pool is treated as a static pool. As the baseline analysis involves ongoing forest management and maintenance of young and vigorous stands, standing dead levels are expected to be maintained at the estimated level. It could be argued that the baseline harvesting scenario would remove poorly formed and suppressed trees, thus capturing mortality that would have otherwise occurred under a harvest scenario that removed fewer trees and less volume over time.

Silvicultural Prescriptions

The following tables show the silvicultural constraints designed to demonstrate conformance with the requirements of the Forest Practice Rules.

Table 4a: Silvicultural Prescriptions used by the Usal Redwood Forest

Regime	Prescription	Description
R1	Selection	The goal of this prescription is to create and maintain, multistoried, uneven-aged stands with varied diameter classes. Trees are harvested individually, or in small groups up to 2.5 acres in size.
	Transition	The goal of this prescription is to develop uneven-aged stands from stands that have an even-aged or irregular stand structure. Trees are harvested individually, or in small groups up to 2.5 acres in size.
	Rehabilitation	The goal of this prescription is to regenerate stands that are primarily experiencing excessive hardwood competition, and that also do not meet minimum stocking standards. Successive harvests will utilize uneven-aged silviculture.
	Commercial Thinning	To promote timber growth and improve forest health through the harvest of trees in a manner that results in a stand capable of being managed using single tree or group selection.
R9	No Harvest	This prescription is used to account for those portions of the Project Area where harvesting is prohibited.
R10	Single Tree Selection (WLPZ/NSO Nest Roost Habitat)	The goal of this prescription is to create and maintain dense, multistoried, uneven-aged stands with varied diameter classes while meeting the retention standards for NSO Nesting/Roosting Habitat.
R2	Single Tree Selection (NSO Foraging Habitat)	The goal of this prescription is to create and maintain dense, multistoried, uneven-aged stands with varied diameter classes while meeting the retention standards for NSO Foraging Habitat.

Table 4b: Pre-harvest Stand Conditions by Silvicultural Prescription

Regime	Prescription	Pre-Harvest Conifer Basal Area (Square Feet per Acre)		Other Pre-Harvest Considerations
		Lower Limit	Upper Limit	
R1	Selection	125	None	Retain at least 15 square feet of basal area in trees 18" or larger.
	Transition	75	125	Retain at least 15 square feet of basal area in trees 18" or larger.
	Rehabilitation	0	50	Less than 300 point count, at least 100 square feet of hardwood basal area.
	Commercial Thinning	100	None	Greater than 100 square feet if basal area or greater than 75 trees per acre in trees 4" or larger.
R9	No Harvest	None	None	
R10	Single Tree Selection (WLPZ/NSO Nest Roost Habitat)	None	None	>11" QMD
R2	Single Tree Selection (NSO Foraging Habitat)	None	None	> 11" QMD

Table 4c: Post-harvest Stocking by Silvicultural Prescription

Regime	Prescription	Stocking Considerations	Conifer Basal Area Retention (sq. ft. per acre)	Hardwood Basal Area Retention (sq. ft. per acre)	Regeneration Assumptions	Time to Next Treatment
R1	Selection	Less than 20% of stand in group openings, at least 15 sq. ft. >18" DBH	≥80 1st period increasing 5 sq. ft. per decade to 100 in 5th period	10	300 Point Count, Sprout 20%	At Least 10 Years
	Transition	Less than 20% of stand in group openings, at least 15 sq. ft. >18" DBH	≥65 1st period, 75 2nd period	10	300 Point Count, Sprout 20%	Selection within 10-20 Years
	Rehabilitation		≥15where conifer≥15 pre-harvest	10	300 Point Count, Sprout 20%	Selection within 30-40 Years
	Commercial Thinning	Equal to or Greater average stand diameter than pre-harvest stand	>100 if QMD >14" and 100 4"+ trees if QMD <14"	10	300 Point Count, Sprout 20%	Selection within 10-20 Years
R9	No Harvest	None	None		None	
R10	Single Tree Selection (WLPZ/NSO Nest Roost Habitat)	>11" QMD	130	20	300 Point Count, Sprout 20% Hardwoods	At Least 10 Years
R2	Single Tree Selection (NSO Foraging Habitat)	> 11" QMD	75	10	300 Point Count, Sprout 20% Hardwoods	At Least 10 Years

Growth and Yield Analysis:

The baseline growth and yield analysis was modeled using the FORSEE model utilizing the above described harvest strategy. Table 5a shows the results of the growth and yield analysis in terms of conifer yields, while table 5b shows the results in terms of tonnes of live carbon for all species. Table 6 shows the results in terms of average basal area per acre over the 100 year planning horizon.

Table 5a: Average Annual per Acre Conifer Growth and Yield through the Planning Horizon (Scribner Board Feet per Acre)

Elapsed Time (years)	Beginning Inventory (board feet)	Average Decadal Growth (board feet)	Average Decadal Harvest (board feet)	Ending Inventory (board feet)
10	10,200	499	573	9,459
20	9,459	613	336	12,229
30	12,229	630	391	14,621
40	14,621	694	416	17,399
50	17,399	710	506	19,439
60	19,439	699	432	22,105
70	22,105	705	472	24,435
80	24,435	714	449	27,083
90	27,083	706	486	29,283
100	29,283	698	543	30,840

Table 5b: Average Annual per Acre Total Live Carbon Growth and Yield through the Planning Horizon (Mg C per Acre)

Elapsed Time (year)	Beginning Inventory (Mg Carbon)	Average Decadal Growth (Mg Carbon)	Average Decadal Harvest (Mg Carbon)	Ending Inventory (Mg Carbon)
10	67.06	1.89	4.03	45.63
20	54.45	1.87	1.95	53.65
30	53.76	1.71	1.13	59.55
40	59.56	1.67	1.47	61.54
50	60.99	1.56	1.33	63.27
60	62.67	1.48	1.10	66.48
70	66.39	1.46	1.11	69.87
80	69.56	1.39	1.07	72.74
90	72.39	1.34	1.06	75.14
100	75.00	1.31	1.11	77.09

Table 6: Average Basal Area per Acre through the Planning Horizon

Elapsed Time (years)	0	10	20	30	40	50	60	70	80	90	100
Conifer	101	91	91	98	105	106	110	115	118	121	124
Hardwood	96	35	27	32	24	24	24	24	24	24	24
Total	197	126	118	130	128	130	134	139	143	145	148

Table 7 presents the percentage of each silvicultural regime applied to the various timber stands for the entire baseline modeling analysis.

Table 7: Application of Silvicultural Regimes through the 100-year Planning Horizon

Regime					
Stand	**R1**	**R2**	**R9**	**R10**	**Total**
Conifer High	33.5%	7.4%	25.6%	33.5%	100%
Conifer Medium High	55.9%	6.9%	10.5%	26.6%	100%
Conifer Medium Low	73.3%	6.1%	6.7%	13.9%	100%
Conifer Low	90.6%	4.4%	0.8%	4.3%	100%
Hardwood High	68.2%	11.4%	18.8%	1.6%	100%
Hardwood Medium High	76.9%	10.9%	9.8%	2.4%	100%
Hardwood Medium Low	79.7%	6.9%	9.1%	4.3%	100%
Hardwood Low	89.8%	2.6%	3.4%	4.2%	100%

Baseline Carbon Stocks

The baseline modeling scenario defined in this document follows the guidelines presented in section 6.2 of the Compliance Offset Protocol U.S. Forest Projects, October 20, 2011.

Key components of the calculated baseline are as follows:

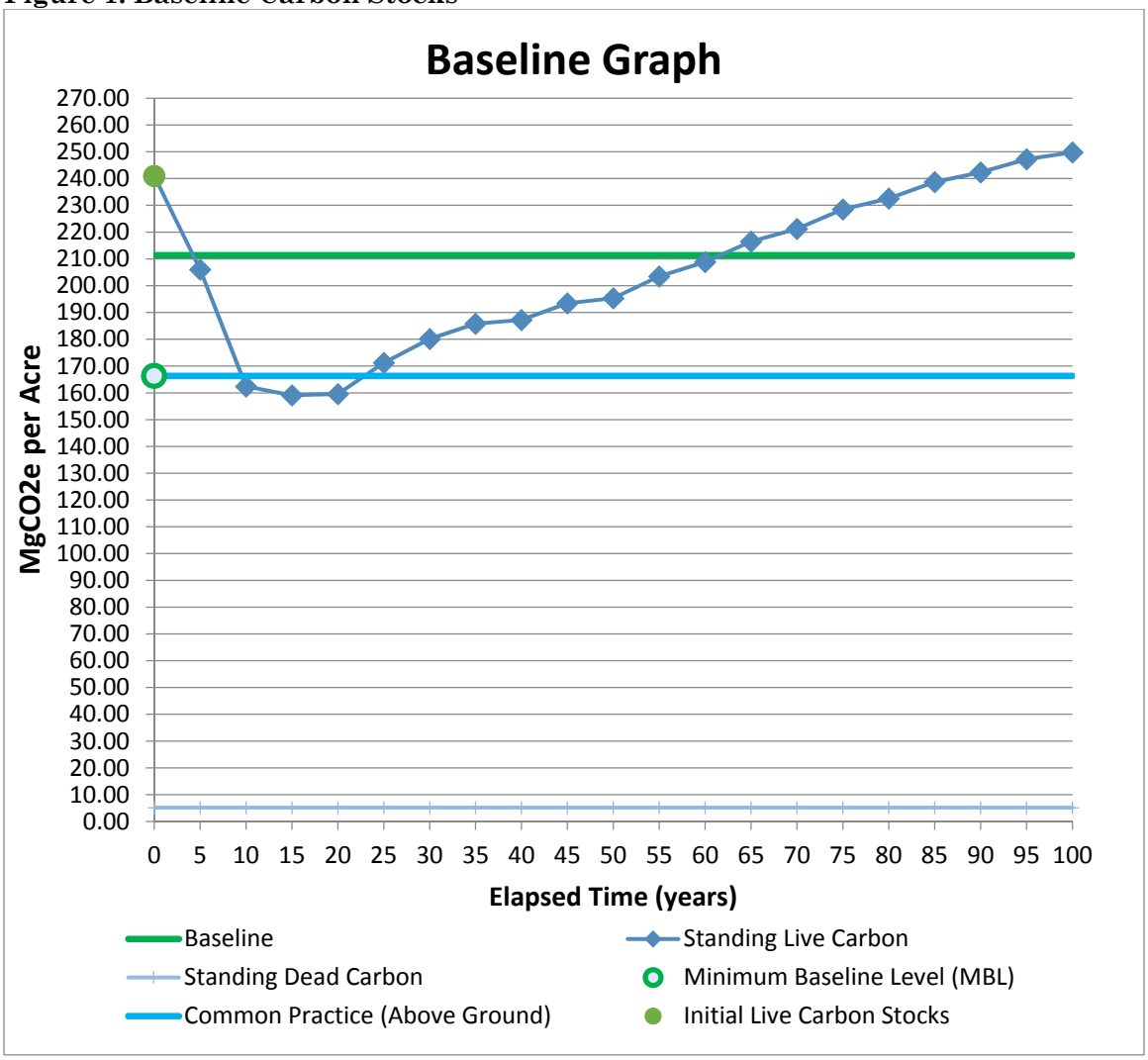
1. Initial Project live carbon stocks are above Common Practice.
2. The Project is not subject to the High Stocking Reference calculation.
3. Initial live carbon stocks have been modeled subject to all legal and financial constraints for a 100-year period.
4. The average carbon stocks of the 100-year baseline growth and yield modeling scenario have been calculated.
5. The average stocks of standing dead carbon over the 100-year period have been calculated.
6. The average production of In-Use carbon, landfill carbon, and harvested carbon prior to delivery to a mill have been calculated from the 100-year baseline growth and yield scenario.

Table 8 below shows the modeled standing live carbon stocks over the 100-year baseline analysis period, the projected standing dead carbon pool, and the resulting average baseline carbon stocks on a per acre basis. These figures are plotted in Figure 1 as well.

Table 8: Average Baseline Carbon Stocks per acre Generated by the Baseline Harvest Scenario (Mg CO2e per Acre).

Elapsed Time	Standing Live Carbon Pool IFM-1	Standing Live Above Ground	Standing Live Below Ground	Standing Dead Carbon Pool IFM-3	Baseline
0	240.98	194.89	46.08	5.14	211.34
5	206.05	166.33	39.72	5.14	211.34
10	162.38	130.31	32.08	5.14	211.34
15	159.10	127.78	31.33	5.14	211.34
20	159.56	127.91	31.66	5.14	211.34
25	171.18	137.45	33.73	5.14	211.34
30	180.15	144.81	35.34	5.14	211.34
35	185.78	149.54	36.24	5.14	211.34
40	187.20	150.75	36.45	5.14	211.34
45	193.43	155.98	37.45	5.14	211.34
50	195.30	157.61	37.70	5.14	211.34
55	203.49	164.36	39.13	5.14	211.34
60	208.84	168.75	40.09	5.14	211.34
65	216.51	175.07	41.44	5.14	211.34
70	221.21	178.95	42.26	5.14	211.34
75	228.49	184.99	43.50	5.14	211.34
80	232.54	188.36	44.18	5.14	211.34
85	238.72	193.50	45.22	5.14	211.34
90	242.34	196.52	45.82	5.14	211.34
95	247.23	200.60	46.63	5.14	211.34
100	249.76	202.72	47.04	5.14	211.34
Average	206.20	166.53	39.67	5.14	211.34

Figure 1: Baseline Carbon Stocks



Wood Products

The baseline growth and yield modeling produces a flow of wood products over the 100-year planning period. Table 9 below shows the average wood products generated over the 100-year period. Three average wood products numbers are presented: average wood products In-use, average wood products stored in landfills, and the average amount of carbon in standing live carbon stocks prior to delivery to a mill.

Table 9: Average Wood Products Carbon per acre Generated by the Baseline Harvest Scenario.

Woods Products	Mg C/ acre	Total Mg CO2e
Average Annual Carbon 100-year In-Use	0.142	25,033.71
Average Annual Carbon 100-year Landfill	0.092	16,173.42
Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill	0.987	173,815.28

Attachments

Exhibit A - Adjustment of Carbon Stocks from 12/31/2014 to the Project Start Date to Account for Harvest

Exhibit A

Adjustment of Carbon Stocks from 12/31/2014 to the Project Start Date to Account for Harvest

The current carbon stock inventory for the Usal Redwood Forest was conducted in early 2015. In order to estimate the carbon stocks as of the project start date, the inventory data must be adjusted backwards approximately seven and a half years, and the harvest conducted in 2012 through 2014 must be accounted for.

Harvesting has occurred in three years since the Project was initiated, 2012, 2013, and 2014. Table 1 presents the gross board foot harvest volumes for each year. These volumes are used in the Harvested Wood Products Calculation Worksheets included in the PDD.

Table 1: Gross Harvest Volumes by Year

Year	Harvest Volume MBF Scribner Short Log Scale
2012	1,230.97
2013	1,287.48
2014	2,810.72

Harvested carbon was calculated using the "Harvested Wood Products Worksheet" developed by the Climate Action Reserve. The total MgCO2e in harvested wood delivered to the mill each year calculated using the worksheet was then multiplied by the ratio of carbon in wood delivered to the mill to carbon in trees harvested for wood products (prior to delivery to the mill) derived from the baseline harvested wood products values. This ratio is approximately 2.16 for the Usal Redwood Forest Project, and is used to account for carbon harvested in hardwoods, and non-merchantable conifers that are not delivered to a mill.

Table 2 shows the calculated carbon associated with the three years of harvest adjusted to account for harvest not delivered to the mill.

Table 2: Harvested Carbon by Year

Year	2012	2013	2014	Total
Adjusted Harvested Carbon[1]	7,994	8,361	18,252	34,606
Harvest Carbon[2]	3,701	3,871	8,450	16,021

[1]Harvested Carbon times 2.16 Adjustment Factor

[2]Based on California Board of Equalization Records

Using GIS data that depicts the areas harvested since 2012, approximately 715 acres were harvested. In order to allocate the harvest by timber stratum, the harvested acreage was intersected with the timber strata layer. Table 3 below shows the acreage of harvest by stratum, and the assignment of harvested carbon by stratum.

Table 3: Assignment of Harvest by Stratum

Stratum	Acres	% of Acreage	Harvest Assignment ($MgCO_2E$)	Unadjusted Stratum Total ($MgCO_2E$)	Preharvest Stratum Total ($MgCO_2E$)	Harvest as % of Unadjusted Total
Conifer High	4.6	0.64%	221	536,442	536,663	0.04%
Conifer Low	74.2	10.38%	3,591	750,491	754,082	0.48%
Conifer Medium High	174.9	24.45%	8,461	2,556,618	2,565,079	0.33%
Conifer Medium Low	166.1	23.22%	8,036	2,796,708	2,804,744	0.29%
Hardwood Low	143.0	19.99%	6,917	370,223	377,140	1.87%
Hardwood Medium Low	152.6	21.33%	7,381	1,677,220	1,684,602	0.44%
Grand Total	**715.5**	**100.00%**	**34,606**	**8,687,703**	**8,722,309**	

The Harvest Assignment and Unadjusted Stratum Total $MgCO_2E$ were added together to estimate the Preharvest Stratum Total $MgCO_2E$, listed in Table 3. To adjust to inventory records to preharvest conditions, the TPAs of all tree records were adjusted uniformly within each strata by a percentage factor, starting with the "Harvest as % of Total" values listed in Table 3. Since effects of these TPA adjustments on $MgCO_2E$ vary depending on the diameter and height of individual tree records, an iterative process was used to determine the appropriate TPA adjustment factor for each stratum.

Table 4: Adjustments to TPA by Stratum

Stratum	Unadjusted Stratum Total ($MgCO_2E$)	Adjustment % to Start Database TPAs by Stratum	Resulting Adjusted Stratum Total ($MgCO_2E$)
Conifer High	536,442	0.0420910770120053%	536,663
Conifer Low	750,491	0.48960154695217%	754,082
Conifer Medium High	2,556,618	0.338395715355125%	2,565,079
Conifer Medium Low	2,796,708	0.293946621907818%	2,804,744
Hardwood Low	370,223	1.9129813450283%	377,140
Hardwood Medium Low	1,677,220	0.450321186255628%	1,684,602
Grand Total	**8,687,703**		**8,722,309**

ATTACHMENT D

Usal Redwood Forest Project

This analysis is provided per section 6.2.1.3 (1) of Version 3.2 of the Forest Project Protocol, and is designed to demonstrate that the baseline growth and harvest regime is financially feasible. This analysis is overly conservative given that the test is simply finalcial feasibility. If herbicide treatments, tree planting and logging costs were significantly increased, the analysis would still demonstrate that the baseline growth and harvest is finalcially feasible. Delivered log values are below trended values based on Board of Equalization values, yet still demonstrate financial feasibility.

