

Coastal Ridges LLC. Willits Woods
Improved Forest Management Project
CAR 661
Forest Project Design Document

For 2004 through 2011 Reporting Years and Initial Verification
Under the Climate Action Reserve's
Forest Project Protocol Version 3.2

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Purpose of This Document

This Forest Project Design Document (FPDD) reports information about the Willits Woods Improved Forest Management Project required by the Climate Action Reserve's Forest Project Protocol Version 3.2. The information presented in the report is organized based on guidance from section 9.1.1 of the Forest Project Protocol. A verification crosswalk document which links the FPDD to the Verification Guidance presented in Section 10 of the Protocol is included as Attachment G.

This FPDD has been submitted for verification as a draft document and is considered to be confidential until such time as the Willits Woods 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.

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1. Introduction

Coastal Ridges, LLC (“Coastal Ridges”) manages timberlands totaling approximately 21,700 acres; comprised of two land tracts located in the Coast Range of Mendocino and Sonoma Counties. The “Willits Woods”, consisting of approximately 19,000 acres of fee timberland in western Mendocino County, is located generally west of the town of Willits, mostly south of Highway 20, between Willits and Fort Bragg. In addition to these fee lands, Coastal Ridges owns timber cutting rights on the approximate 2,700 acre Brant Tract, which lies in southwestern Mendocino and northwestern Sonoma Counties.

A vicinity map showing the location of Coastal Ridges’ managed timberlands relative to local towns and highways is shown as Figure 1 on page 2. A more detailed vicinity map of the Willits Woods is shown as Figure 2 on page 3. Coastal Ridges acquired the Willits Woods, and the Brant Tract cutting rights in 2003. For the last several years, management activities have concentrated on hardwood removals/reduction, maintenance of existing infrastructure, and timber harvest plan preparation.

The Gualala River Forest tract shown in Figure 1 was previously owned by Coastal Ridges until its sale in December of 2011.. The Brant Tract is not being submitted as an Improved Forest Management Project at this time; however it may be submitted at a later date.

2. General Project Information

The Willits Woods is comprised primarily of highly productive timberland. Terrain is of moderate to steep slope. Elevation is from 600 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 Willits Woods Forest Improved Forest Management Project (the “Willits Woods Project”) is comprised of 18,008 acres of timberland on the larger 19,008 acre ownership block. The topographic map included in Attachment A shows the Project Area boundary, topography, roads, watercourses, and public land survey.