Model Inputs:

Discount Rate	8.0%	
Inflation	0.0%	
Real price appreciation for delivered log values	0.0%	
Yield Tax	2.9%	MBF

Production Costs:

Item	**Cost per acre**	**Quantity[1]**	**Total Cost**	**Cost per MBF**
THP Preparation	$100	47,982	$ 4,798,154	$17.44
Logging Supervision				$15.00
Property Management				$25.00
Logging and Hauling (Derived from BOE Stumpage Values)				$0.00
Total				**$57.44**

Herbicide Treatment of Hardwoods:

Period	**Cost per acre**	**% of Acres Treated**	**Total Cost**	**Cost per MBF**
1	$ 230.00	65%	$7,173,240	$26.08
2	$ 230.00	33%	$3,641,799	$22.84
3	$ 230.00	20%	$2,207,151	$12.10
4	$ 230.00	20%	$2,207,151	$11.48
5	$ 230.00	20%	$2,207,151	$9.22
6	$ 230.00	20%	$2,207,151	$9.98
7	$ 230.00	20%	$2,207,151	$9.58
8	$ 230.00	20%	$2,207,151	$9.59
9	$ 230.00	20%	$2,207,151	$9.14
10	$ 230.00	20%	$2,207,151	$8.47

Tree Planting: ($1 per tree cost)

Period	**Cost per acre**	**% of Acres Treated**	**Total Cost**	**Cost per MBF**
1	$ 200.00	50%	$4,798,154	$17.44
2	$ 200.00	25%	$2,399,077	$15.05
3	$ 200.00	20%	$1,919,262	$10.53
4	$ 200.00	20%	$1,919,262	$9.98
5	$ 200.00	20%	$1,919,262	$8.02
6	$ 200.00	20%	$1,919,262	$8.68
7	$ 200.00	20%	$1,919,262	$8.33
8	$ 200.00	20%	$1,919,262	$8.34
9	$ 200.00	20%	$1,919,262	$7.95
10	$ 200.00	20%	$1,919,262	$7.36

CALCULATION OF PRESENT NET VALUE
USAL REDWOOD FOREST TIMBERLANDS

Assumptions: Harvest levels are based on Baseline Harvest Scenario
Logging sytem mix estimated as 30% tractor, 70% cable.
Production costs per MBF are estimates based upon logging system mix.
0% Real price appreciation applied to delivered log values.
All calculations in constant dollars without inflation.
Discount Rate 8.0% Real.

	Annual Harvest Volume				Stumpage Values per MBF				Production	Herbicide	Tree	Yield	Net	Total	Present
	RW	DF	OC	Totals	RW	DF	OC	Camprun	Costs	Treatment	Planting	Taxes	Value	Net	Net
Year	MBF	MBF	MBF	MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	Value	Value
2007	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	4,394,496
2008	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	4,068,978
2009	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	3,767,572
2010	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	3,488,493
2011	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	3,230,086
2012	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	2,990,820
2013	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	2,769,278
2014	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	2,564,146
2015	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	2,374,210
2016	16,670	10,766	54	27,490	400.00	100.00	50.00	281.82	57.45	26.09	17.45	8.17	172.65	4,746,056	2,198,342
2017	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	692,629
2018	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	641,323
2019	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	593,818
2020	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	549,831
2021	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	509,103
2022	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	471,392
2023	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	436,474
2024	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	404,143
2025	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	374,206
2026	5,432	10,643	50	16,125	400.00	100.00	50.00	200.90	57.45	22.59	14.88	5.83	100.15	1,614,962	346,487
2027	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	430,388
2028	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	398,508
2029	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	368,989
2030	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	341,656
2031	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	316,348
2032	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	292,915
2033	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	271,218
2034	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	251,127
2035	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	232,525
2036	6,307	12,417	44	18,768	400.00	100.00	50.00	200.70	57.45	11.76	10.23	5.82	115.43	2,166,504	215,301
2037	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	196,670
2038	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	182,102
2039	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	168,613
2040	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	156,123
2041	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	144,559
2042	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	133,851
2043	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	123,936
2044	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	114,755
2045	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	106,255
2046	6,064	13,732	152	19,948	400.00	100.00	50.00	190.82	57.45	11.06	9.62	5.53	107.15	2,137,350	98,384
2047	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	102,135
2048	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	94,569
2049	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	87,564
2050	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	81,078
2051	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	75,072
2052	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	69,511
2053	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	64,362
2054	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	59,595
2055	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	55,180
2056	6,346	17,886	50	24,283	400.00	100.00	50.00	178.30	57.45	9.09	7.90	5.17	98.69	2,396,337	51,093
2057-2106															530,007
														Total	42,680,222

ATTACHMENT E

FIA Volume Equation Documentation

Updated by FIA on 3-22-2010

The documentation was updated to correct some errors and clarify some of the calculations.

Changes are highlighted in yellow.

Changes to equation assignments were made to Cal. Black Oak, and Ponderosa pine.

Equation 24 (for Redwood) had the wrong formula for CV4.

The Basal Area formula was incorrect in the 'Where' section of equations 22,23,24.

Equations 3, 5, 16, 18, 19, 20, 23 were rewritten to help clarify the procedures. The outdated equations are provided for reference at the end of this document.

Hardwood boardfoot ratio equations were corrected/clarified.

Questions?

Call or email Karen Waddell at 503-808-2046 or kwaddell@fs.fed.us.

Volume estimation for the PNW-FIA Database
Jan 13, 2010

Cubic and board foot volumes (in Scribner and International 1/4" log rules) are calculated for softwood and hardwood trees measured on forest land. A variety of volumes are estimated including gross and net volume of the merchantable stem, gross and net volume of both the sawlog portion and the upper stem portion of the bole, gross total stem volume of the entire bole from ground to tip, current annual growth volume, and annual mortality volume. These volumes are calculated on different sized trees (in terms of diameter at breast height (DBH), depending on the specific type of volume.

All total stem volumes are calculated on all trees in the inventory that are larger than seedlings (>= 1" (2.5cm) DBH).

All other volumes (gross and net growing stock and sawtimber volumes) are calculated on the merchantable stem, originally for the purpose of providing timber information. This is the most common volume most users will see in published reports. Gross volume is generally the first output from volume equations and has not been adjusted for the presence of cull (rot and defect). Net volume is gross volume minus an estimate of volume lost due to rot, physical defect, and/or other damage.

Cubic volume is referred to as growing-stock volume, which is the volume of a tree, from a 1-foot stump to a 4" top, calculated on all trees >= 5" (12.5cm) DBH.
Board foot volume is referred to as sawtimber volume; for softwoods it is the volume of a tree from a 1-foot stump to a 6" top, calculated for softwood species >= 9" (22.5cm) DBH; and for hardwoods, it is the volume of a tree from a 1-foot stump to an 8" top, calculated for hardwood species >= 11" (27.5cm) DBH.

Note, that the sawlog and upper stem volumes are the cubic volume of sawtimber-sized trees, not to be confused with sawtimber (boardfoot) volume.

The log length for the log rule used in sawtimber (board-foot) calculations differs by species group and location, as follows:

On the west side of Oregon and Washington--
Scribner volume uses a 32-foot log rule for softwoods, and
a 16-foot log rule for hardwoods;
International 1/4" volume uses a 16-foot log rule for softwoods, and
an 8-foot log rule for hardwoods.

On the east side of Oregon and Washington, and all of California--
Scribner volume uses a 16-foot log rule for softwoods, and
a 16-foot log rule for hardwoods;
International 1/4" volume uses a 16-foot log rule for softwoods, and
an 8-foot log rule for hardwoods.

Board foot equations estimate volume of the fractional log up to the specified top diameter. The fractional log is the last log of the tree, which is less than the log rule specification.

The following volume names are used throughout the equations and are defined below:

CUBIC VOLUME (in cubic feet)

Type of Volume	Calculated on trees with a DBH of:	Volume name in equations
All softwoods and hardwoods:		
Volume of the total stem, ground to tip	>= 1” (2.5cm)	CVTS
Volume from a 1-foot stump to the tip	>= 1” (2.5cm)	CVT
Volume from a 1-foot stump to a 4-inch top	>= 5” (12.5cm)	CV4
Softwood sawlog volume:		
Volume from a 1-foot stump to a 6-inch top	>= 9” (22.5cm)	CV6
Hardwood sawlog volume:		
Volume from a 1-foot stump to an 8-inch top	>= 11” (27.5cm)	CV8

BOARD FOOT VOLUME (square feet)

Type of Volume	Calculated on trees with a DBH of:	Volume name in equations
Softwoods:		
Scribner volume, 16-foot log rule, 1-foot stump to a 6-inch top (Eastern OR; Eastern WA; CA)	>= 9” (22.5cm)	SV616
Scribner volume, 32-foot log rule, 1-foot stump to a 6-inch top (Western OR; Western WA)	>= 9” (22.5cm)	SV632
International 1/4" volume, 16-foot log rule, 1-foot stump to a 6-inch top (all states)	>= 9” (22.5cm)	XINT6
Hardwoods:		
Scribner volume, 16-foot log rule 1-foot stump to an 8-inch top (all states)	>=11” (27.5cm)	SV816
International 1/4" volume, 8-foot log rule, 1-foot stump to an 8-inch top (all states)	>= 11” (27.5cm)	XINT8

PROCEDURES

The general procedure used to calculate volume is as follows:

a.) estimate cubic volume first to produce CVTS, CVT, CV4, and the TARIF number;
b.) estimate RATIO's from equations that use DBH and TARIF as inputs;
c.) use the RATIO's to convert cubic volume to Scribner and International 1/4" board-foot volumes;
d.) use the RATIO's to convert the Scribner 16-foot log rule to the Scribner 32-foot log rule.

There are three methods to calculate cubic volume, depending on the equation. Each method produces an estimate for CVTS, CVT, CV4, and TARIF. In cases where volume equations do not exist for a given species, a suitable equation has been chosen and assigned to each species.

After cubic volume is calculated, all species use the same set of equations to develop the RATIO's needed to produce the remaining volumes.

CUBIC VOLUME Method 1: The TARIF number is based on CVTS.
Softwood equations 1,2,4,6-15,17,21,22,24
Hardwood equations 1-7

1. Calculate CVTS from published or documented volume equations for the species.
2. Calculate the TARIF number from CVTS, using the equation in DNR note #27.
3. Calculate CV4 from the TARIF number and tree basal area.
4. Calculate CVT from the TARIF number and DBH.

CUBIC VOLUME Method 2: The TARIF number is based on CV4.
Softwood equations 3, 5, 16, 18, 19, 20, 23

5. Calculate CV4 directly from published equations, using a form factor, DBH and height.
6. Calculate the TARIF number from CV4 and tree basal area.
7. If the tree >= 6" DBH then Calculate CVTS from CV4.
8. If the tree < 6" DBH then adjust the TARIF before calculating CVTS.
9. Calculate CVT from the TARIF number and DBH.

CUBIC VOLUME Method 3: The TARIF number is based on CV8.
Hardwood equations 8 to 20

10. Calculate CVTS, CV4, and CV8 directly from published equations;
11. Calculate TARIF from CV8.
12. Calculate CVT from CV8.

For all trees:

13. CALCULATE CONVERSION RATIOS:
After CVTS and CV4 have been estimated, use equations to calculate the ratios. These ratios are used to convert cubic to board foot volume, and 16 to 32-foot log rules as follows:

RATIO	Used to convert:
RC6	CV4 to CV6
RC8	CV4 to CV8 (if needed)
RS616	CV6 to SV616
RS816	SV616 to SV816
RS632	SV616 to SV632
RI6	CV6 to XINT6
RI8	XINT6 to XINT8

SOFTWOOD CUBIC VOLUME EQUATIONS
Volume equation numbers

Species Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
11	Pacific silver fir	11	11	10	10	--
14	Bristlecone fir	--	--	--	--	18
15	White fir	23	--	10	--	23
17	Grand fir	11	11	10	10	23
19	Subalpine fir	11	11	10	10	18
20	California red fir	--	--	--	--	18
21	Shasta red fir	18	18	18	18	18
22	Noble fir	11	11	10	10	18
41	Port-Orford-cedar	19	19	19	19	8
42	Alaska-cedar	9	9	8	8	8
50	Cypress	--	--	--	--	19
51	Arizona cypress	--	--	--	--	19
56	McNabb cypress	--	--	--	--	19
62	California juniper	--	--	--	--	21
64	Western juniper	21	21	21	21	21
65	Utah juniper	--	--	--	--	21
72	Subalpine larch	--	22	--	22	--
73	Western larch	--	22	22	22	--
81	Incense cedar	19	19	19	19	19
92	Brewer spruce	13	--	13	--	12
93	Engelmann spruce	13	13	12	12	12
98	Sitka spruce	13	13	--	--	12
101	Whitebark pine	15	15	15	15	20
102	Bristlecone pine	--	--	--	--	16
103	Knobcone pine	15	--	15	--	16
104	Foxtail pine	--	--	--	--	16
108	Lodgepole pine	15	15	15	15	16
109	Coulter pine	--	--	--	--	5
113	Limber pine	15	--	15	--	16
116	Jeffrey pine	5	--	4	--	5
117	Sugar pine	20	20	20	20	20
119	Western white pine	15	15	15	15	20
120	Bishop pine	--	--	--	--	16
122	Ponderosa pine (>=5" dbh)	5	4	4	4	5
122	Ponderosa pine (<5" dbh)	5	5	5	5	5
124	Monterey pine	--	--	--	--	16
127	Gray pine	--	--	--	--	5
130	Scotch pine	17	17	17	17	17
133	Singleleaf pinyon	--	--	--	--	21
137	Washoe pine	--	--	--	--	5
201	Bigcone Douglas-fir	--	--	--	--	3
202	Douglas-fir	1	1	2	2	3
211	Redwood	24	--	--	--	24
212	Giant Sequoia	24	--	--	--	24
231	Pacific yew	9	9	8	8	8
242	Western redcedar	9	9	8	8	8
251	California nutmeg	--	--	--	--	8
263	Western hemlock	6	6	6	6	6
264	Mountain hemlock	17	17	17	17	17
298	Unknown Conifer	17	17	17	17	17

There are 24 equations used to estimate softwood cubic-foot volume. Each equation below has been crosswalked to a particular tree species in the table above. A brief reference for each equation is listed below—the full citation is at the end of this document.
Click on an equation number to view the actual equation and procedure used to estimate volume.

EQUATION 1 DOUGLAS-FIR	(WEYERHAUSER-DNR RPT#24,1977)
EQUATION 2 DOUGLAS-FIR	(DNR MEMO--SUMMERFIELD,11/7/80)
EQUATION 3 DOUGLAS-FIR	(USDA-FS RES NOTE PNW-266)
EQUATION 4 PONDEROSA PINE	(DNR MEMO--SUMMERFIELD,11/7/80)
EQUATION 5 PONDEROSA PINE	(USDA-FS RES NOTE PNW-266)
EQUATION 6 W.HEMLOCK	(DNR NOTE 27,4/79)
EQUATION 7 W.HEMLOCK	(BROWN (1962) BC FOREST SERV,P33)
EQUATION 8 REDCEDAR	(REDCEDAR INTERIOR--DNR RPT#24,1977)
EQUATION 9 REDCEDAR	(REDCEDAR COAST--DNR RPT#24,1977)
EQUATION10 TRUE FIRS	(INTERIOR BALSAM--DNR RPT#24,1977)
EQUATION11 TRUE FIRS	(COAST BALSAM--DNR RPT#24,1977)
EQUATION12 SPRUCE	(SITKA SPRUCE INTERIOR--DNR RPT#24,1977)
EQUATION13 SPRUCE	(SITKA SPRUCE MATURE--DNR RPT#24,1977)
EQUATION15 LODGEPOLE PINE	(LODGEPOLE PINE--DNR RPT#24,1977)
EQUATION16 LODGEPOLE PINE	(USDA-FS RES NOTE PNW-266)
EQUATION17 MTN.HEMLOCK	(BELL, OSU RES.BULL 35)
EQUATION18 SHASTA RED FIR	(USDA-FS RES NOTE PNW-266)
EQUATION19 INCENSE CEDAR	(USDA-FS RES NOTE PNW-266)
EQUATION20 SUGAR PINE	(USDA-FS RES NOTE PNW-266)
EQUATION21 W.JUNIPER	(CHITTESTER,1984)
EQUATION22 W.LARCH	(LARCH--DNR RPT#24,1977)
EQUATION23 WHITE FIR	(USDA-FS RES NOTE PNW-266)
EQUATION24 REDWOOD	(Krumland, B.E. and L.E. Wensel. 1975. And DNR RPT#24,1977)

Softwood cubic volume equations

Equation 1

$$\mathbf{CVTSL} = -3.21809 + 0.04948 \times \log(HT) \times \log(DBH) - 0.15664 \times (\log(DBH))^2 + 2.02132 \times \log(DBH) + 1.63408 \times \log(HT) - 0.16185 \times (\log(HT))^2 \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 2

$$\mathbf{CVTSL} = -6.110493 + 1.81306 \times ln(DBH) + 1.083884 \times ln(HT) \quad (1)$$

$$\mathbf{CVTS} = exp(CVTSL) \quad (2)$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 3– (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.248569 + 0.0253524*(HT/DBH) - 0.0000560175*(HT**2/ DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.248569 + 0.0253524*(HT/TMP_DBH) - 0.0000560175*(HT**2/ TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 4

$$\mathbf{CVTSL} = -8.521558 + 1.977243 \times \ln(DBH) - 0.105288 \times (\ln(HT))^2 + \frac{136.0489}{2} + 1.99546 \times \ln(HT) \quad (1)$$
$$HT$$

$$\mathbf{CVTS} = exp(CVTSL) \quad (2)$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{((1.033 \times (1.0 + 1.382937 \times exp(-4.015292 \times DBH))) \times (BA + 0.087266) - 0.174533)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 5 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.402060 - 0.899914 * (1/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.402060 - 0.899914 * (1/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 6

$$\text{CVTSL} = -2.72170 + 2.00857 \times \log(DBH) + 1.08620 \times \log(HT) - 0.00568 \times (DBH) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\textbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\textbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 7

$$\mathbf{CVTSL} = -2.663834 + 1.79023 \times log(DBH) + 1.124873 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 8

$$\text{CVTSL} = -2.464614 + 1.701993 \times \log(DBH) + 1.067038 \times \log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\textbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\textbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 9

$$\mathbf{CVTSL} = -2.379642 + 1.682300 \times log(DBH) + 1.039712 \times log(HT) \quad (1)$$