Figure 1: Coastal Ridges Vicinity Map

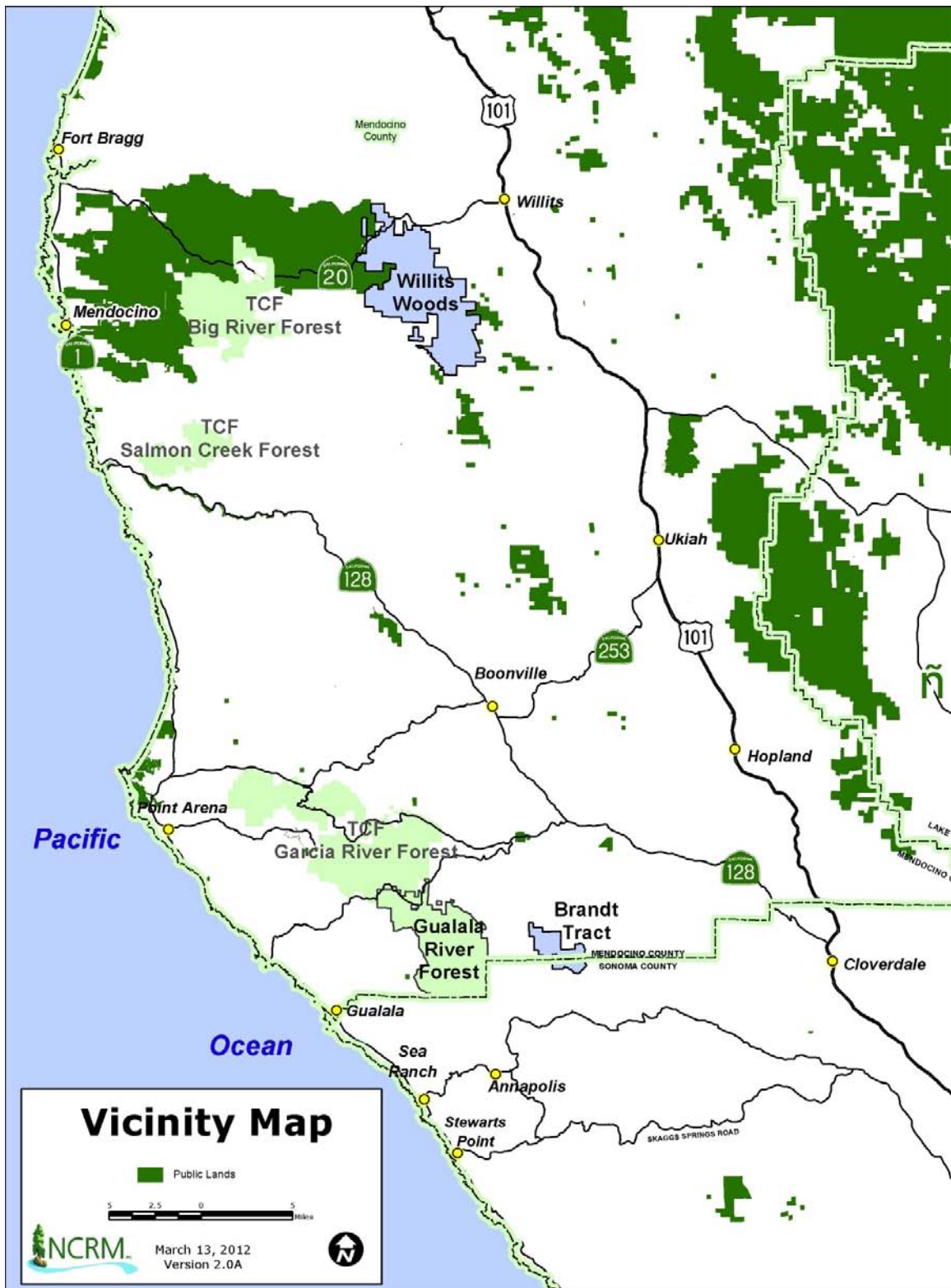
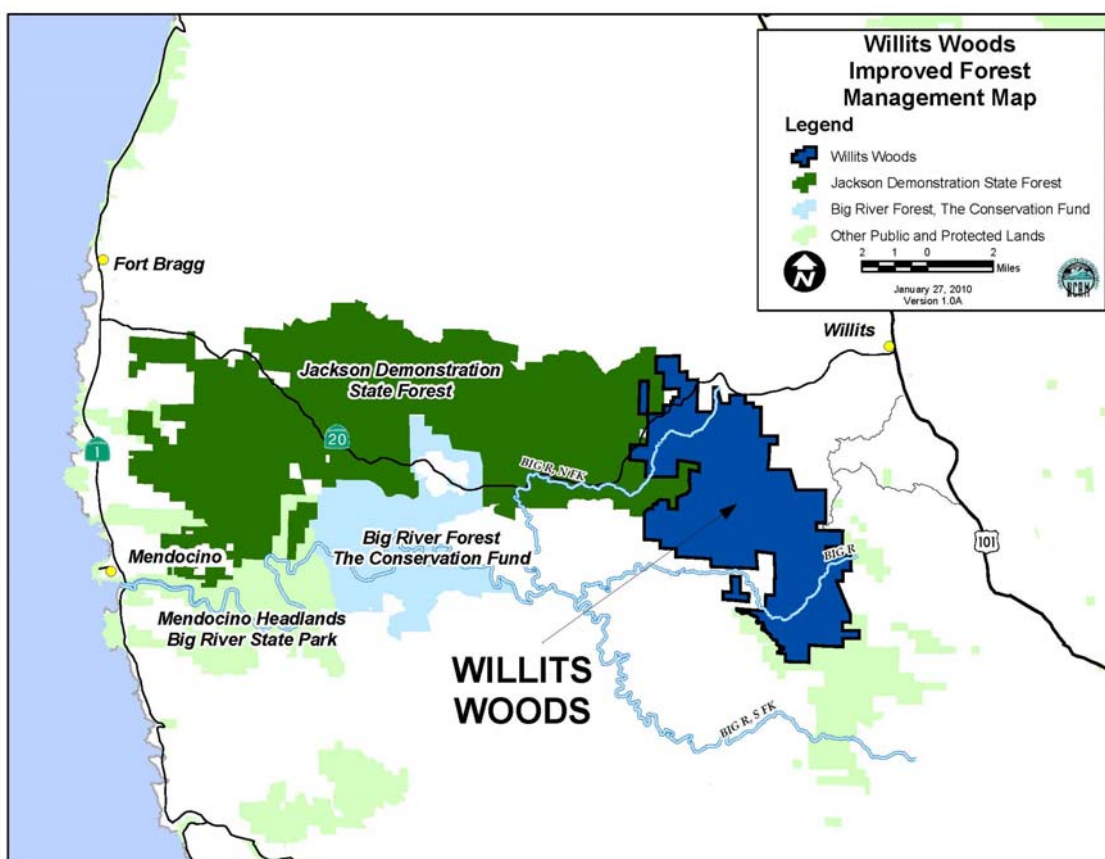


Figure 2: Willits Woods Vicinity Map



2.1. Project start date

The Willits Woods Project has an initiation date of 12/22/2003. There has been no commercial harvesting within the Project Area since 2004. The only stand management activities that have occurred since Coastal Ridges' purchase of the property in December 2003 are chemical treatment of hardwoods, for the purpose of improving conifer site occupation and subsequent growth. As a result, the Project's total live carbon stocks have increased significantly since 12/22/2003.