(2)

CVTS=10**CVTSL

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 10

$$\mathbf{CVTSL} = -2.502332 + 1.864963 \times log(DBH) + 1.004903 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 11

$$\mathbf{CVTSL} = -2.575642 + 1.806775 \times log\left(DBH\right) + 1.094665 \times log\left(HT\right) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 12

$$\text{CVTSL} = -2.539944 + 1.841226 \times \log(DBH) + 1.034051 \times \log(HT) \quad (1)$$

CVTS=10**CVTSL

$$\textbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\textbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 13

$$\mathbf{CVTSL} = -2.700574 + 1.754171 \times log(DBH) + 1.164531 \times log(HT) \quad (1)$$

CVTS=10**CVTSL

(2)

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 14

NOT USED

Equation 15

$$\mathbf{CVTSL} = -2.615591 + 1.847504 \times log\left(DBH\right) + 1.085772 \times log\left(HT\right) \quad (1)$$

CVTS=10**CVTSL

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 16 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.422709 - 0.0000612236 * (HT**2/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.422709 - 0.0000612236 * (HT**2/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 17

$$\mathbf{CVTS} = 0.001106485 \times (DBH)^{1.8140497} \times (HT)^{1.2744923} \tag{1}$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \tag{2}$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \tag{3}$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \tag{5}$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 18 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.231237 + 0.028176 * (HT/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.231237 + 0.028176 * (HT/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 19 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.225786 + 4.44236 * (1/HT)
IF(CF4 < .27) CF4=.27
CF4_TMP = 0.225786 + 4.44236 * (1/HT)
IF(CF4_TMP < .27) CF4_TMP=.27

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 20 – (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.358550 - 0.488134 * (1/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.358550 - 0.488134 * (1/ TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 21

$$\mathbf{CVTS} = 0.005454154 \times \left[0.30708901 + 0.00086157622 \times HT - 0.0037255243 \times DBH \times \frac{HT}{HT - 4.5} \right] \times DBH^2 \times HT \times \left(\frac{HT}{HT - 4.5} \right)^2 \quad (1)$$

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733 \right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)} \quad (2)$$

$$\mathbf{CV4} = \frac{\left(CVTS + 3.48 \right)}{\left(1.18052 + 0.32736 \times exp\left(-0.1 \times DBH \right) \right)} - 2.948 \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 22

Use for dbh>2

$$\mathbf{CVTSL} = -2.624325 + 1.847123 \times log(DBH) + 1.044007 \times log(HT) \quad (1)$$

$$\mathrm{CVTS} = 10.0^{CVTSL} \quad (2)$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \quad (3)$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 23 (uses PNW 266 formulas from MacLean and Berger)

'FOR THIS SET OF EQUATIONS CREATE A TEMPORARY DBH AND BA for trees less than 6"DBH

IF DBH < 6.0 THEN **TMP_DBH** = 6.0

'CALCULATE BASAL AREA PER TREE USING DBH AND DBH_TEMP
BA = DBH**2 * 0.005454154
BA_TMP = TMP_DBH **2 * 0.005454154

'CALCULATE A **CUBIC FORM FACTOR** (CF4) USING TMP_DBH and DBH
'CF4 EQUATIONS VARY BY VOLUME EQUATION

CF4 = 0.299039 + 1.91272 * (1/HT) + 0.0000367217 * (HT**2/DBH)
IF(CF4 < 0.3) CF4=0.3
IF(CF4 > 0.4) CF4=0.4
CF4_TMP = 0.299039 + 1.91272 * (1/HT) + 0.0000367217 * (HT**2/TMP_DBH)
IF(CF4_TMP < 0.3) CF4_TMP=0.3
IF(CF4_TMP > 0.4) CF4_TMP=0.4

'----------
'For ease of use and to improve readability of equations, calculate the following term and use it
'in the equations that follow. Note that actual DBH and BA are used for all trees.
'Do not use TMP_DBH or BA_TMP here.

TERM = ((1.033 * (1.0 + 1.382937 * EXP(-4.015292 * (DBH/10.0)))) * (BA + 0.087266) - 0.174533)
'----------

IF DBH >= 6.0 THEN
CV4 = CF4 * BA * HT
TARIF = (CV4 * 0.912733) / (BA - 0.087266)
IF (TARIF <= 0.0) TARIF=0.01
CVTS = (CV4 * TERM)/ (BA - 0.087266)
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733

ELSEIF

DBH < 6.0 THEN
CV4 _TMP = CF4_TMP *BA_TMP * HT
TARIF_TMP = (CV4_TMP * 0.912733) / (BA_TMP - 0.087266)
IF (TARIF_TMP <= 0.0) TARIF_TMP = 0.01
'CALCULATE An **ADJUSTED TARIF** FOR SMALL TREES (Both DBH and TMP_DBH are used)
TARIF = TARIF_TMP * (0.5 * (TMP_DBH - DBH)**2 + (1.0 + 0.063 * (TMP_DBH - DBH)**2))
IF (TARIF <= .0.0) TARIF = 0.01
CVTS = TARIF * TERM
CVT = TARIF * (0.9679 - 0.1051 * 0.5523**(DBH-1.5)) * TERM / 0.912733
CV4 = CF4 * BA * HT (calculated with actual DBH and BA)

END IF

IF DBH < 5.0 THEN CV4 = NULL
IF DBH >= 5.0 THEN KEEP CV4 (i.e. don't keep CV4_TMP)

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 24

$$\mathbf{CVTS} = exp\left(-6.2597 + 1.9967 \times ln(DBH) + 0.9642 \times ln(HT)\right) \quad (1)$$

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)} \quad (2)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)}{0.912733} \quad (4)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) $BA = .005454154 \times DBH^2$
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

SOFTWOOD BOARDFOOT VOLUME EQUATIONS

$$\textbf{RC6} = 0.993\text{-}\left(0.993 \times 0.62^{(DBH-6.0)}\right)$$

$$\textbf{CV6} = RC6 \times CV4$$

IF CV6 > CV4 THEN CV6 =CV4

$$\textbf{CUBUS} = CV4 - CV6$$

$$\textbf{B4} = \frac{TARIF}{0.912733}$$

$$\textbf{RS616L} = 0.174439 + 0.117594 \times log(DBH) \times log(B4) - \frac{8.210585}{DBH^2} + 0.236693 \times log(B4) - 0.00001345 \times (B4)^2 - 0.00001937 \times DBH^2$$

$$\textbf{RS616} = 10.0^{RS616L}$$

$$\textbf{RS632} = 1.001491 - \frac{6.924097}{TARIF} + 0.00001351 \times DBH^2$$

$$\textbf{SV616} = RS616 \times CV6$$

$$\textbf{SV632} = RS632 \times SV616$$

$$\textbf{SCRIB} = SV632$$

note: West-side Scribner conifer volumes are based on 32 foot logs, for areas other than western Oregon and western Washington SCRIB = sv616

$$\textbf{RI6} = -2.904154 + 3.466328 \times log(DBH \times TARIF) - 0.02765985 \times DBH - 0.00008205 \times TARIF^2 + \frac{11.29598}{DBH^2}$$

$$\textbf{XINT6} = RI6 \times CV6$$

Where:

B4 = BINGO FACTOR
CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION
RC6 = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP
CV6 = CUBIC FOOT VOLUME, 6-INCH TOP (SAWLOG)
RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS
RS632 = RATIO TO CONVERT SCRIB 6-INCH TOP IN 16-FT LOGS TO SCRIB 6-INCH TOP IN 32-FT LOGS (WEST-SIDE ONLY)
SV632 = SCRIBNER VOLUME--6-INCH TOP (IN 32-FT LOGS) (WEST-SIDE ONLY)
SV616 = SCRIBNER VOLUME--6-INCH TOP (IN 16-FT LOGS)
RI6 = RATIO TO CONVERT CUBIC 6-INCH TOP TO INTERNATIONAL ¼ INCH 6-INCH TOP
XINT6 =INTERNATIONAL ¼ INCH VOLUME--6-INCH TOP (IN 16-FT LOGS)

SOFTWOOD VOLUME EQUATION SOURCES

Brackett, Michael. 1977. Notes on TARIF tree-volume computation. DNR report #24. State of Washington, Department of Natural Resources, Olympia, WA. 132p. (see Weyerhaeuser Eqn. #4, page 6)

Summerfield, Edward. 1980. In-house memo describing equations for Douglas-fir and ponderosa pine. State of Washington, Department of Natural Resources. On file with the PNW Research Station.

MacLean, Colin and John M. Berger. 1976. Softwood tree-volume equations for major California species. PNW Research Note, PNW-266. Pacific Northwest Forest and Range Experiment Station, Portland Oregon. 34p. (see page 4)

Chambers, Charles and Bruce Foltz. 1979. The TARIF system--revisions and additions. DNR Note #27. State of Washington, Department of Natural Resources. (see page 2)

Bell, J.F., Marshall, D.D. and Johnson G.P. 1981. Tarif tables for mountain hemlock: developed from an equation of total stem cubic-foot volume. Research Bulletin #35.Forest Research Lab, School of Forestry, Oregon State University, Corvallis, OR. (see page 6)

Chittester, Judith and Colin MacLean. 1984. Cubic-foot tree-volume equations and tables for western juniper. Research Note, PNW_420. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 8p. (see page 4)

Krumland, B.E. and L.E. Wensel. 1975. Preliminary young growth volume tables for coastal California conifers. Research Note #1. In-house memo. Co-op Redwood Yield Research Project. Department of Forestry and Conservation, College of Natural Resources, U of Cal, Berkeley. On file with the PNW Research Station. (see Table 1, page 4)

HARDWOOD CUBIC VOLUME EQUATIONS

Species Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
312	Bigleaf maple	37	26	37	26	37
313	Boxelder	--	--	--	--	38
321	Rocky Mountain maple	--	--	--	--	--
322	Bigtooth maple	--	--	--	--	--
330	California buckeye	--	--	--	--	43
341	Tree of heaven	--	--	--	--	26
351	Red alder	26	25	26	25	26
352	White alder	26	--	26	--	26
361	Pacific madrone	40	26	40	26	40
374	Water birch	--	--	--	--	26
375	Paper birch	--	--	--	--	--
376	Western paper birch	--	26	--	26	--
431	Golden chinkapin	32	26	--	26	32
475	Curlleaf mountain-mahogany	--	--	45	--	45
492	Pacific dogwood	--	26	--	26	26
500	Hawthorn	--	--	--	--	--
510	Eucalyptus	26	--	--	--	31
542	Oregon ash	38	26	38	26	38
590	Holly	26	26	26	26	26
600	Walnut	26	26	26	--	38
631	Tanoak	34	--	--	--	34
660	Apple	26	26	26	26	42
730	California sycamore	26	26	26	26	42
740	Cottonwood and poplar	--	--	--	--	--
741	Balsam poplar	--	--	--	--	--
742	Eastern cottonwood	--	--	--	--	--
745	Plains cottonwood	--	--	--	--	--
746	Quaking aspen	26	26	26	26	28
747	Black cottonwood	26	26	26	26	27
748	Fremont poplar	--	--	--	--	27
755	Mesquite	--	--	--	--	--
760	Cherry	26	26	26	26	26
800	Oak-deciduous	--	--	--	--	43
801	California live oak	--	--	--	--	43
805	Canyon live oak	42	--	--	--	42
807	Blue oak	--	--	--	--	39
810	Emory oak	--	--	--	--	--
811	Englemann oak	--	--	--	--	36
815	Oregon white oak	41	26	41	26	41
818	California black oak	38	--	38	26	38
821	California white oak	--	--	--	--	35
839	Interior live oak	--	--	--	--	44
901	Black locust	--	--	--	--	41
920	Willow	26	26	26	26	40
981	California-laurel	33	--	--	--	33
998	Unknown hardwood	26	26	26	26	41
999	Unknown Tree	26	26	26	26	41

HARDWOOD VOLUME EQUATION SOURCE

EQUATION 25	ALDER	(CURTIS/BRUCE, PNW-56)
EQUATION 26	ALDER	(BC-ALDER--DNR RPT#24,1977)
EQUATION 27	COTTONWOOD	(BC-COTTONWOOD--DNR RPT#24,1977)
EQUATION 28	ASPEN	(BC-ASPEN--DNR RPT#24,1977)
EQUATION 29	BIRCH	(BC-BIRCH--DNR RPT#24,1977)
EQUATION 30	BIGLEAF MAPLE	(BC-MAPLE--DNR RPT#24,1977)
EQUATION 31	EUCALYPTUS	(MEMO,COLIN D. MacLEAN 1/27/83,(REVISED 2/7/83))
EQUATION 32	G.CHINQUAPIN	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 33	C.LAUREL	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION34	TANOAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION35	CALIF WHITE OAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION36	ENGELMANN OAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION37	BIGLEAF MAPLE	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION38	CALIF BLACK OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION39	BLUE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION40	PACIFIC MADRONE	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION41	ORE WHITE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION42	CANYON LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION43	COAST LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION44	INT LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION45	MTN. MAHOGANY	(Chojnacky, 1985)

HARDWOOD CUBIC VOLUME EQUATIONS

EQUATION 25

$$\mathbf{F} = 0.3651 \times Z^{2.5} - 7.9032 \times Z^{2.5} \frac{DBH}{1000.0} + 3.295 \times Z^{2.5} \times \frac{HT}{1000.0}$$
$$- 1.9856 \times Z^{2.5} \times HT \times \frac{DBH}{100000.0} - 2.9668 \times Z^{2.5} \times \frac{HT^2}{1000000.0}$$
$$+ 1.5092 \times Z^{2.5} \times \frac{HT^{0.5}}{1000.0} + 4.9395 \times Z^{4} \times \frac{DBH}{1000.0}$$
$$- 2.05937 \times Z^{4} \times \frac{HT}{1000.0} + 1.5042 \times Z^{33} \times HT \times \frac{DBH}{1000000.0}$$
$$- 1.1433 \times Z^{33} \times \frac{HT^{0.5}}{10000.0} + 1.809 \times Z^{41} \times \frac{HT^2}{10000000.0} \quad (1)$$

Where: $$\mathrm{Z} = \frac{\left(HT - 0.5 - \frac{DBH}{24.0} \right)}{HT - 4.5}$$

$$\mathbf{CVT} = 0.00545415 \times \left(DBH\right)^2 \times \left(HT - 4.5\right) \times F \quad (2)$$

$$\mathrm{TARIF} = \frac{\left(CVT \times 0.912733\right)}{\left(\left(0.9679 - 0.1051 \times 0.5523^{\left(DBH - 1.5\right)}\right) \times \left(\left(1.0330 \times \left(1.0 + 1.382937 \times \exp\left(- 4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266\right) - 0.174533 \right) \right)} \quad (3)$$

$$\mathbf{CVTS} = TARIF \times \frac{\left(\left(1.0330 \times \left(1.0 + 1.382937 \times exp\left(- 4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266\right) - 0.174533 \right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{\left(DBH - 8.6\right)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE:
DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 26

$$\mathbf{CVTSL} = -2.672775 + 1.920617 \times log(DBH) + 1.074024 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 27

$$\mathbf{CVTSL} = -2.945047 + 1.803973 \times log(DBH) + 1.238853 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 28

$$\mathbf{CVTSL} = -2.635360 + 1.946034 \times log(DBH) + 1.024793 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 29

$$\mathbf{CVTSL} = -2.757813 + 1.911681 \times log(DBH) + 1.105403 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right)\right) - 0.174533\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983 - \left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 30

$$\mathbf{CVTSL} = -2.770324 + 1.885813 \times log(DBH) + 1.119043 \times log(HT) \quad (1)$$

CVTS=10**CVTSL (2)

$$\mathbf{TARIF} = \frac{\left(CVTS \times 0.912733\right)}{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)} \quad (3)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)\right)}{0.912733} \quad (4)$$

$$\mathbf{CV4} = \frac{TARIF \times \left(BA - 0.087266\right)}{0.912733} \quad (5)$$

$$\mathbf{RC8} = 0.983\text{-}\left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \quad (6)$$

$$\mathbf{CV4X} = CV4$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 31

$$\mathbf{CVTS} = 0.0016144 \times DBH^2 \times HT \tag{1}$$

$$\mathbf{TARIF} = \frac{(CVTS \times 0.912733)}{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)} \tag{2}$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \tag{3}$$

$$\mathbf{CV4} = \frac{TARIF \times (BA - 0.087266)}{0.912733} \tag{4}$$

$$\mathbf{RC8} = 0.983 - \left(0.983 \times 0.65^{(DBH - 8.6)}\right)$$

$$\mathbf{CV8} = RC8 \times CV4 \tag{5}$$

$$\mathbf{CV4X} = CV4$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 32

$$\text{CVTS} = 0.0120372263 \times DBH^{2.02232} \times HT^{0.68638} \quad (1)$$

$$\textbf{CV4} = 0.0055212937 \times DBH^{2.07202} \times HT^{0.77467} \quad (2)$$

$$\textbf{CV8} = 0.0018985111 \times DBH^{2.38285} \times HT^{0.77105} \quad (3)$$

$$\text{CVT} = CVTS * RTS \quad (4)$$
$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)}$$

$$\textbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\textbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 33

$$\mathbf{CVTS} = 0.0057821322 \times DBH^{1.94553} \times HT^{0.88389} \quad (1)$$

$$\mathbf{CV4} = 0.0016380753 \times DBH^{2.05910} \times HT^{1.05293} \quad (2)$$

$$\mathbf{CV8} = 0.0007741517 \times DBH^{2.23009} \times HT^{1.03700} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)}$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 34

$$\mathbf{CVTS} = 0.0058870024 \times DBH^{1.94165} \times HT^{0.86562} \quad (1)$$

$$\mathbf{CV4} = 0.0005774970 \times DBH^{2.19576} \times HT^{1.14078} \quad (2)$$

$$\mathbf{CV8} = 0.0002526443 \times DBH^{2.30949} \times HT^{1.21069} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$
$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)}$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 35

$$\mathbf{CVTS} = 0.0042870077 \times DBH^{2.33631} \times HT^{0.74872} \quad (1)$$

$$\mathbf{CV4} = 0.0009684363 \times DBH^{2.39565} \times HT^{0.98878} \quad (2)$$

$$\mathrm{CV8} = 0.0001880044 \times DBH^{1.87346} \times HT^{1.62443} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 36

$$\mathbf{CVTS} = 0.0191453191 \times DBH^{2.40248} \times HT^{0.28060} \quad (1)$$

$$\mathbf{CV4} = 0.0053866353 \times DBH^{2.61268} \times HT^{0.31103} \quad (2)$$