California Senate bill 1771 (Sher) was signed by the Governor on September 30, 2000. Senate bill 527 (Sher) made technical changes to SB1771, and was signed by the Governor on October 11, 2001. The Forest Project Protocol's use of January 1, 2001 as the earliest possible project start date coincides with the launch of CCAR as an approved mechanism for registering GHG emissions and reductions. "The launch of CCAR sent a signal to GHG-emitting entities and potential project developers that revenue from GHG reductions could be an important component of project financing." (CAR Program Manual, February 23, 2009). The launch of CCAR, the development of forest carbon protocols, and developing markets for GHG reduction credits, and subsequent sales of CRTs from neighboring property owned by The Conservation Fund were extensively noted and described in public media.

The Willits Woods, beginning with the ownership of Coastal Ridges LLC, has been managed under a policy of reduced timber harvesting during the period 12/22/2003 to 12/31/2011. This policy was followed in spite of the fact that there were approved timber harvest plans on portions of the property and timber prices were sufficiently high during most of this period to harvest timber at a profit. As a result of the management decision to forego timber harvesting, carbon stocks within the Project Area increased relative to baseline levels. The reduction in timber harvesting during this period had the combined effect of (i) increasing the overall age of the forest by increasing rotation ages, and (ii) increasing the stocking of trees on understocked areas of the property thus increasing site occupation and increasing forest productivity. Both of these are identified under Forest Project Protocol Version 3.2, Section 2.1.2 as eligible management activities for an Improved Forest Management Project.

The Climate Action Reserve Program Manual dated March 16, 2010 states in Section 2.4.3: “In general, the start date for a project will correspond to the start of activity that generates the GHG reductions”. With respect to Forest Protocol Version 3.2. The Climate Action Reserve has adopted a specific policy that allows a start date of 01/01/2001 for projects submitted prior to April 30, 2010. In the case of the Willits Woods Project, eligible management activities that resulted in GHG reductions beginning in late 2003 have been employed continuously through 12/31/2011. These policies have resulted in substantial GHG reductions during the period that are eligible for registration as CRTs under Protocol 3.2.

When Coastal Ridges took full ownership of the Willits Woods in late 2003, it was with the expectation of realizing the potential for generating income from the sale of carbon off-set credits and, simultaneously increasing timber stocking by deferring harvest.

In order to simplify calculations, carbon sequestration in the last 10 days of 2003 will not be included. All calculations in this Forest Project Design Document will use carbon stocks as of 1/1/2004 as the initial carbon stocking reference.

The initial reporting period for this Project is 1/1/2004 through 12/31/2011.

2.2. Broadcast Fertilization

The Project does not employ broadcast fertilization.

2.3. Sustainable Harvesting Practices

Commercial harvesting is planned within the Project Area however, since 2003 no commercial harvest activity has taken place. Coastal Ridges obtained approval of an Option A from the California Department of Forestry and Fire Protection (“Cal-Fire”) in 2006 for its entire ownership. The Option A document describes how Coastal Ridges’ timberlands will demonstrate sustainable long-term timber harvesting. All harvest

documents currently approved on the Willits Woods Project Area have been approved subject to the provisions of Coastal Ridges' Option A document.

Coastal Ridges' approved Option A document covers all of Coastal Ridges' timberlands and presents growth and yield information at the ownership level. The underlying data used to develop the Option A document is maintained at the smaller management unit level of the Willits Woods and Gualala River Forest. A review of the approved Option A document will show that timber cruise data and site index data are maintained separately for each tract. The modeling is performed at the plot level and then summarized by strata. This methodology produces yield streams which are distinct to each tract. These distinct yield streams are then combined and summarized at the ownership level in the Option A document.

2.4. Natural Forest Management

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

Native species: The Willits Woods Project Area is characterized by a mix of redwood, Douglas-fir, tanoak, madrone, and other native hardwoods. Approximately 98.5% of the Project's biomass is in native species, with less than 1.5% consisting of a knobcone pine hybrid, and thus the Project meets the 95% criteria for carbon in native species. Regeneration activities proposed under the Project will utilize only native species.

Composition of native species: As of 12/31/2011, the Project Area is composed of approximately 24% redwood, 25% Douglas-fir, 1% other conifer (pine), 37% tanoak, and 13% other hardwoods by basal area. Coastal Ridges 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 1: Project Species Composition by Basal Area

Species	Basal Area per Acre	Relative Percentage
Redwood	45.3	23.7%
Douglas-fir	48.8	25.6%
Pine	1.9	1.0%
Tanoak	70.1	36.7%
Other Hardwood	24.9	13.0%
Total	191.0	100%

Distribution of age classes/sustainable management: The target stand condition for the Willits Woods Project is characterized by a multi-aged conifer stand containing between 180 to 210 square feet of conifer basal area per acre, and approximately 32,000 board feet per acre of conifer volume. Hardwoods will be reduced to approximately 35% of the

stand basal area. Coastal Ridges will demonstrate sustainable management through its approved Option A document. In addition, the project proposes to employ 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 the Project Area is larger than 10,000 acres, the Project Area will be split by CALWATER planning watershed groups in order to determine compliance with the above requirement. The Project is located within ten CALWATER planning watersheds with approximately 48% of its timbered acreage within the Olds Creek (1113.200102), James Creek (1113.300301), Broadus Creek (1111.610103), Upper North Fork Big River (1113.300305), East Branch North Fork Big River (1113.300303), Baechtel Creek (1111.610101), or Russell Brook (1113.300202) watershed group, and 52% of its timbered acreage within the Martin Creek (1113.300201), Rice Creek (1113.300203), or Mill Creek (1114.330101) watershed group. Due to past unevenaged management, no more than 40% of the forested area in each watershed group described above is currently less than 20 years in age.

Structural elements: Coastal Ridges does not actively remove lying dead wood as a part of its stand management activities. In fact Coastal Ridges hardwood reduction program since 2003, and the hardwood reductions performed by Pioneer Resources, Inc in 2001 have contributed significant amounts of lying dead wood within the timber stands in general. It is expected that the accumulation of lying dead wood will be commensurate with recruitment from standing dead trees. Coastal Ridges is committed to maintaining if not increasing, the number of standing dead trees within the Project Area as a component of its forest management objectives. Coastal Ridges does not currently, nor does it intend in the future to actively pursue salvage operations on its timberlands. Coastal Ridges has a policy of allowing standing dead trees to remain and recruiting large specimen trees across their ownership as components of its overall timber management strategy.

In the case of the Willits Woods Project, the project area has not undergone any 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 0.29 Mg C per acre and 0.49% of standing live carbon stocks in standing dead wood. The project will continue to make progress towards the above mentioned standing dead wood target.

3. Description of the Project Area

3.1. Existing land cover and land use

The existing land cover on the Willits Woods Project Area is generally timberland with small areas of brush land, grasslands and rock outcroppings. The Willits Woods property is zoned Timber Production (TP). The permitted uses on TP land are timber production, row crops (including vineyard) and one single-family residence per legal parcel.

3.2. Forest vegetation types

The following Wildlife Habitat Relationship (WHR) vegetation types occur on the Willits Woods:

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 RDW “Redwood” type. Primary conifer species are coastal redwood and Douglas-fir. 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 dominate if vegetation succession were allowed to proceed naturally.

3.3. Site Productivity

The Willits Woods Project Area is characterized as moderate to highly productive timberland. The determination of site index for the purposes of growth and yield modeling is described within the Modeling Plan (Attachment C), as well as within the documentation provided in Attachment I.

3.4. Land pressure and climate zone

The Willits Woods Project Area 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 or agricultural uses such as vineyards. Certificates of Compliance for the 92 separate legal parcels comprising the Willits Woods Project Area have been obtained, 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 Willits Woods Project 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 Big River 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.

4. Inventory methodology for each of the carbon pools.

4.1. Stratification

The Willits Woods inventory was designed to be comprised of one timber strata with inventory plots evenly distributed throughout the strata.

4.2. Sampling Methodology

The Willits Woods Improved Forest Management Project utilizes inventory data collected on Coastal Ridges' timberlands in the spring and summer of 2008, for the calculation of the standing live, standing dead, and in-use wood products carbon pools. These are the only carbon pools being reported by the Project.

The 2008 inventory design consists of 514 sample plots installed across the approximate 32,900 fee timberland acres. The cruise installed 298 plots on the Willits Woods, and 216 plots on the Gualala River Forest. The cruise plots were installed by Western Timber Services (WTS), and check cruised by North Coast Resource Management (NCRM).

WTS began the cruise during the first week of May 2008, and completed the cruise in the middle of July 2008. The cruise design consists of a series of nested fixed area plots installed on a systematic grid across the entire Coastal Ridges ownership without regard to timber stratification. The cruise design document attached 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 Willits Woods.

The cruise was based on a systematic sample of the ownership with nested plots installed on a square plot grid 25.4 chains on a side (1,675 feet). A 1/5th acre plot measured conifers 10.5" DBH and larger, conifers 3.5" DBH to 10.4" DBH and hardwoods 3.5" DBH and larger were measured on a 1/50th acre plot, and conifers and hardwoods less than 3.5" DBH were measured on a 1/250th acre plot.

4.3. Quality Control

Check cruising of the plots installed by WTS was conducted concurrent with WTS timber cruise work; beginning the second day of timber cruise field work, and continuing to the end of data collection. NCRM provided WTS with daily updates of check cruise results so as to facilitate conformity with cruise standards and to obtain data of the highest quality.

Plots measured by each WTS cruise team were randomly selected for check cruising within 3 days of the plot's measurement. Overall, 95 check cruise plots were installed for a check cruise intensity of 18.5%. The check cruising results showed that the data collected by WTS followed the cruise protocol, and that the cruise data was accurate.

Attached is a Check Cruise Procedure summary document dated August 22, 2008, which more fully describes the check cruise methodology and its results.

4.4. Data Management and Analytical System

Cruise data from field cards were reviewed for completeness and entered into an Access database. Plot data within the database was extensively sorted and queried to look for data entry errors. The cruise data was entered independently by two individuals and a plot by plot comparison of the data was performed. 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.