CV8=CV4 (3)

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 37

$$\mathbf{CVTS} = 0.0101786350 \times DBH^{2.22462} \times HT^{0.57561} \quad (1)$$

$$\mathrm{CV4} = 0.0034214162 \times DBH^{2.35347} \times HT^{0.69586} \quad (2)$$

$$\mathbf{CV8} = 0.0004236332 \times DBH^{2.10316} \times HT^{1.08584} \times FC^{0.40017} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC = HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 38

$$\mathbf{CVTS} = 0.0070538108 \times DBH^{1.97437} \times HT^{0.85034} \quad (1)$$

$$\mathbf{CV4} = 0.0036795695 \times DBH^{2.12635} \times HT^{0.83339} \quad (2)$$

$$\mathbf{CV8} = 0.0012478663 \times DBH^{2.68099} \times HT^{0.42441} \times FC^{0.28385} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC =HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 39

$$\mathbf{CVTS} = 0.0125103008 \times DBH^{2.33089} \times HT^{0.46100} \quad (1)$$

$$\mathbf{CV4} = 0.0042324071 \times DBH^{2.53987} \times HT^{0.50591} \quad (2)$$

$$\mathbf{CV8} = 0.0036912408 \times DBH^{1.79732} \times HT^{0.83884} \times FC^{0.15958} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC =HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 40

$$\mathbf{CVTS} = 0.0067322665 \times DBH^{1.96628} \times HT^{0.83458} \quad (1)$$

$$\mathbf{CV4} = 0.0025616425 \times DBH^{1.99295} \times HT^{1.01532} \quad (2)$$

$$\mathrm{CV8} = 0.0006181530 \times DBH^{1.72635} \times HT^{1.26462} \times FC^{0.37868} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC =HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 41

$$\mathbf{CVTS} = 0.0072695058 \times DBH^{2.14321} \times HT^{0.74220} \quad (1)$$

$$\mathbf{CV4} = 0.0024277027 \times DBH^{2.25575} \times HT^{0.87108} \quad (2)$$

$$\mathbf{CV8} = 0.0008281647 \times DBH^{2.10651} \times HT^{0.91215} \times FC^{0.32652} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC =HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 42

$$\mathbf{CVTS} = 0.0097438611 \times DBH^{2.20527} \times HT^{0.61190} \quad (1)$$

$$\mathbf{CV4} = 0.0031670596 \times DBH^{2.32519} \times HT^{0.74348} \quad (2)$$

$$\mathbf{CV8} = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC =HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 43

$$\mathbf{CVTS} = 0.0065261029 \times DBH^{2.31958} \times HT^{0.62528} \quad (1)$$

$$\mathbf{CV4} = 0.0024574847 \times DBH^{2.53284} \times HT^{0.60764} \quad (2)$$

$$\mathbf{CV8} = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC =HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 44

$$\mathbf{CVTS} = 0.0136818837 \times DBH^{2.02989} \times HT^{0.63257} \quad (1)$$

$$\mathbf{CV4} = 0.0041192264 \times DBH^{2.14915} \times HT^{0.77843} \quad (2)$$

$$\mathbf{CV8} = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$\mathrm{CVT} = CVTS * RTS \quad (4)$$

$$RTS = 0.9679 - 0.1051 \times 0.5523^{(DBH-1.5)} \quad (4)$$

$$\mathbf{CV4X} = CVT \times \left(0.99875 - \frac{43.336}{DBH^3} - \frac{124.717}{DBH^4} + \frac{(0.193437 \times HT)}{DBH^3} + \frac{479.83}{(DBH^3 \times HT)} \right) \quad (5)$$

$$\mathbf{TARIF} = \frac{(CV8 \times 0.912733)}{\left(\left(0.983 - o.983 \times 0.65^{(DBH-8.6)} \right) \times (BA - 0.087266) \right)} \quad (6)$$

WHERE

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)
HT = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
FC =HARDWOOD FORM CLASS
CVTS = CUBIC FOOT VOLUME, TOP AND STUMP
TARIF = TARIF NUMBER EQUATION
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME, 4-IN TOP
CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 45

CVTS = $(A + B \times DSXH^{.3333} + C \times D)^3$

WHERE

A = -0.13363
B = 0.128222
C = 0 .080208
D = 1
DSXH = $DRC \times DRC \div THT$ DRC is diameter at root collar and THT is total height

Mountain mahogany
Cubic foot volume of all wood and bark to a 1.5 inch branch diameter
From INT-339, Chojnacky, 1985
Pinyon-Juniper Volume Equations for the Central Rocky Mountain States

No boardfoot equation is available

HARDWOOD BOARDFOOT VOLUME RATIOS and EQUATIONS

$$\mathbf{CUBUS} = CV4 - CV8 \quad (1)$$

$$\mathbf{RC6} = 0.993 - 0.993 \times 0.62^{(DBH-6.0)} \quad (2)$$

IF Hardwood Equation Number is 25 to 31 THEN set
CV4X = CVT
TARIFX = TARIF (note that TARIF was calculated in the cubic volume equation)

Otherwise, for all other hardwood equation numbers, calculate CV4X and TARIFX as follows:

$$\mathrm{CV4X} = \mathrm{CVT} \times 0.99875 - \frac{43.336}{\mathrm{DBH}^3} - \frac{124.717}{\mathrm{DBH}^4} + \frac{0.193437 \times \mathrm{HT}}{\mathrm{DBH}^3} + \frac{479.83}{\mathrm{DBH}^3 \times \mathrm{HT}}$$

$$\mathrm{TARIFX} = \frac{\mathrm{CV8} \times 0.912733}{0.983 - 0.983 \times 0.65^{\mathrm{DBH}-8.6} \times \mathrm{BA} - 0.087266}$$

If TARIF or TARIFX are <0 then set them to .01

$$\mathrm{CV6} = RC6 \times CV4X \quad (3)$$

$$\mathrm{B4} = \frac{TARIFX}{0.912733}$$

$$\mathrm{RS616L} = 0.174439 + 0.117594 \times \log(DBH) \times \log(B4) - \frac{8.210585}{DBH^2} + 0.236693 \times \log(B4) - 0.00001345 \times (B4)^2 - 0.00001937 \times DBH^2 \quad (4)$$

$$\mathrm{RS616} = 10.0^{RS616L} \quad (5)$$

$$\mathrm{SV616} = RS616 \times CV6$$

$$\mathrm{RI6} = -2.904154 + 3.466328 \times \log(DBH \times TARIFX) - 0.02765985 \times DBH - 0.00008205 \times TARIFX^2 + \frac{11.29598}{DBH^2} \quad (6)$$

$$\mathrm{XINT6} = RI6 \times CV6 \quad (7)$$

$$RS616 = 0.990 - 0.58 \times (0.484^{DBH-9.5}) \quad (8)$$

$$SV816 = RS816 \times SV616 \quad (9)$$

Calculated on hardwood species only:

$$RI8 = 0.990 - 0.55 \times (0.485^{DBH-9.5}) \quad (10)$$

$$XINT8 = XINT6 \times RI8 \quad (11)$$

WHERE:

B4 = BINGO FACTOR
CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION
RC6 = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP
CV6 = CUBIC FOOT VOLUME, 6-INCH TOP (SAWLOG)
RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS
SV616 = SCRIBNER VOLUME--6-INCH TOP (IN 16-FT LOGS)
RS816 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 8-INCH TOP IN 16-FT LOGS
SV816 = SCRIBNER VOLUME--8-INCH TOP (IN 16-FT LOGS)
XINT6 = INTERNATIONAL ¼ INCH VOLUME--6-INCH TOP (IN 16-FT LOGS)
RI8 =RATIO TO CONVERT INTERNATIONAL ¼ INCH 6-INCH TOP TO INTERNATIONAL ¼ INCH 8-INCH TOP
XINT8 = INTERNATIONAL ¼ INCH VOLUME--8-INCH TOP (IN 8-FT LOGS)

HARDWOOD VOLUME EQUATION SOURCES

Curtis, Robert O., Bruce, David, and Caryanne VanCoevering. 1968. Volume and taper tables for red alder. US Forest Serv. Res. Pap. PNW-56. PNW Forest & Range Exp. Sta., Portland, Oregon. 35p.

Brackett, Michael. 1977. Notes on TARIF tree-volume computation. DNR report #24. State of Washington, Department of Natural Resources, Olympia, WA. 132p. (see page 5)

Colin MacLean and Tom Farrenkopf. 1983. Eucalyptus volume equation. In-house memo describing the volume equation for CVTS, to be used for all species of Eucalyptus. The equation was developed from 111 trees. On file at the PNW Research Station,Portland,OR

Pillsbury, Norman H. and Michael L. Kirkley. 1984. Equations for Total, Wood, and Saw-log Volume for Thirteen California Hardwoods. PNW Research Note, PNW-414. Pacific Northwest Research Station, Portland Oregon. 52p.

OUTDATED EQUATIONS

EARLIER VERSION OF SOFTWOOD EQUATIONS 3,5,16,18,19,20,23

These were replaced due to confusion about calculations for trees with a dbh < 6”

DELETE THESE PAGES (THEY ARE ONLY INCLUDED AS A REFERENCE TO THE PAST)

Equation 3--outdated

Set: $\mathbf{TMP\_DBH} = DBH$

If DBH $<$ 6.0 inches then set :

TMP_DBH $=$ 6.0 inches

BA $= 6^2 \times 0.0054541 54$

Calculate a cubic foot form factor

$$\mathbf{CF4} = 0.248569 + 0.0253524 \times \frac{HT}{TMP\_DBH} - 0.0000560175 \times \left(\frac{HT^2}{TMP\_DBH} \right) \quad (1)$$

IF CF4 < 0.3 THEN CF4 = 0.3
IF CF4 > 0.4 THEN CF4 = 0.4

$$\mathbf{CV4} = 0.005454154 \times TMP\_DBH^2 \times HT \times CF4 \quad (2)$$

$$\mathbf{TARIF} = \frac{CV4 \times 0.912733}{BA - 0.087266} \quad (3)$$

IF TMP_DBH > 6.0 THEN

$$\mathbf{CVTS} = CV4 \times \frac{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)}{\left(BA - 0.087266 \right)} \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)}{0.912733} \quad (5)$$

IF TMP_DBH = 6.0 THEN

$$\mathbf{SMALL\_TARIF} = 0.5 \times \left(6.0 - DBH \right)^2 + \left(1.0 + 0.063 \times \left(6.0 - DBH \right)^2 \times TARIF \right) \quad (3)$$

IF SMALL_TARIF <= 0.0 THEN SMALL_TARIF = 0.01

$$\mathbf{CVTS} = SMALL\_TARIF \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right) \quad (4)$$

$$\mathbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 5--outdated

TMP_DBH $= DBH$

If DBH < 6.0 **inches then TMP_DBH** $=$ **6.0 inches and BA** $= 6^2 \times 0.005454154$

$$\textbf{CF4} = 0.402060 - 0.899914 \times \left(\frac{1}{TMP\_DBH} \right) \quad (1)$$

IF CF4 < 0.3 THEN CF4 = 0.3
IF CF4 > 0.4 THEN CF4 = 0.4

$$\textbf{CV4} = 0.005454154 \times TMP\_DBH^2 \times HT \times CF4 \quad (2)$$

$$\textbf{TARIF} = \frac{CV4 \times 0.912733}{BA - 0.087266} \quad (3)$$

IF TMP_DBH > 6.0 THEN

$$\textbf{CVTS} = CV4 \times \frac{\left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)}{\left(BA - 0.087266 \right)} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)}{0.912733} \quad (5)$$

IF TMP_DBH = 6.0 THEN

$$\textbf{SMALL\_TARIF} = 0.5 \times \left(6.0 - DBH \right)^2 + \left(1.0 + 0.063 \times \left(6.0 - DBH \right)^2 \times TARIF \right) \quad (3)$$

IF SMALL_TARIF <= 0.0 THEN SMALL_TARIF = 0.01

$$\textbf{CVTS} = SMALL\_TARIF \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right) \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 16--outdated

TMP_DBH $= DBH$

If DBH < 6.0 **inches then TMP_DBH** $=$ **6.0 inches and BA** $= 6^2 \times 0.005454154$

$$\textbf{CF4} = 0.422709 - 0.0000612236 \times \left(\frac{HT^2}{TMP\_DBH} \right) \quad (1)$$

IF CF4 < 0.3 THEN CF4 = 0.3
IF CF4 > 0.4 THEN CF4 = 0.4

$$\textbf{CV4} = 0.005454154 \times TMP\_DBH^2 \times HT \times CF4 \quad (2)$$

$$\textbf{TARIF} = \frac{CV4 \times 0.912733}{BA - 0.087266} \quad (3)$$

IF TMP_DBH > 6.0 THEN

$$\textbf{CVTS} = CV4 \times \frac{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right)}{\left(BA - 0.087266 \right)} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right)}{0.912733} \quad (5)$$

IF TMP_DBH = 6.0 THEN

$$\textbf{SMALL\_TARIF} = 0.5 \times \left(6.0 - DBH \right)^2 + \left(1.0 + 0.063 \times \left(6.0 - DBH \right)^2 \times TARIF \right) \quad (3)$$

IF SMALL_TARIF <= 0.0 THEN SMALL_TARIF = 0.01

$$\textbf{CVTS} = SMALL\_TARIF \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right) \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times \left(BA + 0.087266 \right) - 0.174533 \right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 18--outdated

TMP_DBH = *DBH*

If DBH < 6.0 **inches then TMP_DBH** = **6.0 inches and BA** = $6^2 \times 0.005454154$

$$\textbf{CF4} = 0.231237 + 0.028176 \times \left(\frac{HT}{TMP\_DBH} \right) \quad (1)$$

IF CF4 < 0.3 THEN CF4 = 0.3
IF CF4 > 0.4 THEN CF4 = 0.4

$$\textbf{CV4} = 0.005454154 \times TMP\_DBH^2 \times HT \times CF4 \quad (2)$$

$$\textbf{TARIF} = \frac{CV4 \times 0.912733}{BA - 0.087266} \quad (3)$$

IF TMP_DBH > 6.0 THEN

$$\textbf{CVTS} = CV4 \times \frac{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right)}{(BA - 0.087266)} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right)}{0.912733} \quad (5)$$

IF TMP_DBH = 6.0 THEN

$$\textbf{SMALL\_TARIF} = 0.5 \times (6.0 - DBH)^2 + \left(1.0 + 0.063 \times (6.0 - DBH)^2 \times TARIF \right) \quad (3)$$

IF SMALL_TARIF <= 0.0 THEN SMALL_TARIF = 0.01

$$\textbf{CVTS} = SMALL\_TARIF \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times \exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right) \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 19--outdated

TMP_DBH $= DBH$

If DBH < 6.0 **inches then TMP_DBH** $=$ **6.0 inches and BA** $= 6^2 \times 0.005454154$

$$\textbf{CF4} = 0.225786 + 4.44236 \times \left(\frac{1}{HT}\right) \quad (1)$$

IF CF4 < 0.27 THEN CF4 = 0.27

$$\textbf{CV4} = 0.005454154 \times TMP\_DBH^2 \times HT \times CF4 \quad (2)$$

$$\textbf{TARIF} = \frac{CV4 \times 0.912733}{BA - 0.087266} \quad (3)$$

IF TMP_DBH > 6.0 THEN

$$\textbf{CVTS} = CV4 \times \frac{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{(BA - 0.087266)} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

IF TMP_DBH = 6.0 THEN

$$\textbf{SMALL\_TARIF} = 0.5 \times (6.0 - DBH)^2 + \left(1.0 + 0.063 \times (6.0 - DBH)^2 \times TARIF\right) \quad (3)$$

IF SMALL_TARIF <= 0.0 THEN SMALL_TARIF = 0.01

$$\textbf{CVTS} = SMALL\_TARIF \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right) \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times (BA + 0.087266) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP
DBH = DIAMETER BREAST HEIGHT IN CENTIMETERS
HT = HEIGHT IN METERS

Equation 20--outdated

TMP_DBH = *DBH*

If DBH < 6.0 **inches then TMP_DBH** = **6.0 inches and BA** = $6^2 \times 0.005454154$

$$\textbf{CF4} = 0.358550 - 0.488134 \times \left(\frac{1}{TMP\_DBH} \right) \quad (1)$$

IF CF4 < 0.3 THEN CF4 = 0.3
IF CF4 > 0.4 THEN CF4 = 0.4

$$\textbf{CV4} = 0.005454154 \times TMP\_DBH^2 \times HT \times CF4 \quad (2)$$

$$\textbf{TARIF} = \frac{CV4 \times 0.912733}{BA - 0.087266} \quad (3)$$

IF TMP_DBH > 6.0 THEN

$$\textbf{CVTS} = CV4 \times \frac{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right)}{(BA - 0.087266)} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right)}{0.912733} \quad (5)$$

IF TMP_DBH = 6.0 THEN

$$\textbf{SMALL\_TARIF} = 0.5 \times (6.0 - DBH)^2 + \left(1.0 + 0.063 \times (6.0 - DBH)^2 \times TARIF \right) \quad (3)$$

IF SMALL_TARIF <= 0.0 THEN SMALL_TARIF = 0.01

$$\textbf{CVTS} = SMALL\_TARIF \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right) \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5} \right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0} \right) \right) \right) \right) \times (BA + 0.087266) - 0.174533 \right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

REGIONAL BIOMASS EQUATIONS USED BY FIA TO ESTIMATE BOLE, BARK, AND BRANCHES

BIOMASS OF THE TREE STEM

Tree stem biomass, regardless of whether it is merchantable bole or total stem, is calculated from cubic volume estimates and the wood density factor (in tables below) as follows:

Cubic volume = green cubic volume in cubic feet (ft3)
Wood density = (Specific gravity of a tree species) * (62.4 lbs/ft3)

Weight of water = 62.4 pounds/cubic foot

Biomass of the tree stem (in tons**) =** (cubic foot volume * wood density) / 2000

The tables below contain specific gravity and wood density values for many species.

Softwoods

Code	Species	Specific gravity	Wood density
11	Pacific silver fir	0.4	24.96
14	Bristlecone fir	0.36	22.46
15	White fir	0.37	23.09
17	Grand fir	0.35	21.84
19	Subalpine fir	0.31	19.34
20	California red fir	0.36	22.46
21	Shasta red fir	0.36	22.46
22	Noble fir	0.37	23.09
41	Port-Orford-cedar	0.39	24.34
42	Alaska-cedar	0.42	26.21
50	Cypress	0.67	41.81
56	McNabb cypress	.67	41.81
62	California juniper	0.54	33.7
64	Western juniper	0.54	33.7
65	Utah juniper	0.54	33.7
72	Subablpine larch	0.48	29.95
73	Western larch	0.48	29.95
81	Incense cedar	0.35	21.84
92	Brewer spruce	0.35	21.84
93	Engelmann spruce	0.33	20.59
98	Sitka spruce	0.37	23.09
101	Whitebark pine	0.37	23.09
102	Bristlecone pine	0.37	23.09
103	Knobcone pine	0.37	23.09
104	Foxtail pine	0.37	23.09
108	Lodgepole pine	0.38	23.71
109	Coulter pine	0.43	26.83
113	Limber pine	0.37	23.09
116	Jeffrey pine	0.38	23.71
117	Sugar pine	0.34	21.22
119	Western white pine	0.35	21.84
120	Bishop pine	0.43	26.83
122	Ponderosa pine	0.38	23.71
124	Monterey pine	0.35	21.84
127	Gray pine	0.43	26.83
133	Singleleaf pinyon	0.37	23.09
137	Washoe pine	.37	23.09
201	Bigcone Douglas-fir	0.46	28.7
202	Douglas-fir	0.46	28.7
211	Redwood	0.34	21.22
212	Giant Sequoia	0.38	23.71
231	Pacific yew	0.67	41.81
242	Western redcedar	0.31	19.34
251	California nutmeg	0.51	31.82
263	Western hemlock	0.42	26.21
264	Mountain hemlock	0.42	26.21
298	Unknown softwood	0.41	25.58

Hardwoods

Code	Species	Specific gravity	Wood density
312	Bigleaf maple	0.44	27.46
313	Boxelder		19.34
330	California buckeye	0.38	23.71
341	Tree of heaven	0.3	18.72
351	Red alder	0.37	23.09
352	White alder	0.37	23.09
361	Pacific madrone	0.69	43.06
374	Water birch	0.3	18.72
376	Western paper birch	0.3	18.72
431	Golden chinkapin	0.48	29.95
475	Curlleaf mountain-mahogany		
492	Pacific dogwood	0.7	43.68
510	Eucalyptus	0.8	49.92
542	Oregon ash	0.5	31.2
590	Holly		37.44
600	Walnut	0.51	31.82
631	Tanoak	0.58	36.19
660	Apple	0.58	36.19
730	California sycamore	0.46	28.7
740	Cottonwood and poplar		
746	Quaking aspen	0.35	21.84
747	Black cottonwood	0.31	19.34
748	Fremont poplar	0.31	19.34
760	Cherry		29.32
801	California live oak	0.8	49.92
805	Canyon live oak	0.8	49.92
807	Blue oak	0.6	37.44
811	Englemann oak	0.6	37.44
815	Oregon white oak	0.6	37.44
818	California black oak	0.56	34.94
821	California white oak	0.6	37.44
839	Interior live oak	0.8	49.92
920	Willow	0.36	22.46
981	California-laurel	0.59	36.82
998	Unknown hardwood	0.51	31.82
999	Unknown tree	0.45	28.08

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF BARK

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
11	Pacific silver fir	22	22	22	22	--
14	Bristlecone fir	--	--	--	--	2
15	White fir	1	1	1	1	1
17	Grand fir	2	2	2	2	2
18	Corkbark fir	--	--	--	--	0
19	Subalpine fir	3	3	3	3	3
20	California red fir	--	--	--	--	4
21	Shasta red fir	4	4	4	4	4
22	Noble fir	5	5	5	5	5
41	Port-Orford-cedar	13	13	13	13	13
42	Alaska-cedar	23	23	23	23	13
50	Cypress	--	--	--	--	13
51	Arizona cypress	--	--	--	--	0
56	Mcnabb cypress	--	--	--	--	13
58	Pinchot juniper	--	--	--	--	0
59	Redberry juniper	--	--	--	--	0
62	California juniper	--	--	--	--	16
63	Alligator juniper	--	--	--	--	0
64	Western juniper	16	16	16	16	16
65	Utah juniper	--	--	--	--	16
66	Rocky Mountain juniper	--	--	--	--	0
69	Oneseed juniper	--	--	--	--	0
72	Subablpine larch	24	24	24	24	--
73	Western larch	24	24	24	24	--
81	Incense cedar	12	12	12	12	12
92	Brewer spruce	7	7	7	7	7
93	Engelmann spruce	7	7	7	7	7
94	White spruce	--	--	--	--	0
96	Blue spruce	--	--	--	--	0
98	Sitka spruce	6	6	6	6	6
101	Whitebark pine	11	11	11	11	14
102	Bristlecone pine	--	--	--	--	14
103	Knobcone pine	14	14	14	14	14
104	Foxtail pine	--	--	--	--	14
106	Twoneedle pinyon	--	--	--	--	0
108	Lodgepole pine	14	14	14	14	14
109	Coulter pine	--	--	--	--	9
112	Apache pine	--	--	--	--	0
113	Limber pine	--	--	--	--	14
114	Southwestern white pine	--	--	--	--	0
116	Jeffrey pine	9	9	9	9	9

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS
--continued--
BIOMASS OF BARK

		Halfstate				
Code	Species	WOR	WWA	EOR	EWA	CA
117	Sugar pine	10	10	10	10	10
118	Chihuahuan pine	--	--	--	--	0
119	Western white pine	11	11	11	11	11
120	Bishop pine	--	--	--	--	14
122	Ponderosa pine	9	9	9	9	9
124	Monterey pine	--	--	--	--	14
127	Gray pine	--	--	--	--	9
130	Scotch pine	0	0	0	0	0
133	Singleleaf pinyon	--	--	--	--	14
134	Border pinyon	--	--	--	--	0
135	Arizona pine	--	--	--	--	0
137	Washoe pine	--	--	--	--	9
201	Bigcone Douglas-fir	--	--	--	--	8
202	Douglas-fir	8	8	25	25	8
211	Redwood	17	17	17	17	17
212	Giant Sequoia	17	17	17	17	17
231	Pacific yew	13	13	13	13	13
242	Western redcedar	13	13	13	13	13
251	California nutmeg	--	--	--	--	13
263	Western hemlock	26	26	26	26	15
264	Mountain hemlock	21	21	21	21	21
298	Unknown Conifer	21	21	21	21	21

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF LIVE BRANCHES

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
11	Pacific silver fir	18	18	18	18	--
14	Bristlecone fir	--	--	--	--	1
15	White fir	1	1	1	1	1
17	Grand fir	1	1	1	1	1
18	Corkbark fir	--	--	--	--	0
19	Subalpine fir	2	2	2	2	2
20	California red fir	--	--	--	--	3
21	Shasta red fir	3	3	3	3	3
22	Noble fir	3	3	3	3	3
41	Port-Orford-cedar	10	10	10	10	10
42	Alaska-cedar	19	19	19	19	10
50	Cypress	--	--	--	--	10
51	Arizona cypress	--	--	--	--	0
56	Mcnabb cypress	--	--	--	--	10
58	Pinchot juniper	--	--	--	--	0
59	Redberry juniper	--	--	--	--	0
62	California juniper	--	--	--	--	13
63	Alligator juniper	--	--	--	--	0
64	Western juniper	13	13	13	13	13
65	Utah juniper	--	--	--	--	13
66	Rocky Mountain juniper	--	--	--	--	0
69	Oneseed juniper	--	--	--	--	0
72	Subablpine larch	20	20	20	20	--
73	Western larch	20	20	20	20	--
81	Incense cedar	10	10	10	10	10
92	Brewer spruce	4	4	4	4	4
93	Engelmann spruce	4	4	4	4	4
94	White spruce	--	--	--	--	0
96	Blue spruce	--	--	--	--	0
98	Sitka spruce	5	5	5	5	5
101	Whitebark pine	9	9	9	9	11
102	Bristlecone pine	--	--	--	--	11
103	Knobcone pine	11	11	11	11	11
104	Foxtail pine	--	--	--	--	11
106	Twoneedle pinyon	--	--	--	--	0
108	Lodgepole pine	11	11	11	11	11
109	Coulter pine	--	--	--	--	7
112	Apache pine	--	--	--	--	0
113	Limber pine	--	--	--	--	11
114	Southwestern white pine	--	--	--	--	0
116	Jeffrey pine	7	7	7	7	7
117	Sugar pine	8	8	8	8	8
118	Chihuahuan pine	--	--	--	--	0

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS
--continued--
BIOMASS OF LIVE BRANCHES

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
119	Western white pine	9	9	9	9	9
120	Bishop pine	--	--	--	--	11
122	Ponderosa pine	7	7	7	7	7
124	Monterey pine	--	--	--	--	11
127	Gray pine	--	--	--	--	7
130	Scotch pine	--	--	--	--	0
133	Singleleaf pinyon	--	--	--	--	11
134	Border pinyon	--	--	--	--	0
135	Arizona pine	--	--	--	--	0
137	Washoe pine	--	--	--	--	7
201	Bigcone Douglas-fir	--	--	--	--	6
202	Douglas-fir	6	6	22	22	6
211	Redwood	10	10	10	10	10
212	Giant Sequoia	10	10	10	10	10
231	Pacific yew	10	10	10	10	10
242	Western redcedar	10	10	10	10	10
251	California nutmeg	--	--	--	--	10
263	Western hemlock	23	23	23	23	12
264	Mountain hemlock	24	24	24	24	17
298	Unknown Conifer	24	24	24	24	17

HARDWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF BARK

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
300	Acacia	--	--	--	--	0
312	Bigleaf maple	29	29	29	29	--
313	Boxelder	--	--	--	--	--
321	Rocky Mountain maple	--	--	--	--	0
322	Bigtooth maple	--	--	--	--	0
330	California buckeye	--	--	--	--	0
341	Tree of heaven	20	20	20	20	20
351	Red alder	20	20	20	20	20
352	White alder	20	20	20	20	20
361	Pacific madrone	34	34	34	34	--
374	Water birch	20	20	20	20	20
375	Paper birch	--	--	--	--	0
376	Western paper birch	--	--	--	--	0
431	Golden chinkapin	32	32	32	32	--
475	Curlleaf mountain-mahogany	--	--	--	--	0
476	True mountain-mahogany	--	--	--	--	0
477	Hairy mountain-mahogany	--	--	--	--	0
478	Birchleaf mountain-mahogany	--	--	--	--	0
479	Littleleaf mountain-mahogany	--	--	--	--	0
492	Pacific dogwood	29	--	29	29	--
500	Hawthorn	--	--	--	--	0
510	Eucalyptus	--	--	--	--	0
542	Oregon ash	20	20	20	20	--
590	Holly	27	27	27	27	--
600	Walnut	30	30	30	30	--
631	Tanoak	36	36	36	36	--
660	Apple	31	31	31	31	--
730	California sycamore	--	--	--	--	0
740	Cottonwood and poplar	--	--	--	--	0
741	Balsam poplar	--	--	--	--	0
742	Eastern cottonwood	--	--	--	--	0
745	Plains cottonwood	--	--	--	--	0
746	Quaking aspen	18	18	18	18	18
747	Black cottonwood	28	28	28	28	18
748	Fremont poplar	18	18	18	18	18
755	Mesquite	--	--	--	--	0
760	Cherry	27	27	27	27	--
800	Oak-deciduous	--	--	--	--	0
801	California live oak	--	--	--	--	0
805	Canyon live oak	31	31	31	31	31

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
807	Blue oak	--	--	--	--	0
810	Emory oak	--	--	--	--	0
811	Englemann oak	--	--	--	--	0
814	Gambel oak	--	--	--	--	0
815	Oregon white oak	35	35	35	35	--
818	California black oak	30	30	30	30	--
821	California white oak	--	--	--	--	0
829	Mexican blue oak	--	--	--	--	0
839	Interior live oak	--	--	--	--	0
843	Silverleaf oak	--	--	--	--	0
850	Oak-evergreen	--	--	--	--	0
901	Black locust	--	--	--	--	0
902	New Mexico locust	--	--	--	--	0
920	Willow	34	34	34	34	--
981	California-laurel	33	33	33	33	--
990	Tesota (Arizona ironwood)	--	--	--	--	0
998	Unknown hardwood	20	20	20	20	20
999	Unknown Tree	35	35	35	35	0

HARDWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF LIVE BRANCHES

Code	Species	WOR	WWA	Halfstate EOR	EWA	CA
300	Acacia	--	--	--	--	0
312	Bigleaf maple	--	--	--	--	--
313	Boxelder	--	--	--	--	0
321	Rocky Mountain maple	--	--	--	--	0
322	Bigtooth maple	--	--	--	--	0
330	California buckeye	--	--	--	--	0
341	Tree of heaven	14	14	14	14	14
351	Red alder	16	16	16	16	16
352	White alder	16	16	16	16	16
361	Pacific madrone	--	--	--	--	--
374	Water birch	14	14	14	14	14
375	Paper birch	--	--	--	--	0
376	Western paper birch	25	25	25	25	3
431	Golden chinkapin	--	--	--	--	--
475	Curlleaf mountain-mahogany	--	--	--	--	0
476	True mountain-mahogany	--	--	--	--	0
477	Hairy mountain-mahogany	--	--	--	--	0
478	Birchleaf mountain-mahogany	--	--	--	--	0
479	Littleleaf mountain-mahogany	--	--	--	--	0
492	Pacific dogwood	--	--	--	--	--
500	Hawthorn	--	--	--	--	0
510	Eucalyptus	--	--	--	--	0
542	Oregon ash	--	--	--	--	--
590	Holly	25	25	25	25	0
600	Walnut	--	--	--	--	--
631	Tanoak	--	--	--	--	--
660	Apple	--	--	--	--	0
730	California sycamore	--	--	--	--	0
740	Cottonwood and poplar	--	--	--	--	0
741	Balsam poplar	--	--	--	--	0
742	Eastern cottonwood	--	--	--	--	0
745	Plains cottonwood	--	--	--	--	0
746	Quaking aspen	14	14	14	14	14
747	Black cottonwood	15	15	15	15	15
748	Fremont poplar	5	5	5	5	5
755	Mesquite	--	--	--	--	0
760	Cherry	25	25	25	25	0
800	Oak-deciduous	--	--	--	--	0
801	California live oak	--	--	--	--	--
805	Canyon live oak	--	--	--	--	--
807	Blue oak	--	--	--	--	--
810	Emory oak	0	0	0	0	0
811	Englemann oak	0	0	0	0	0

Code	Species	WOR	WWA	Halfstate EOR	EWA	CA
814	Gambel oak	--	--	--	--	0
815	Oregon white oak	--	--	--	--	--
818	California black oak	--	--	--	--	--
821	California white oak	--	--	--	--	--
829	Mexican blue oak	--	--	--	--	0
839	Interior live oak	--	--	--	--	--
843	Silverleaf oak	--	--	--	--	0
850	Oak-evergreen	--	--	--	--	0
901	Black locust	--	--	--	--	0
902	New Mexico locust	--	--	--	--	0
920	Willow	--	--	--	--	--
981	California-laurel	--	--	--	--	--
990	Tesota (Arizona ironwood)	--	--	--	--	--
998	Unknown hardwood	16	16	16	16	16
999	Unknown Tree	16	16	16	16	16

SPECIES 312, 330, 361, 431, 492, 600, 631, 801, 805, 807, 811, 815, 818, 821, 839, 920, and 981 hardwood volumes are calculated with Pillsbury equations; this means that total stem volume includes branches and bark, thus bark biomass and live branch biomass are not available as separate components of biomass.

BIOMASS OF BARK

All equations produce Biomass of Bark in Kilograms --- to convert to tons multiply by 0.0011023

Log in the equations is = NATURAL LOG

EQUATION 1 BIOPAK EQUATION 379

$$\mathrm{BB} = \frac{\exp(2.1069 + 2.7271 \times \log(DBH))}{1000}$$

EQUATION 2 BIOPAK EQUATION 887

$$\mathrm{BB} = 0.6 + 16.4 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 3 BIOPAK EQUATION 917

$$\mathrm{BB} = 1.0 + 17.2 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 4 BIOPAK EQUATION 382

$$\mathrm{BB} = \frac{\exp(1.47146 + 2.8421 \times \log(DBH))}{1000}$$

EQUATION 5 BIOPAK EQUATION 251

$$\mathrm{BB} = \frac{\exp(2.79189 + 2.4313 \times \log(DBH))}{1000}$$

EQUATION 6 BIOPAK EQUATION 845

$$\mathrm{BB} = 1.3 + 12.6 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 7 BIOPAK EQUATION 875

$$\mathrm{BB} = 4.5 + 9.3 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 8 BIOPAK EQUATION 5

$$\mathrm{BB} = \exp(-4.3103 + 2.4300 \times \log(DBH))$$

EQUATION 9 BIOPAK EQUATION 705

$$\mathrm{BB} = \exp(-3.6263 + 1.34077 \times \log(DBH) + 0.8567 \times \log(HT))$$

EQUATION 10 BIOPAK EQUATION 391

$$\mathrm{BB} = \frac{\exp(2.183174 + 2.6610 \times \log(DBH))}{1000}$$

EQUATION 11 BIOPAK EQUATION 899

$$\mathrm{BB} = 1.2 + 11.2 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 12 (updated) BIOPAK EQUATION 385

$$\mathrm{BB} = \frac{\exp(-13.3146 + 2.8594 \times \log(DBH)) * 1000}{}$$

EQUATION 13 BIOPAK EQUATION 461

$$\mathrm{BB} = 0.336 + 0.00058 \times DBH^2 \times HT$$

EQUATION 14 BIOPAK EQUATION 904

$$\mathrm{BB} = 3.2 + 9.1 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 15

$$\mathrm{BB} = \exp(-4.371 + 2.259 \times \log(DBH))$$

EQUATION 16 BIOPAK EQUATION 54

$$\mathrm{BB} = \exp(-10.175 + 2.6333 \times \log(DBH \times \pi))$$

EQUATION 17 BIOPAK EQUATION 394

$$\mathrm{BB} = \frac{\exp(7.189689 + 1.5837 \times \log(DBH))}{1000}$$

EQUATION 18 BIOPAK EQUATION 942

$$\mathrm{BB} = 1.3 + 27.6 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 19

$$\mathrm{BB} = 0.0$$

EQUATION 20 BIOPAK EQUATION 275

$$\mathrm{BB} = \exp(-4.6424 + 2.4617 \times \log(DBH))$$

EQUATION 21 BIOPAK EQUATION 911

$$\mathrm{BB} = 0.9 + 27.4 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 22 BIOPAK EQUATION 881

$$\mathrm{BB} = 1.0 + 15.6 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 23 BIOPAK EQUATION 923

$$\mathrm{BB} = 1.8 + 9.6 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 24 BIOPAK EQUATION 893

$$\mathrm{BB} = 2.4 + 15.0 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 25 BIOPAK EQUATION 857

$$\mathrm{BB} = 3.6 + 18.2 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 26 Weyerhaeuser Co Equation

$$\mathrm{BB} = -0.025 + 0.00134 \times DBH^2 \times HT$$

EQUATION 27

$$\mathrm{BB} = -1.2 + 29.1 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 28 BIOPAK EQUATION 930

$$\mathrm{BB} = 1.2 + 15.5 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 29 (Bigleaf maple)

$$ADBH = \frac{(DBH - 0.21235)}{0.94782} \quad (1)$$

$$OUTERVOL = 0.0000246916 \times \left(ADBH^{2.354347}\left(HT^{0.69586}\right)\right) \quad (2)$$

$$INNERVOL = 0.0000246916 \times \left(DBH^{2.354347}\left(HT^{0.69586}\right)\right) \quad (3)$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad (4)$$