4.5. Inventory Update

As timber management activities take place on the Willits Woods Project Area, or disturbance such as fire or mortality resulting from pathogens or other factors occurs, plots installed in 2008 will be relocated and remeasured within areas that have been harvested, treated for hardwood reduction, or subject to other disturbance. By 2020, all of the plots installed in 2008 will have been remeasured regardless of whether or not the plot had been harvested, treated for hardwood reduction, or subject to other disturbance. On this basis, Coastal Ridges will maintain a forest inventory system that will meet the inventory specifications and requirements contained in Appendix E 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.
2. Existing inventory plots will be updated using Visual CRYPTOS or 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. Inventory updates following harvest or disturbance will be re-measured within 12 months of the harvest or disturbance.

The carbon stocks presented herein as of 12/31/2011 are based on the 2008 inventory grown 3.5 years using CRYPTOS as described in the Modeling Plan.

5. Calculation methodologies for determining metric tonnes per acre for each of the included carbon pools

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

5.1. Above-ground Standing Live Carbon Pool

Above-ground standing live carbon was calculated using the appropriate biomass equation by species taken from the PNW-FIA Integrated Database User Guide and Documentation: Version 2.0, by Waddell, K. L. & Hiserote, B. (2005). The biomass equation documentation provided by the Reserve is attached as Attachment H¹. 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 2: FIA Equations

Species	Bole Cubic Ft Volume	Bark Biomass	Live Crown Biomass
Redwood	Equation 24	Equation 17 when DBH > 39.37”, otherwise Equation 13	Equation 10
Douglas-fir	Equation 3	Equation 8	Equation 6
Sugar pine	Equation 20	Equation 10	Equation 8
Ponderosa pine	Equation 5	Equation 9	Equation 7
Knobcone pine	Equation 16	Equation 14	Equation 11
Nutmeg	Equation 8	Equation 13	Equation 10
Tanoak	Equation 34	None	None
Pacific madrone	Equation 40	None	None
Live oak	Equation 43	None	None
Black oak	Equation 38	None	None
White oak	Equation 41	None	None
California laurel	Equation 33	None	None
Golden chinkapin	Equation 32	None	None
Bigleaf maple	Equation 37	None	None
Other hardwood	Equation 41	None	None

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

¹The volume equation documentation in Attachment H includes updated guidance from FIA regarding the proper implementation of certain volume equations. The volume equations are the same equations required by CAR, and documented on the CAR website, only with improved implementation guidance by FIA.

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.

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 megagrams (Mg) per hectare is calculated by multiplying the FIA calculated kg by each trees per hectare value, and then by 0.001. The Mg per hectare value of each tree on the plot is summed to derive above-ground live biomass Mg per hectare for the plot. This value is used to calculate the respective below-ground live biomass Mg per hectare for the plot. Total standing live carbon values presented herein are for trees 2.5” DBH and larger.

5.2. Below-ground Live Carbon

This is calculated at the plot level using the regression equation 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.

5.3. Total Standing Live Carbon Pool

Total standing live biomass for each plot is the sum of the above-ground and below-ground live biomass Mg per hectare. Mg of carbon (Mg C) per acre per plot is then calculated by multiplying by 0.5 to estimate carbon biomass, and then dividing by 2.471 to convert Mg C per hectare to Mg C per acre.

5.4. Standing Dead Above-ground Carbon Pool

Data on standing dead trees was collected as a part of Coastal Ridges’ 2008 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” DBH and larger.

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, 2008). These decay classes are generally described as follows:

- Class 0 Tree has recently died with leaves intact.
- Class 1 Leaves mostly still attached, intact bark, fine twigs, and branches.
- Class 2 Leaves mostly gone, fine branches mostly gone, bark loose and starting to fall off.
- Class 3 A few large branches or stubs remain, bark falling off in large patches, softwood sloughing is evident.
- Class 4 Highly decomposed, no branches, little bark, broken off top.
- Class 5 Mostly decomposed, no branches, very little bark, broken off close to the ground.

In order to calculate the proportion of the bole remaining standing, each standing dead tree is assigned a total height based on the DBH to total height regressions calculated from the 2008 cruise data. Based on average 16-foot log height by species and DBH developed from the 2008 cruise data, while giving consideration to the field recorded height, a 16-foot log height to the nearest whole log where a log height was not recorded in the field. The field recorded total height is then compared to the calculated height to determine the proportion of the tree's bole volume which was missing, by assigning missing 16-foot log segments, and then deducting the proportion of the trees volume in the missing logs. The proportion of tree volume by log segment was taken from Mason, Bruce, and Girard table which estimates the proportion of a trees total volume by log segment.

Using the volume and biomass functions for live trees described above, biomass for the various components of each tree is calculated based on the measured DBH, and calculated total height. The sum of the biomass components of each tree is multiplied by the percentage of each tree's remaining cubic foot volume after adjusting for any missing portions as described above. Based on the decay class of the standing dead tree, not all portions of a trees biomass are included. Table 3 below lists the components of biomass included for conifers and hardwoods by decay class. For hardwoods with a decay class of 2 or higher, cubic volume is computed only for the wood in the tree², and not for the total tree volume³ as the FIA biomass equations use.