EQUATION 30 (California Black Oak)

$$ADBH = \frac{(DBH + 0.68133)}{0.95767} \quad 1$$

$$OUTERVOL = 0.0000386403 \times \left(ADBH^{2.12635}\left(HT^{0.83339}\right)\right) \quad 2$$

$$INNERVOL = 0.0000386403 \times \left(DBH^{2.12635}\left(HT^{0.83339}\right)\right) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 31 (Canyon Live Oak)

$$ADBH = \frac{(DBH + 0.48584)}{0.96147} \quad 1$$

$$OUTERVOL = 0.0000248325 \times \left(ADBH^{2.32519}\left(HT^{0.74348}\right)\right) \quad 2$$

$$INNERVOL = 0.0000248325 \times \left(DBH^{2.32519}\left(HT^{0.74348}\right)\right) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 32 (Golden Chinkapin)

$$ADBH = \frac{(DBH - 0.39534)}{0.90182} \quad 1$$

$$OUTERVOL = 0.000056884 \times \left(ADBH^{2.07202}\left(HT^{0.77467}\right)\right) \quad 2$$

$$INNERVOL = 0.000056884 \times \left(DBH^{2.07202}\left(HT^{0.77467}\right)\right) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 33 (California Laurel)

$$ADBH = \frac{(DBH + 0.32491)}{0.96579} \quad 1$$

$$OUTERVOL = 0.0000237733 \times \left(ADBH^{2.05910}\left(HT^{1.05293}\right)\right) \quad 2$$

$$INNERVOL = 0.0000237733 \times \left(DBH^{2.05910}\left(HT^{1.05293}\right)\right) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 34 **(Pacific Madrone)**

$$ADBH = \frac{(DBH + 0.03425)}{0.98155} \quad 1$$

$$OUTERVOL = 0.0000378129 \times (ADBH^{1.99295}(HT^{1.01532})) \quad 2$$

$$INNERVOL = 0.0000378129 \times (DBH^{1.99295}(HT^{1.01532})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 35 **(Oregon White Oak)**

$$ADBH = \frac{(DBH + 0.78034)}{0.95956} \quad 1$$

$$OUTERVOL = 0.0000236325 \times (ADBH^{2.25575}(HT^{0.87108})) \quad 2$$

$$INNERVOL = 0.0000236325 \times (DBH^{2.25575}(HT^{0.87108})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 36 **(Tanoak)**

$$ADBH = \frac{(DBH + 4.1177)}{0.95354} \quad 1$$

$$OUTERVOL = 0.0000081905 \times (ADBH^{2.19576}(HT^{1.14078})) \quad 2$$

$$INNERVOL = 0.0000081905 \times (DBH^{2.19576}(HT^{1.14078})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

WHERE

Log	= NATURAL LOG
DBH	= DIAMETER OF TREE IN CENTIMETERS
HT	= HEIGHT OF TREE IN METERS
DENSFAC	= DENSITY FACTOR FOR SPECIES
BB	= BIOMASS OF BARK, WEIGHT IN KILOGRAMS, OF THE BARK ON THE TREE BOLE
π	= 3.141593

BIOMASS OF LIVE BRANCHES

All equations produce Biomass of Live Branches in Kilograms --- to convert to tons multiply by 0.0011023

Log in the equations is = NATURAL LOG

Log = natural log

EQUATION 1 BIOPAK EQUATION 889

$$\mathrm{BLB} = 13.0 + 12.4 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 2 BIOPAK EQUATION 919

$$\mathrm{BLB} = 3.6 + 44.2 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 3 BIOPAK EQUATION 28

$$\mathrm{BLB} = \exp\left(-4.1817 + 2.3324 \times \log\left(DBH\right)\right)$$

EQUATION 4 BIOPAK EQUATION 877

$$\mathrm{BLB} = 16.8 + 14.4 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 5 BIOPAK EQUATION 847

$$\mathrm{BLB} = 9.7 + 22.0 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 6 BIOPAK EQUATION 2

$$\mathrm{BLB} = \exp\left(-3.6941 + 2.1382 \times \log\left(DBH\right)\right)$$

EQUATION 7 BIOPAK EQUATION 702

$$\mathrm{BLB} = \exp\left(-4.1068 + 1.5177 \times \log\left(DBH\right) + 1.0424 \times \log\left(HT\right)\right)$$

EQUATION 8

$$\mathrm{BLB} = \exp\left(-7.637 + 3.3648 \times \log\left(DBH\right)\right)$$

EQUATION 9 BIOPAK EQUATION 901

$$\mathrm{BLB} = 9.5 + 16.8 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 10 BIOPAK EQUATION 459

$$\mathrm{BLB} = 0.199 + 0.00381 \times DBH^2 \times HT$$

EQUATION 11 BIOPAK EQUATION 907

$$\mathrm{BLB} = 7.8 + 12.3 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 12

$$\mathrm{BLB} = \exp\left(-4.570 + 2.271 \times \log\left(DBH\right)\right)$$

EQUATION 13 BIOPAK EQUATION 51

$$\mathrm{BLB} = \exp\left(-7.2775 + 2.3337 \times \log\left(DBH \times \pi\right)\right)$$

EQUATION 14 BIOPAK EQUATION 944

$$\mathrm{BLB} = 1.7 + 26.2 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 15 BIOPAK EQUATION 932

$$\mathrm{BLB} = 2.5 + 36.8 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 16

$$\mathrm{BLB} = \exp\left(-4.5648 + 2.6232 \times \log\left(DBH\right)\right) - BF$$

where: $$\mathrm{BF} = \left(\exp\left(-4.5648 + 2.6232 \times \log\left(DBH\right)\right)\right) \times \frac{1}{(2.7638 + 0.062 \times DBH^{1.3364}}$$

EQUATION 17

$$\mathrm{BLB} = \exp\left(-5.2581 + 2.6045 \times \log\left(DBH\right)\right)$$

EQUATION 18 BIOPAK EQUATION 883

$$\mathrm{BLB} = 4.5 + 22.7 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 19 BIOPAK EQUATION 925

$$\mathrm{BLB} = 5.3 + 9.7 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 20 BIOPAK EQUATION 895

$$\mathrm{BLB} = 20.4 + 7.7 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 21 BIOPAK EQUATION 446

$$\mathrm{BLB} = 0.626 + 0.00079 \times DBH^2 \times HT$$

EQUATION 22 BIOPAK EQUATION 859

$$\mathrm{BLB} = 12.6 + 23.5 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 23 Weyerhaeuser Co Equation

$$\mathrm{BLB} = 0.047 + 0.00413 \times DBH^2 \times HT$$

EQUATION 24 BIOPAK EQUATION 913

$$\mathrm{BLB} = 4.2 + 17.4 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 25 BIOPAK EQUATION 950

$$\mathrm{BLB} = -0.6 + 45.1 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

WHERE

Log = NATURAL LOG
DBH = DIAMETER OF TREE IN CENTIMETERS
HT = HEIGHT OF TREE IN METERS
BLB = BIOMASS OF LIVE BRANCHES,
WEIGHT IN KILOGRAMS, OF THE WOOD AND BARK OF LIVE BRANCHES IN THE CROWN
π = 3.141593

Equation 23--outdated

TMP_DBH $= DBH$

If DBH < 6.0 **inches then TMP_DBH** $=$ **6.0 inches and BA** $= 6^2 \times 0.005454154$

$$\textbf{CF4} = 0.299039 + 1.91272 \times \left(\frac{1}{HT}\right) + 0.0000367217 \times \frac{\left(HT^2\right)}{TMP\_DBH} \quad (1)$$

IF CF4 < 0.3 THEN CF4 = 0.3
IF CF4 > 0.4 THEN CF4 = 0.4

$$\textbf{CV4} = 0.005454154 \times TMP\_DBH^2 \times HT \times CF4 \quad (2)$$

$$\textbf{TARIF} = \frac{CV4 \times 0.912733}{BA - 0.087266} \quad (3)$$

IF TMP_DBH > 6.0 THEN

$$\textbf{CVTS} = CV4 \times \frac{\left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)}{\left(BA - 0.087266\right)} \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)}{0.912733} \quad (5)$$

IF TMP_DBH = 6.0 THEN

$$\textbf{SMALL\_TARIF} = 0.5 \times \left(6.0 - DBH\right)^2 + \left(1.0 + 0.063 \times \left(6.0 - DBH\right)^2 \times TARIF\right) \quad (3)$$

IF SMALL_TARIF <= 0.0 THEN SMALL_TARIF = 0.01

$$\textbf{CVTS} = SMALL\_TARIF \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right) \quad (4)$$

$$\textbf{CVT} = \frac{TARIF \times \left(0.9679 - 0.1051 \times 0.5523^{DBH - 1.5}\right) \times \left(\left(1.033 \times \left(1.0 + 1.382937 \times exp\left(-4.015292 \times \left(\frac{DBH}{10.0}\right)\right)\right)\right) \times \left(BA + 0.087266\right) - 0.174533\right)}{0.912733} \quad (5)$$

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
BA = BASAL AREA (DBH IN INCHES) BA= .05454154 x DBH^2
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE NO.27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

ATTACHMENT F

Type of Project:		Data determined by Forest Owner at each verification
Improved Forest Management		Data determined by Forest Owner at time project is registered
		Data calculated automatically

	Reporting Periods	Start Date - 1	2	3	4	5	6	7	8	9	10	11	12	13
	Project Start Date	13-Jun-07												
	Reporting Period Begin Date		13-Jun-07	1-Jan-08	1-Jan-09	1-Jan-10	1-Jan-11	1-Jan-12	1-Jan-13	1-Jan-14	1-Jan-15	1-Jan-16	1-Jan-17	1-Jan-18
	Reporting Period End Date		31-Dec-07	31-Dec-08	31-Dec-09	31-Dec-10	31-Dec-11	31-Dec-12	31-Dec-13	31-Dec-14	31-Dec-15	31-Dec-16	31-Dec-17	31-Dec-18
	Reporting Date		31-Dec-14	31-Dec-14	31-Dec-14	31-Dec-14	31-Dec-14	31-Dec-14	31-Dec-14	31-Dec-14				
Calc Row	**Calculating GHG Reductions/Removals for Onsite Carbon Stocks - All Project Types - all data should be entered as the end of the Reporting Period**													
1	Sampled Onsite Carbon Stocks (tonnes CO_2e)	11,809,132	11,975,895	12,314,132	12,661,921	13,019,533	13,387,245	13,765,342	14,154,118	14,553,874				
2	Confidence Deduction		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%				
3	Adjusted Sampled Onsite Carbon Stocks (adjusted for confidence deduction) (tonnes CO_2e)		11,975,895	12,314,132	12,661,921	13,019,533	13,387,245	13,765,342	14,154,118	14,553,874	-	-	-	-
4	Soil Carbon Emissions													
5	Increment in Actual Onsite Carbon Stocks (tonnes CO_2e)		11,975,895	338,236	347,789	357,612	367,712	378,097	388,776	399,756	-	-	-	-
6	Baseline Onsite Carbon Stocks (tonnes CO_2e)	11,809,132	10,140,581	10,140,581	10,140,581	10,140,581	10,140,581	10,140,581	10,140,581	10,140,581				
7	Increment in Baseline Onsite Carbon Stocks (tonnes CO_2e)			-	-	-	-	-	-	-	-	-	-	-
8	Quantified GHG Reductions / Removals for Onsite Carbon Stocks (tonnes CO_2e)		1,835,314	338,236	347,789	357,612	367,712	378,097	388,776	399,756	-	-	-	-
Calc Row	**Calculating Carbon Stored in Wood Products Including Market Effects and Leakage - All Project Types - all data should be entered as the end of the Reporting Period**													
9	Actual Carbon in Trees Harvested for Wood Products in (tonnes CO_2e)		-	-	-	-	-	7,978	8,345	18,218				
10	Baseline Carbon in Trees Harvested for Wood Products (tonnes CO_2e)		86,908	173,815	173,815	173,815	173,815	173,815	173,815	173,815				
11	Actual Carbon in Harvested Wood Delivered to Mills (tonnes CO_2e)		-	-	-	-	-	3,701	3,871	8,450				
12	Baseline Carbon in Harvested Wood Delivered to Mills (tonnes CO_2e)		40,311	80,622	80,622	80,622	80,622	80,622	80,622	80,622				
13	Actual Carbon Stored Long-term in Wood Products (tonnes CO2e) - Excl Landfill		-	-	-	-	-	1,149	1,202	2,624				
14	Actual Carbon Stored Long-term in Wood Products (tonnes CO2e) - Incl Landfill		-	-	-	-	-	1,891	1,978	4,319				
15	Baseline Carbon Stored Long-term in Wood Products (tonnes CO2e) - Excl Landfill		12,517	25,034	25,034	25,034	25,034	25,034	25,034	25,034				
16	Baseline Carbon Stored Long-term in Wood Products (tonnes CO2e) - Incl Landfill		20,604	41,207	41,207	41,207	41,207	41,207	41,207	41,207				
17	Diff Between Actual and Baseline Carbon in Harvested Wood (tonnes CO_2e) - Excl Landfill		(12,517)	(25,034)	(25,034)	(25,034)	(25,034)	(23,885)	(23,832)	(22,410)	0	0	0	0
18	Difference Between Actual and Baseline Carbon in Harvested Wood (tonnes CO_2e) - Incl Landfill		(20,604)	(41,207)	(41,207)	(41,207)	(41,207)	(39,316)	(39,229)	(36,888)	0	0	0	0
19	Difference in Actual and Baseline Carbon Stored in Wood Products (tonnes CO_2e) - Landfill Adj		(20,604)	(41,207)	(41,207)	(41,207)	(41,207)	(39,316)	(39,229)	(36,888)	0	0	0	0
20	GHG Reductions / Removals for Carbon Stored in Wood Products (tonnes CO_2e) w/ mkt response		(16,483)	(32,966)	(32,966)	(32,966)	(32,966)	(31,453)	(31,383)	(29,511)	0	0	0	0
Calc Row	**Calculation Other Secondary Effects - Reforestation Projects - all data should be entered as has occurred during Reporting Period**													
21	Mobile Combustion Emission Factor (average tonnes CO_2e per acre)													
22	Initial Site Prep Acres in Project Area (Acres)													
23	One-time combustion emissions associated with machinery use in site preparation (CO_2e tonnes)		-	-	-	-	-	-	-	-	-	-	-	-
24	Leakage Risk Percentage for Leakage from Shifting Cropland and Grazing Activities (%)			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
25	Secondary Effect emissions due to shifting cropland or grazing activities (tonnes CO_2e)		-	-	-	-	-	-	-	-	-	-	-	-
26	Other Secondary Effect Emissions for Reforestation Projects (tonnes CO_2e)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc Row	**Calculating Other Secondary Effects - Improved Forest Management Projects**													
27	Difference Between Actual and Baseline Carbon in Trees Harvested for Wood Products (tonnes CO_2e)		(86,908)	(173,815)	(173,815)	(173,815)	(173,815)	(165,837)	(165,471)	(155,598)	-	-	-	-
28	Other Secondary Effects Emissions (shifting activities/materials) IFM Projects (tonnes CO_2e)		(17,382)	(34,763)	(34,763)	(34,763)	(34,763)	(33,167)	(33,094)	(31,120)	-	-	-	-
Calc Row	**Determing the Uncertainty Discount Factor and Calculating Other Secondary Effects - Avoided Conversion Projects**													
29	Appraised Fair Market Value of Anticipated Alternative Land Use of Project Area (000$)													
30	Appraised Fair Market Value of the Current Forested Land use of Project Area (000$)													
31	Avoided Conversion Discount Factor		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
32	Quantified GHG Reductions / Removals for Onsite Carbon Stocks (tonnes CO_2e)		1,835,314	338,236	347,789	357,612	367,712	378,097	388,776	399,756	-	-	-	-
33	Other Secondary Effect Emissions for Avoided Conversion Projects (tonnes CO_2e)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Calc Row	**Quantified GHG Reductions and Removals**													
34	Annual GHG Reductions/Removals Net of Discounts and Secondary Effects (tonnes CO_2e)		1,801,450	270,508	280,060	289,883	299,983	313,477	324,299	339,126	0	0	0	0
35	Cumulative GHG Reductions/Removals; not incl.neg. carryover or reversals (tonnes CO_2e)		1,801,450	2,071,957	2,352,018	2,641,901	2,941,884	3,255,361	3,579,660	3,918,786	3,918,786	3,918,786	3,918,786	3,918,786
36	Cumulative Negative Carryover from Prior Year (tonnes CO_2e)			0	0	0	0	0	0	0	0	0	0	0
37	CRTs Issued - Net of Negative Carryover, bef. Buffer or adjust for Reversals (tonnes CO2e)		1,801,449	270,507	280,060	289,883	299,983	313,477	324,298	339,125	0	0	0	0
Calc Row	**Calculation of Buffer Pool Contribution - all data should be entered as end of Reporting Period**													
38	Project Specific Reversal Risk Rating		19.2%	19.2%	19.2%	19.2%	19.2%	19.2%	19.2%	19.2%				
39	CRTs from other Reporting Periods submitted to Buffer Pool													
40	Buffer Pool Contributions (CRTs)		345,879	51,938	53,772	55,658	57,597	60,188	62,266	65,112	-	-	-	-
Calc Row	**Accounting for Reversals - all data should be reported as sum during Reporting Period**													
41	Annual Reversals (tonnes CO_2e)		-	-	-	-	-	-	-	-	-	-	-	-
42	Total "Avoidable Reversals" to be compensated by the Forest Owner (tonnes CO_2e)													
43	"Unavoidable Reversals" compensated by the Reservefrom the Buffer Pool (tonnes CO_2e)		-	-	-	-	-	-	-	-	-	-	-	-
Calc Row	**Compensating for Avoidable Reversals - all data should be reported as sum during Reporting Period**													
44	"Avoidable Reversals" compensated by retirement of CRTs in the Forest Owners Reserve Account (tonnes CO2e)													
45	"Avoidable Reversals" compensated by retirement of CRTs issued to other Forest Projects Registered with the Reserve (tonnes CO2e)													
46	Carryover "Avoidable Reversals" which need to be compensated by Forest Owner (tonnes CO2e)		-	-	-	-	-	-	-	-	-	-	-	-
Calc Row	**CRTs Issued to Account Holder - following verification**													
47	Annual CRTs Issued to Account Holder		1,455,570	218,569	226,288	234,225	242,386	253,289	262,032	274,013	-	-	-	-
48	Vintage I-Calendar year of Reporting Period start date (Vintage)		**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
49	Portion of CRTs in first vintage in Reporting Period		1,455,570	218,569	226,288	234,225	242,386	253,289	262,032	274,013	-	-	-	-
50	Vintage II - Calendar year of Reporting Period end date (Vintage - if different from start date vintage)													
51	Portion of CRTs in second vintage Reporting Period		-	-	-	-	-	-	-	-	-	-	-	-
52	Cumulative CRTs Issued to Account Holder		1,455,570	1,674,139	1,900,427	2,134,652	2,377,038	2,630,327	2,892,359	3,166,372	3,166,372	3,166,372	3,166,372	3,166,372