Table 3: Biomass components by Decay Class

Decay Class	Conifers	Hardwoods
0	All portions	All portions
1	All portions	All portions
2	Bole and bark	Cubic volume of wood
3	Bole	Cubic volume of wood
4	Bole	Cubic volume of wood
5	Bole	Cubic volume of wood

² WVOL equation from Research Note PNW-414, June 1984.

³ TVOL equation from Research Note PNW-414, June 1984.

Once the biomass of each tree has been calculated and adjusted for the portion of the tree still standing, 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 3.1 below lists the relative densities applied by species and decay class taken from General Technical Report NRS-29 (Harmon et al, 2008).

Table 3.1: Relative Density by Species and Decay Class

	Decay Class					
Species	0	1	2	3	4	5
Redwood	1.00	0.956	0.827	0.678	0.426	0.366
Douglas-fir	1.00	0.858	0.723	0.444	0.305	0.329
Other Conifer	1.00	1.000	0.788	0.553	0.364	0.407
Tanoak	1.00	0.944	0.734	0.583	0.37	0.282
Other Hardwood	1.00	0.944	0.734	0.583	0.37	0.282

5.5. Standing Dead Below-ground Carbon

This is calculated at the plot level using the regression equation 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.

5.6. 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 hectare. Mg of carbon (Mg C) per acre per plot is then calculated by multiplying by 0.5 to estimate carbon biomass, and then dividing by 2.471 to convert Mg C per hectare to Mg C per acre.

5.7. 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:

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 6.5" DBH and larger. This value is calculated by the model as an output following each harvest cycle. 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 are included in the FIA volume equation documentation in Attachment I. 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, as specified in Appendix F of the Protocol.

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. Table 3.2 lists the assignment of wood products by class per Appendix F of the Protocol, as well as the 100-year average storage factors applied to each wood product class per tables C.2 and C.3 of the protocol.

Table 3.2 Wood Product class Assignment

Wood Product Class	% Assigned	100-year average in-use storage factor	100-year average landfill storage factor
Softwood Lumber	97%	0.463	0.298
Softwood Plywood	2%	0.484	0.287
Paper	1%	0.058	0.178
Weighted Average		0.45937	0.29658

In order to calculate secondary effects per the Protocol, the total amount of live carbon (prior to delivery to the mill) must be calculated. This represents all of the carbon stored in all portions of the tree (bole, live crown, bark, and roots) for species and size classes delivered to the mill. The model generates these calculations following each harvest by calculating the total live carbon value for conifers 6.5 inches DBH and larger for each plot just before a harvest, and comparing that value to the same total live carbon calculation just after the harvest. This includes all of the above-ground components, and the below-ground component.

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 harvests in any year. The values for each of these pools are then compared to the average values for each pool derived from the baseline analysis. On this basis, net wood products sequestered, as well as any secondary effects are calculated.

6. 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 2004 and 2011, 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.

7. Summary of the carbon stock inventory for the Forest Project by each pool as of 1/1/2004 and 12/31/2011

As of 12/31/2011, the Project area contains an average of 59.49 Mg C per acre of live carbon, and approximately 200 square feet of combined conifer and hardwood basal area per acre. Tree canopy cover averages approximately 75% across the Project area.

Tables 4.1 and 4.2 below provide a summary of carbon stocks for the Project area by the reported pools. Above Ground mean carbon tonnes are shown as AG Mg C per acre, and are referenced below with regard to the Project's disposition relative to Common Practice.

Table 4.1: Carbon Stocks by Carbon Pool as of 12/31/2011

Carbon Pool	AG Mg C per Acre	Total Mg C per Acre	Total Property Mg C	Total Property Mg CO2e
Standing Live	48.04	59.49	1,071,314	3,931,721
Standing Dead		0.29	5,257	19,292
Total	48.04	59.78	1,076,570	3,951,013

Table 4.2: Carbon Stocks by Carbon Pool as of 1/1/2004

Carbon Pool	AG Mg C per Acre	Total Mg C per Acre	Total Property Mg C	Total Property Mg CO2e
Standing Live	30.67	38.33	690,186	2,532,982
Standing Dead		0.29	5,257	19,292
Total	30.67	38.62	695,442	2,552,274

8. Inventory Confidence Statistics.

Simple random sampling formulas are used for the calculation of sampling error for Coastal Ridges' inventory as of 12/31/2010, the date of the field verification. The formulas used are as follows:

The mean of the sample is computed by:

$$\bar{y} = \frac{1}{n} \sum_{i=1}^n y_i$$

The variance of the sample mean is computed by:

$$S_{\bar{y}}^2 = \frac{S_y^2}{n}$$

Where:

$$S_y^2 = \frac{1}{n-1} \left[\sum_{i=1}^n y_i^2 - \frac{\left(\sum_{i=1}^n y_i \right)^2}{n} \right]$$

y_i = the Mg C per acre for the standing live and standing dead carbon pools for plot i .
 n = the number of plots sampled

The Finite Population Coefficient (fpc) is omitted from the variance of the mean calculation as less than 5% of the population was sampled i.e. the fpc is less than 0.05. Omitting the fpc results in a slightly higher variance calculation and is therefore a more conservative approach.