Notes	Equation(s) Reference	Symbol Reference (FPP)
This is the total carbon in all reported pools within the Project Area, reported as a best estimate, regardless of statistical confidence.	6.1	$AC_{onsite, y}$
The confidence deduction is based on the sampling error of the combined estimate of carbon in all onsite carbon pools (Appendix A, Section A.4). Can't be greater than 15% or the project is not eligible.	6.1	CD_y
Actual onsite carbon stocks adjusted using the confidence deduction.	6.1	$AC_{onsite, y}$ x $(1-CD_y)$
Emissions from Management Activities		
Difference in onsite carbon from prior year In year 1, prior year stocks are set to zero, so the increment is equal to initial adjusted onsite carbon stocks.	6.1	ΔAC_{onsite}
Baseline estimates of onsite carbon stocks are not affected by the confidence deduction. Baseline carbon stocks are determined from an initial inventory and are modeled thereafter following the guidelines in FPP Section 6.	6.1	$BC_{onsite, y}$
Difference in baseline onsite carbon from prior year. In year 1, prior year stocks are set to zero, so the increment is equal to initial (unadjusted) onsite carbon stocks.	6.1	ΔBC_{onsite}
In the initial data at Start Date, the difference between the actual and baseline carbon stocksFor all other Reporting periods, the difference between the increments in actual and baseline carbon stocks may be negative, which would indicate that a reversal has occurred (if credits were issued in any previous year). If no CRTs have been issued previously, then any negative amount is added to the "negative carryover".	6.1	$\Delta AC_{onsite} - \Delta BC_{onsite}$
Based on actual carbon in standing live carbon stocks harvested in each period, prior to delivery to mills. Guidance for providing this number in Appendix C (C.1).	C.2	$AC_{hv, n}$
Based on estimated carbon in standing live carbon stocks harvested each period in the baseline, prior to delivery to mills. Guidance for providing this number in Appendix C (C.1).	C.2	$BC_{hv, n}$
Based on actual amount of carbon harvested in each period that is delivered to mills. Guidance for calculating and providing this number in Appendix C (C.1). Biomass Equations available on the Forest Project Protocol Resources section of the Reserve's website.		
Based on estimated amount of carbon harvested in each period in the baseline that is delivered to mills. Guidance for calculating and providing this number in Appendix C (C.1). Biomass Equations available on the Forest Project Protocol Resources section of the Reserve's website.		
Calculated from guidance in Appendix C. See worksheet "Wood Prod - Factors." This value represents the average amount of carbon (tonnes CO2e) contained in in-use wood products, as calcuated over a 100-year time period for the actual project.	C.1	$WP_{in\text{-}use, y}$
Calculated from guidance in Appendix C. See worksheet "Wood Prod - Factors." This value represents the average amount of carbon (tonnes CO2e) contained in both in-use and landfilled wood products, as calcuated over a 100-year time period fo actual project.	C.2, C.3	$WP_{total, y}$
Calculated from guidance in Appendix C. See worksheet "Wood Prod - Factors." This value represents the average amount of carbon (tonnes CO2e) contained in in-use wood products, as calcuated over a 100-year time period for the baseline.	C.1	$WP_{in\text{-}use, y}$
Calculated from guidance in Appendix C. See worksheet "Wood Prod - Factors." This value represents the average amount of carbon (tonnes CO2e) contained in both in-use and landfilled wood products, as calcuated over a 100-year time period fo baseline.	C.2, C.3	$WP_{total, y}$
Calculated from lines 10 and 12.	6.1	$AC_{wp, y} - BC_{wp, y}$
Calculated from lines 11 and 13.	6.1	$AC_{wp, y} - BC_{wp, y}$
Difference between actual and baseline carbon stored long-term in wood products in each year. May be negative. If total *cumulative* actual harvested volumes exceed total *cumulative* baseline harvested volumes (through previous period), then calculation will *exclude* carbon in landfills. If total cumulative actual harvested volumes are less than total cumulative baseline harvested volumes (through previous period), then this calculation will *include* carbon in landfills.	C.2, 6.1	$AC_{wp, y} - BC_{wp, y}$
The difference from above line is multiplied by 80% to account for market responses to changes in wood product production. Thus, any one tonne increase/decrease in wood product production will result in only a 0.8 tonne increase/decrease overall because other landowners will decrease/increase production by 0.2 tonnes in response. The result is the net quantified GHG reductions/removals for carbon stored in wood products.	6.1	$(AC_{wp, y} - BC_{wp, y})*80\%$
Mobile combustion emission factor from Table 6.1 in the FPP. Units are Average tonnes CO_2e per acre. Matched to the acres undergoing initial site prep in that particular period.	6.2	EF_{mc}
The portion of the Project Area, in acres, undergoing initial site prep activities prior to planting seedlings in that period.	6.2	PA (adjusted for applicable period)
To quantify combustion emissions associated with initial site preparation, the appropriate standard emission factor is multiplied by the number of acres in the Project Area for that period.	6.2	MC_y
Leakage risk percentage determined by risk assessment for Reforestation Projects in Figure 6.3 of the FPP. The leakage risk percentage must only be determined once, at the outset of the project.	6.3	L
Each year, this percentage must be applied to the net increase in onsite carbon stocks to determine the annual Secondary Effects due to shifting of cropland or grazing activities.	6.3	AS_y
Add the secondary emissions from mobile combustion (line 20) to the secondary emissions from leakage of shifting activity to cropland or agriculture. Cannot be higher than 0.	6.4	SE_y
The difference between the values in actual and baseline carbon in harvested wood. (Difference in Rows 8 and 9)	6.10	$AC_{hv, n} - BC_{hv, n}$
If actual harvest is less than baseline harvest on a cumulative basis through the previous reporting period, then this value will be 20% of the difference between actual and baseline harvest prior to delivery to mills in the given reporting period. If actual harvest is greater than baseline harvest, on a cumulative basis through the previous reporting period, this value will be zero in the given reporting period.	6.10	SE_y
The appraised fair market value of the anticipated alternative land use for the Project Area as determined by the appraisal required in Section 3.1.2.3 of the FPP	6.11	VA
The appraised fair market value of the current forested land use for the Project Area as determined by the appraisal required in Section 3.1.2.3 of the FPP	6.11	VP
If the value of the alternative land use is less than 80% greater than the value of the current forested land use, then a discount factor must be applied each year to the project's quantified GHG reductions and removals. If the appraised alternative is less than 40% greater, the discount is 100% and the project is ineligible. If the quantified GHG reductions and removals for the year are negative, then the discount is equal to 0. If it is not an Avoided Conversion Project Type, it is equaol to 0.	6.11	ACD
Difference between the increments in actual and baseline onsite carbon stocks from above. (Copied from Row 7)	6.12	$\Delta AC_{onsite} - \Delta BC_{onsite}$
Calculation of secondary effects for Avoided Conversion Projects which can arise if the type of land use conversion that would have happened on the Project Area is shifted to other forest land. Calculated using equation 6.12 in the FPP.	6.12	SE_y
Equal to the sum of the values in lines 7, 17, and project-type specific other secondary effect emissions, adjusted by the Avoided Conversion Discount Factor (Line 28) for Avoided Conversion projects where appropriate.	6.1	
Cumulative Gross CRTs produced by the project.		
If annual GHG reductions or removals are negative prior to the first issuance of CRTs for a project, the negative amount is carried forward as a debit to future year totals. This line tracks any negative carryover prior to the issuance of CRTs.	6.1	N_{y-1}
Total number of CRTs the Reserve will issue for quantified GHG reductions/removals. CRTs are not issued for partial tonnes. Cannot be a negative number.	6.1	QR_y
This value is determined by completing a reversal risk analysis according to the requirements in Appendix D.		
The number of CRTs that must be contributed to the Buffer Pool each year, based on the risk of reversal. Calculated by mutliplying the the total net GHG reductions/removals by the project specific reversal risk rating. Any remainder must be rounded up.		
If CRTs have been issued to a project in previous years, then any negative GHG reductions/removals are treated as a reversal. This line tracks such reversals. If a reversal lowers the Forest Project's actual standing live carbon stocks below its approved baseline standing live carbon stocks, the Forest Project will be terminated.		
The Reserve requires that all reversals be compensated through the retirement of CRTs. If a reversal was avoidable (as defined in FPP, Section 7.3.2) then the Forest Owner must compensate for the reversal by surrendering CRTs from its Reserve account.		
If a reversal associated with a Forest Project was unavoidable (as defined in FPP Section 7.3.1), then the Reserve will compensate for the reversal on the Forest Owner's behalf by retiring CRTs from the Buffer Pool. This is calculated by subtracting Row 38 from Row 37.		
This value is equal to the quantity of CRTs retired from the Forest Owner's account issued to the Forest Project. (FPP, Section 7.3.2)		
This value is equal to the quantity of CRTs retired from the Forest Owner's account issued to other Forest Projects registered on the Reserve. (FPP, Section 7.3.2)		
Carryover reversals which need to be compensated for by the Forest Owner.		
Net CRTs issued to the project. This number cannot be negative.		
Cumulative Net CRTs issued to the project. This number cannot be negative.		

ATTACHMENT G

Harvested Wood Products Worksheet

The Harvested Wood Products (HWP) Worksheet is designed to standardize and facilitate the reporting of harvested wood products for each Reporting Period in the Calculation Worksheet. The HWP worksheet produces standardized outputs that Project Developers must insert into the Calculation Worksheet for the following areas:

1) Actual Project Carbon in Harvested Wood Delivered to Mill (tCO2e)
2) Actual Project Carbon in Trees Harvested for Wood Products (tCO2e)
3) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
4) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill
5) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
6) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill

The default values (conversions, mill efficiencies, etc) must be used unless the Project Developer can provide verifiable alternatives. The HWP worksheet is divided into 3 sections (Data Inputs, Estimates of Carbon Storage in Wood Products and Emissions associated with Harvested Trees, and Conversion Assumptions). Project Developers must make a separate copy of the HWP worksheet for each Reporting Period and submit it as part of the Annual Monitoring Report.

Section 1. Data Inputs

Table 1. Key to worksheet inputs

The key below provides a color-coded reference to cells in this worksheet. User action is required wherever a 'Step' is mentioned.

Step Guidance	
Project data entered by Project Developer	
Assumptions and/or data populated automatically	
Default Values	
Data calculated automatically for input into the Calculation Worksheet	

Table 2. Project Characteristics

Step 1. Using the pull-down menus where provided, enter the current reporting period project data into Table 2. If multiple hardwood and/or softwood harvest units were recorded, consolidate into one hardwood and one softwood harvest unit using the values in Table 9.

Region*:	Pacific Southwest (PSW)
Reporting Period:	1/1/2012 to 12/31/2012
Hardwood Harvest Units:	Cubic Feet
Softwood Harvest Units:	MBF-Scribner ("Large" or "Long")

***From the Reserve's Assessment Area Data File.**

Table 3. Default Wood Products Classes; Volume Totals

Step 2. If the default wood products classes are being used, enter the appropriate values from the Assessment Area data file and proceed to **Step 3** if harvesting occurred or **Step 5** if there was no harvest. If the actual distribution of wood products generated from the reporting period harvest is known, skip this step and proceed to **Step 4**.

Softwood Lumber	Hardwood Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Miscellaenous	Paper
97%	0%	2%	0%	0%	0%	1%

Step 3. If the default wood products classes are being used, enter the total amount of wood delivered to the mill(s) and proceed to **Step 5**.

Hardwood		Softwood	
Total	0	Total	1,230.97
%	0%	%	100%

Table 4. Volume in Logs Delivered to Mill

Step 4. Enter the name of the mill(s) and the volume of harvested wood sent to the mill(s) during the current reporting period in Table 4. Both the hardwood and softwood volumes must be categorized based on the wood product classes shown below. If wood products class data is only partially available, categorize the unknown wood products as "miscellaneous". If wood products class data is unavailable **or no wood products were harvested in the current reporting period**, refer to **Steps 2 and 3**. Default mill efficiencies are listed in Table 12. These default values may be overwritten if mill-specific data is available and verifiable.

	Hardwood							Softwood							
	Wood Product Classes							Wood Product Classes							
Mill	*Mill Efficiency*	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper	*Mill Efficiency*	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
Gross Total:		-	-	-	-		-	-	-	-	-	-	-		-
Net Total:		-	-	-	-		-	-	-	-	-	-	-		-

Section 2. Estimates of Carbon Storage in Wood Products and Emissions Associated with Harvested Trees

Table 5. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Project Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
Project carbon in harvested wood delivered to mills (Cubic Feet)	-	-	-	-	-	173,256	3,345	-	436	173	1,281	178,491
Project carbon in harvested wood delivered to mills (tCO_2e)	-	-	-	-	-	3,592	69	-	9	4	27	3,701
Project carbon transferred to wood products (Cubic Feet)	-	-	-	-	-	116,948	2,258	-	294	117	864	120,481
Project carbon transferred to wood products (tCO_2e)	-	-	-	-	-	2,425	47	-	6	2	18	2,498
% Product	0%	0%	0%	0%	0%	97%	2%	0%	0%	0%	1%	100%
Long-term storage in in-use wood products (tCO_2e)	-	-	-	-	-	1,123	23	-	2	0	1	1,149
Long-term storage in wood products in landfills (tCO_2e)	-	-	-	-	-	723	13	-	2	1	3	742

Table 6. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Baseline Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
tCO2e	-	-	-	-	-	52,824	1,020	-	133	53	390	54,420
% Product	0%	0%	0%	0%	0%	97%	2%	0%	0%	0%	1%	100%
Long-term storage in in-use wood products (tCO2e)	-	-	-	-	-	24,458	494	-	51	9	23	25,034
Long-term storage in wood products in landfills (tCO2e)	-	-	-	-	-	15,742	293	-	46	24	70	16,173

Table 7. Calculation Worksheet Information

Calculation Sheet Inputs (for Current Reporting Period)		Row Location in Calculation Worksheet
Actual Project Carbon in Harvested Wood Delivered to Mill (tCO2e)	3,701	11 (Excel 22)
Actual Project Carbon in Trees Harvested for Wood Products (tCO2e)	7,978	9 (Excel 20)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	1,149	13 (Excel 24)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	1,891	14 (Excel 25)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	25,034	15 (Excel 26)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	41,207	16 (Excel 27)

Table 8. Ratio of Harvested Wood Carbon to Harvested Tree Carbon

Step 5. Enter the 100-year baseline data to calculate a ratio of carbon in trees harvested for wood products to carbon in harvested wood delivered to the mill.

Baseline Carbon in Trees Harvested for Wood Products (tCO_2e) (from Excel Row 21 of the Monitoring Calculation Worksheet)	173815.28
Baseline Carbon in Harvested Wood Delivered to Mill (tCO_2e) (from Row 23 of the Monitoring Calculation Worksheet)	80622.39
Multiplier of Carbon in Wood Delivered to Mill to Carbon in Trees Harvested for Wood Products	**2.16**

Section 3. Conversion Assumptions

Table 9. Volume multipliers for converting timber and chip units to Cubic Feet

Unit	Factor
Bone Dry Tons	71.3
Bone Dry Units	82.5
Cords	75
Cubic Feet	1
Cubic Meters	35.3
Cunits-Chips (CCF)	100
Cunits-Roundwood	100
Cunits-Whole tree chip	126
Green tons	31.5
MBF-Doyle	222
MBF-International 1/4"	146
MBF-Scribner ("C" or "Small")	165
MBF-Scribner ("Large" or "Long")	145
MCF-Thousand Cubic Feet	1000
Oven Dried Tonnes	75.8

Source: American Forest & Paper Association, Sustainable Forestry Initiative Program Annual Progress Reporting Form

Table 10. Conversion Factors: to convert volume estimates to CO2-e

		Source
Cubic Feet / Hardwood Harvest Unit	1	Table 9.
Cubic Feet / Softwood Harvest Unit	145	Table 9.
SG of Softwoods by Region	0.399	Table 12.
SG of Hardwoods by Region	0.51	Table 12.
Tree Carbon:Wood Carbon	2.16	Table 8.
Pounds to Metric Tons	0.0004535970	-
Portion of Carbon in Biomass	0.5	-
Carbon to CO2-e	3.67	Reserve FPP
Density of water (lbs/cf)	62.43	-

Table 11. 100-year average storage factors

Wood Product Class	In-Use	Landfills
Softwood Lumber	0.463	0.298
Hardwood Lumber	0.250	0.414
Softwood Plywood	0.484	0.287
Oriented Strandboard	0.582	0.233
Non Structural Panels	0.380	0.344
Miscellaneous Products	0.176	0.454
Paper	0.058	0.178

Source: Reserve Forest Project Protocol, Appendix C.3 & C.4

Table 12. Average regional factors: specific gravity (SG) and mill efficiencies (ME)

	Hardwoods			Softwoods		
Region	SG	Saw Log ME	Pulp ME	SG	Saw Log ME	Pulp ME
Northeast (NE)	0.518	0.614	0.650	0.371	0.569	0.513
Northern Lake States (NLS)	0.473	0.585	0.685	0.360	0.630	0.514
Northern Prairie States (NPS)	0.537	0.585	0.685	0.434	0.630	0.514
Pacific Northwest, East (PWE)	0.424	0.568	0.568	0.396	0.637	0.637
Pacific Northwest, West (PWW)	0.415	0.531	0.531	0.426	0.740	0.500
Pacific Southwest (PSW)	0.510	0.568	0.568	0.399	0.675	0.675
Rocky Mountain, North (RMN)	0.389	0.568	0.568	0.394	0.704	0.704
Rocky Mountain, South (RMS)	0.353	0.568	0.568	0.369	0.704	0.704
Southeast (SE)	0.508	0.609	0.591	0.462	0.636	0.553
South Central (SC)	0.529	0.587	0.581	0.463	0.629	0.570

Sources: USDA Forest Service, Forest Inventory and Analysis Program database of forest surveys (SG) and *Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program* (ME). Average wood specific gravity is the density of wood divided by the density of water based on wood dry mass associated with green tree volume.