The standard error of the mean is computed by:

$$s_{\bar{y}} = \sqrt{s_y^2}$$

Statistician Dr. Howard Stauffer has prepared a statistical analysis of Coastal Ridges' 2008 timber inventory projected to 12/31/2010 which is included as Attachment D. Dr. Stauffer's analysis calculates a sampling error of 7.0% with 90% confidence for, the Willits Woods Project carbon stocks⁴. Per Appendix A of Version 3.2 of the Forest Project Protocol, a 6.9% sampling error at the 90% confidence level requires a 1.9% Inventory Confidence Deduction for the Project.

A summary of the calculations is as follows:

Mean standing live and standing dead pools	56.62*	Mg C per acre
SE of mean	2.389	Mg C per acre
SE of mean as %	4.219%	2.389 ÷ 56.62
Sampling Error at 90% CI	6.941%	(4.219%)*1.645
Confidence Deduction	1.9%	6.941% - 5.0%

*The sample mean included here includes only the sampled standing dead trees

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

9.1. 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. Small areas of the Northern California Coast Mixed Oak Woodland Assessment Area are intermixed within the Project Area, but they do not exceed 10% of the Project acreage. The Common Practice Indicator for the Coast Redwood/Douglas-fir Mixed Conifer Assessment Area is 51 Mg C of above ground live carbon per acre for High Site and 45 Mg C of above ground live

⁴ Dr. Stauffer's analysis utilized the student's t-distribution and 283 degrees of freedom to arrive at a t-value of 1.65026 to estimate the sampling error at the 90% confidence level. The Protocol requires that a value of 1.645 be used to calculate the sampling error at the 90% confidence level. Utilizing the guidance in the Protocol, the sampling error at 90% confidence is 6.941%, which rounds to 6.9%.

carbon per acre for Low Site. The Project Area's above ground live carbon stocks are 36.75⁵ Mg C per acre in 1/1/2004, and as such are below 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. The current Forest Owner purchased the property in 2003, and since 2003 there has been no commercial harvesting on the Project area. Approximately 991 acres of the Project area have been treated with herbicides for the purpose of reducing hardwood stocking since 2000. These treatments occurred on less than 10% of the Project Area, and occurred within timber stands where existing conifer stocking could be released.

9.2. Minimum Baseline Level

As described in the introduction on page 1 of this document, Coastal Ridges' timberlands are located in two tracts, the Willits Woods in central Mendocino County, and the Brant Tract in southwestern Mendocino and northwestern Sonoma Counties. These two ownership blocks are managed as separate logical management units (LMUs), or planning subunits as defined in section 6.2.1.1 of the Protocol. These two non-contiguous tracts have unique biological and geographical attributes, are located in distinct watershed units, and contain unique road networks. Coastal Ridges LLC's affiliates own or control certain timberlands located in eastern Mendocino County and northern Lake County. These timberlands are separate LMUs as defined in Section 6.2.1.1 of the Protocol as they have unique biological and geographical attributes, are located in distinct watershed units, contain unique road networks, and are managed as separate planning subunits.

The Willits Woods is a sustainable planning sub-unit of Coastal Ridges' ownership as demonstrated by the growth and harvest projections contained in Coastal Ridges' Option A document, as well as the baseline modeling presented in the attached modeling plan. Since purchasing the property in late 2003, no commercial timber harvesting has been conducted; however, Coastal Ridges has obtained approval of timber harvest plans which would have permitted harvesting consistent with the harvest levels permitted under Coastal Ridges' approved Option A document. The annualized allowable harvest represented by these approved timber harvest plans is within 20% of the annualized allowable harvest projected over the first 20-years within Coastal Ridges' Option A document.

Willits Woods Project has an initial above-ground standing live carbon stock per acre (ICS) of 30.67 Mg C. Since the Willits Woods tract is a separate LMU, the Weighted Average Carbon Stock (WCS) is equal to the ICS for the Willits Woods Project, and as the Project is not subject to HSR, the MBL for the Project is equal to the Project's ICS per equation 6.6.

⁵ Calculated using the same biomass equations as those utilized in the calculation of the published Common Practice carbon stock values. CAR has not yet provided Common Practice values calculated using the revised redwood bark equation guidance.