Harvested Wood Products Worksheet

The Harvested Wood Products (HWP) Worksheet is designed to standardize and facilitate the reporting of harvested wood products for each Reporting Period in the Calculation Worksheet. The HWP worksheet produces standardized outputs that Project Developers must insert into the Calculation Worksheet for the following areas:

1) Actual Project Carbon in Harvested Wood Delivered to Mill (tCO2e)
2) Actual Project Carbon in Trees Harvested for Wood Products (tCO2e)
3) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
4) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill
5) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
6) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill

The default values (conversions, mill efficiencies, etc) must be used unless the Project Developer can provide verifiable alternatives. The HWP worksheet is divided into 3 sections (Data Inputs, Estimates of Carbon Storage in Wood Products and Emissions associated with Harvested Trees, and Conversion Assumptions). Project Developers must make a separate copy of the HWP worksheet for each Reporting Period and submit it as part of the Annual Monitoring Report.

Section 1. Data Inputs

Table 1. Key to worksheet inputs

The key below provides a color-coded reference to cells in this worksheet. User action is required wherever a 'Step' is mentioned.

Step Guidance	
Project data entered by Project Developer	
Assumptions and/or data populated automatically	
Default Values	
Data calculated automatically for input into the Calculation Worksheet	

Table 2. Project Characteristics

Step 1. Using the pull-down menus where provided, enter the current reporting period project data into Table 2. If multiple hardwood and/or softwood harvest units were recorded, consolidate into one hardwood and one softwood harvest unit using the values in Table 9.

Region*:	Pacific Southwest (PSW)
Reporting Period:	1/1/2013 to 12/31/2013
Hardwood Harvest Units:	Cubic Feet
Softwood Harvest Units:	MBF-Scribner ("Large" or "Long")

***From the Reserve's Assessment Area Data File.**

Table 3. Default Wood Products Classes; Volume Totals

Step 2. If the default wood products classes are being used, enter the appropriate values from the Assessment Area data file and proceed to **Step 3** if harvesting occurred or **Step 5** if there was no harvest. If the actual distribution of wood products generated from the reporting period harvest is known, skip this step and proceed to **Step 4**.

Softwood Lumber	Hardwood Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Miscellaenous	Paper
97%	0%	2%	0%	0%	0%	1%

Step 3. If the default wood products classes are being used, enter the total amount of wood delivered to the mill(s) and proceed to **Step 5**.

Hardwood		Softwood	
Total	0	Total	1,287.48
%	0%	%	100%

Table 4. Volume in Logs Delivered to Mill

Step 4. Enter the name of the mill(s) and the volume of harvested wood sent to the mill(s) during the current reporting period in Table 4. Both the hardwood and softwood volumes must be categorized based on the wood product classes shown below. If wood products class data is only partially available, categorize the unknown wood products as "miscellaneous". If wood products class data is unavailable **or no wood products were harvested in the current reporting period**, refer to **Steps 2 and 3**. Default mill efficiencies are listed in Table 12. These default values may be overwritten if mill-specific data is available and verifiable.

	Hardwood							Softwood							
	Wood Product Classes							Wood Product Classes							
Mill	*Mill Efficiency*	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper	*Mill Efficiency*	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
Gross Total:		-	-	-	-		-	-	-	-	-	-	-		-
Net Total:		-	-	-	-		-	-	-	-	-	-	-		-

Section 2. Estimates of Carbon Storage in Wood Products and Emissions Associated with Harvested Trees

Table 5. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Project Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
Project carbon in harvested wood delivered to mills (Cubic Feet)	-	-	-	-	-	181,209	3,499	-	456	181	1,339	186,685
Project carbon in harvested wood delivered to mills (tCO_2e)	-	-	-	-	-	3,757	73	-	9	4	28	3,871
Project carbon transferred to wood products (Cubic Feet)	-	-	-	-	-	122,316	2,362	-	308	122	904	126,012
Project carbon transferred to wood products (tCO_2e)	-	-	-	-	-	2,536	49	-	6	3	19	2,613
% Product	0%	0%	0%	0%	0%	97%	2%	0%	0%	0%	1%	100%
Long-term storage in in-use wood products (tCO_2e)	-	-	-	-	-	1,174	24	-	2	0	1	1,202
Long-term storage in wood products in landfills (tCO_2e)	-	-	-	-	-	756	14	-	2	1	3	776

Table 6. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Baseline Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
tCO2e	-	-	-	-	-	52,824	1,020	-	133	53	390	54,420
% Product	0%	0%	0%	0%	0%	97%	2%	0%	0%	0%	1%	100%
Long-term storage in in-use wood products (tCO2e)	-	-	-	-	-	24,458	494	-	51	9	23	25,034
Long-term storage in wood products in landfills (tCO2e)	-	-	-	-	-	15,742	293	-	46	24	70	16,173

Table 7. Calculation Worksheet Information

Calculation Sheet Inputs (for Current Reporting Period)		Row Location in Calculation Worksheet
Actual Project Carbon in Harvested Wood Delivered to Mill (tCO2e)	3,871	11 (Excel 22)
Actual Project Carbon in Trees Harvested for Wood Products (tCO2e)	8,345	9 (Excel 20)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	1,202	13 (Excel 24)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	1,978	14 (Excel 25)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	25,034	15 (Excel 26)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	41,207	16 (Excel 27)

Table 8. Ratio of Harvested Wood Carbon to Harvested Tree Carbon

Step 5. Enter the 100-year baseline data to calculate a ratio of carbon in trees harvested for wood products to carbon in harvested wood delivered to the mill.

Baseline Carbon in Trees Harvested for Wood Products (tCO_2e) (from Excel Row 21 of the Monitoring Calculation Worksheet)	173815.28
Baseline Carbon in Harvested Wood Delivered to Mill (tCO_2e) (from Row 23 of the Monitoring Calculation Worksheet)	80622.39
Multiplier of Carbon in Wood Delivered to Mill to Carbon in Trees Harvested for Wood Products	**2.16**

Section 3. Conversion Assumptions

Table 9. Volume multipliers for converting timber and chip units to Cubic Feet

Unit	Factor
Bone Dry Tons	71.3
Bone Dry Units	82.5
Cords	75
Cubic Feet	1
Cubic Meters	35.3
Cunits-Chips (CCF)	100
Cunits-Roundwood	100
Cunits-Whole tree chip	126
Green tons	31.5
MBF-Doyle	222
MBF-International 1/4"	146
MBF-Scribner ("C" or "Small")	165
MBF-Scribner ("Large" or "Long")	145
MCF-Thousand Cubic Feet	1000
Oven Dried Tonnes	75.8

Source: American Forest & Paper Association, Sustainable Forestry Initiative Program Annual Progress Reporting Form

Table 10. Conversion Factors: to convert volume estimates to CO2-e

		Source
Cubic Feet / Hardwood Harvest Unit	1	Table 9.
Cubic Feet / Softwood Harvest Unit	145	Table 9.
SG of Softwoods by Region	0.399	Table 12.
SG of Hardwoods by Region	0.51	Table 12.
Tree Carbon:Wood Carbon	2.16	Table 8.
Pounds to Metric Tons	0.0004535970	-
Portion of Carbon in Biomass	0.5	-
Carbon to CO2-e	3.67	Reserve FPP
Density of water (lbs/cf)	62.43	-

Table 11. 100-year average storage factors

Wood Product Class	In-Use	Landfills
Softwood Lumber	0.463	0.298
Hardwood Lumber	0.250	0.414
Softwood Plywood	0.484	0.287
Oriented Strandboard	0.582	0.233
Non Structural Panels	0.380	0.344
Miscellaneous Products	0.176	0.454
Paper	0.058	0.178

Source: Reserve Forest Project Protocol, Appendix C.3 & C.4

Table 12. Average regional factors: specific gravity (SG) and mill efficiencies (ME)

	Hardwoods			Softwoods		
Region	SG	Saw Log ME	Pulp ME	SG	Saw Log ME	Pulp ME
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Northern Prairie States (NPS)	0.537	0.585	0.685	0.434	0.630	0.514
Pacific Northwest, East (PWE)	0.424	0.568	0.568	0.396	0.637	0.637
Pacific Northwest, West (PWW)	0.415	0.531	0.531	0.426	0.740	0.500
Pacific Southwest (PSW)	0.510	0.568	0.568	0.399	0.675	0.675
Rocky Mountain, North (RMN)	0.389	0.568	0.568	0.394	0.704	0.704
Rocky Mountain, South (RMS)	0.353	0.568	0.568	0.369	0.704	0.704
Southeast (SE)	0.508	0.609	0.591	0.462	0.636	0.553
South Central (SC)	0.529	0.587	0.581	0.463	0.629	0.570

Sources: USDA Forest Service, Forest Inventory and Analysis Program database of forest surveys (SG) and *Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program* (ME). Average wood specific gravity is the density of wood divided by the density of water based on wood dry mass associated with green tree volume.

Harvested Wood Products Worksheet

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3) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
4) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill
5) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
6) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill

The default values (conversions, mill efficiencies, etc) must be used unless the Project Developer can provide verifiable alternatives. The HWP worksheet is divided into 3 sections (Data Inputs, Estimates of Carbon Storage in Wood Products and Emissions associated with Harvested Trees, and Conversion Assumptions). Project Developers must make a separate copy of the HWP worksheet for each Reporting Period and submit it as part of the Annual Monitoring Report.

Section 1. Data Inputs

Table 1. Key to worksheet inputs

The key below provides a color-coded reference to cells in this worksheet. User action is required wherever a 'Step' is mentioned.

Step Guidance	
Project data entered by Project Developer	
Assumptions and/or data populated automatically	
Default Values	
Data calculated automatically for input into the Calculation Worksheet	

Table 2. Project Characteristics

Step 1. Using the pull-down menus where provided, enter the current reporting period project data into Table 2. If multiple hardwood and/or softwood harvest units were recorded, consolidate into one hardwood and one softwood harvest unit using the values in Table 9.

Region*:	Pacific Southwest (PSW)
Reporting Period:	1/1/2014 to 12/31/2014
Hardwood Harvest Units:	Cubic Feet
Softwood Harvest Units:	MBF-Scribner ("Large" or "Long")

***From the Reserve's Assessment Area Data File.**

Table 3. Default Wood Products Classes; Volume Totals

Step 2. If the default wood products classes are being used, enter the appropriate values from the Assessment Area data file and proceed to **Step 3** if harvesting occurred or **Step 5** if there was no harvest. If the actual distribution of wood products generated from the reporting period harvest is known, skip this step and proceed to **Step 4**.

Softwood Lumber	Hardwood Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Miscellaenous	Paper
97%	0%	2%	0%	0%	0%	1%

Step 3. If the default wood products classes are being used, enter the total amount of wood delivered to the mill(s) and proceed to **Step 5**.

Hardwood		Softwood	
Total	0	Total	2,810.72
%	0%	%	100%

Table 4. Volume in Logs Delivered to Mill

Step 4. Enter the name of the mill(s) and the volume of harvested wood sent to the mill(s) during the current reporting period in Table 4. Both the hardwood and softwood volumes must be categorized based on the wood product classes shown below. If wood products class data is only partially available, categorize the unknown wood products as "miscellaneous". If wood products class data is unavailable **or no wood products were harvested in the current reporting period**, refer to **Steps 2 and 3**. Default mill efficiencies are listed in Table 12. These default values may be overwritten if mill-specific data is available and verifiable.

	Hardwood							Softwood							
	Wood Product Classes							Wood Product Classes							
Mill	*Mill Efficiency*	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper	*Mill Efficiency*	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
Gross Total:		-	-	-	-		-	-	-	-	-	-	-		-
Net Total:		-	-	-	-		-	-	-	-	-	-	-		-

Section 2. Estimates of Carbon Storage in Wood Products and Emissions Associated with Harvested Trees

Table 5. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Project Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
Project carbon in harvested wood delivered to mills (Cubic Feet)	-	-	-	-	-	395,601	7,638	-	996	395	2,924	407,554
Project carbon in harvested wood delivered to mills (tCO_2e)	-	-	-	-	-	8,202	158	-	21	8	61	8,450
Project carbon transferred to wood products (Cubic Feet)	-	-	-	-	-	267,031	5,156	-	672	267	1,974	275,099
Project carbon transferred to wood products (tCO_2e)	-	-	-	-	-	5,536	107	-	14	6	41	5,704
% Product	0%	0%	0%	0%	0%	97%	2%	0%	0%	0%	1%	100%
Long-term storage in in-use wood products (tCO_2e)	-	-	-	-	-	2,563	52	-	5	1	2	2,624
Long-term storage in wood products in landfills (tCO_2e)	-	-	-	-	-	1,650	31	-	5	3	7	1,695

Table 6. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Baseline Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
tCO2e	-	-	-	-	-	52,824	1,020	-	133	53	390	54,420
% Product	0%	0%	0%	0%	0%	97%	2%	0%	0%	0%	1%	100%
Long-term storage in in-use wood products (tCO2e)	-	-	-	-	-	24,458	494	-	51	9	23	25,034
Long-term storage in wood products in landfills (tCO2e)	-	-	-	-	-	15,742	293	-	46	24	70	16,173

Table 7. Calculation Worksheet Information

Calculation Sheet Inputs (for Current Reporting Period)		Row Location in Calculation Worksheet
Actual Project Carbon in Harvested Wood Delivered to Mill (tCO2e)	8,450	11 (Excel 22)
Actual Project Carbon in Trees Harvested for Wood Products (tCO2e)	18,218	9 (Excel 20)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	2,624	13 (Excel 24)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	4,319	14 (Excel 25)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	25,034	15 (Excel 26)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	41,207	16 (Excel 27)

Table 8. Ratio of Harvested Wood Carbon to Harvested Tree Carbon

Step 5. Enter the 100-year baseline data to calculate a ratio of carbon in trees harvested for wood products to carbon in harvested wood delivered to the mill.

Baseline Carbon in Trees Harvested for Wood Products (tCO_2e) (from Excel Row 21 of the Monitoring Calculation Worksheet)	173815.28
Baseline Carbon in Harvested Wood Delivered to Mill (tCO_2e) (from Row 23 of the Monitoring Calculation Worksheet)	80622.39
Multiplier of Carbon in Wood Delivered to Mill to Carbon in Trees Harvested for Wood Products	**2.16**

Section 3. Conversion Assumptions

Table 9. Volume multipliers for converting timber and chip units to Cubic Feet

Unit	Factor
Bone Dry Tons	71.3
Bone Dry Units	82.5
Cords	75
Cubic Feet	1
Cubic Meters	35.3
Cunits-Chips (CCF)	100
Cunits-Roundwood	100
Cunits-Whole tree chip	126
Green tons	31.5
MBF-Doyle	222
MBF-International 1/4"	146
MBF-Scribner ("C" or "Small")	165
MBF-Scribner ("Large" or "Long")	145
MCF-Thousand Cubic Feet	1000
Oven Dried Tonnes	75.8

Source: American Forest & Paper Association, Sustainable Forestry Initiative Program Annual Progress Reporting Form

Table 10. Conversion Factors: to convert volume estimates to CO2-e

		Source
Cubic Feet / Hardwood Harvest Unit	1	Table 9.
Cubic Feet / Softwood Harvest Unit	145	Table 9.
SG of Softwoods by Region	0.399	Table 12.
SG of Hardwoods by Region	0.51	Table 12.
Tree Carbon:Wood Carbon	2.16	Table 8.
Pounds to Metric Tons	0.0004535970	-
Portion of Carbon in Biomass	0.5	-
Carbon to CO2-e	3.67	Reserve FPP
Density of water (lbs/cf)	62.43	-

Table 11. 100-year average storage factors

Wood Product Class	In-Use	Landfills
Softwood Lumber	0.463	0.298
Hardwood Lumber	0.250	0.414
Softwood Plywood	0.484	0.287
Oriented Strandboard	0.582	0.233
Non Structural Panels	0.380	0.344
Miscellaneous Products	0.176	0.454
Paper	0.058	0.178

Source: Reserve Forest Project Protocol, Appendix C.3 & C.4

Table 12. Average regional factors: specific gravity (SG) and mill efficiencies (ME)

	Hardwoods			Softwoods		
Region	SG	Saw Log ME	Pulp ME	SG	Saw Log ME	Pulp ME
Northeast (NE)	0.518	0.614	0.650	0.371	0.569	0.513
Northern Lake States (NLS)	0.473	0.585	0.685	0.360	0.630	0.514
Northern Prairie States (NPS)	0.537	0.585	0.685	0.434	0.630	0.514
Pacific Northwest, East (PWE)	0.424	0.568	0.568	0.396	0.637	0.637
Pacific Northwest, West (PWW)	0.415	0.531	0.531	0.426	0.740	0.500
Pacific Southwest (PSW)	0.510	0.568	0.568	0.399	0.675	0.675
Rocky Mountain, North (RMN)	0.389	0.568	0.568	0.394	0.704	0.704
Rocky Mountain, South (RMS)	0.353	0.568	0.568	0.369	0.704	0.704
Southeast (SE)	0.508	0.609	0.591	0.462	0.636	0.553
South Central (SC)	0.529	0.587	0.581	0.463	0.629	0.570

Sources: USDA Forest Service, Forest Inventory and Analysis Program database of forest surveys (SG) and *Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program* (ME). Average wood specific gravity is the density of wood divided by the density of water based on wood dry mass associated with green tree volume.