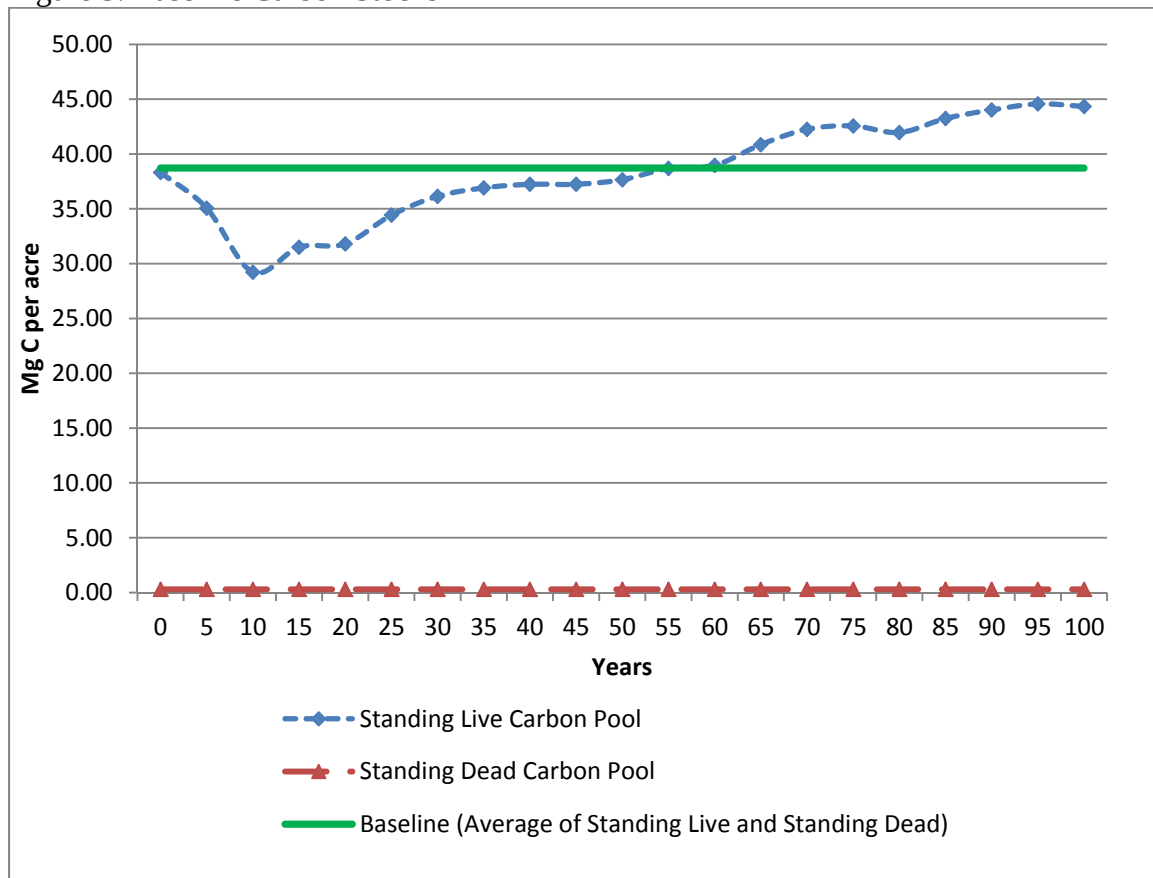
9.3. Calculated Baseline

The Modeling Plan included as Attachment C describes the methodology employed for the calculation of the Project's baseline. Table 5 below summarizes the above ground carbon stocks and the wood products calculations for the baseline analysis.

Table 5: Baseline Carbon Stocks

	Mg C per acre	Total Mg CO ₂ e
Average Standing Live and Standing Dead Pools	38.72	2,558,969
Average Annual Wood Products In-use	0.240	15,871
Average Annual Wood Products Landfill	0.155	10,247
Average Annual Wood Products Prior to Delivery to a Mill in use	1.41	93,133

Figure 3: Baseline Carbon Stocks



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

As described above, since 2003 there has been no commercial timber harvesting within the Project Area leading to a significant increase in carbon stocks. The forest owner chose to forgo all conifer harvesting during this period in order to allow both conifer and carbon stocking to increase.

The forest owner intends to allow conifer stocking levels to develop on the property in excess of the minimum requirements of the California Forest Practice Rules. The projected target stand condition for the Willits Woods Project 20-years from now, will be characterized by a multi-aged conifer stand containing between 180 to 210 square feet of conifer basal area per acre, and approximately 32,000 board feet per acre of conifer volume. At that time hardwoods will comprise approximately 35% of the stand basal area.

At a minimum, management activities conducted on the Project Area must exceed the minimum standards which define the baseline, while also conforming to specific requirements of the Forest Project Protocol. Changes in Project carbon stocks over time will also be governed by economic decisions such that more or less carbon may be sequestered over any given period. Therefore, a combination of economic decisions by the forest owner as to whether or not to commercially harvest the Project Area combined with the constraints imposed by the California Forest Practice Rules, and specific terms of the Forest Project Protocol will guide carbon stock levels over time. As this is the case, it is impossible to characterize a definite set of activities over time which will define the Project.

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

Table 6 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%.

Table 6: Reversal Risk Rating:

Risk Category	PIA and Qualified Deed Restriction
Financial Failure ⁶	7%
Conversion	2%
Over-harvesting	2%
Social	2%
Wildfire	4%
Disease/Insect	3%
Other Catastrophic	3%
Total Buffer Pool Contribution	20.937%

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

$$100\% - (((1-0.07)*(1-0.02)*(1-0.02)*(1-0.02)*(1-0.04)*(1-0.03)*(1-0.03)*100)) = 20.937\%$$

⁶ Risk of Financial Failure includes an additional 2% per the PIA.

12. Calculation of the Project's GHG Reductions from 1/1/2004 to 12/31/2011

The calculation of GHG reductions shown in the Forest Project Calculation Worksheet included as Attachment J is based on Equation 6.1 of 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 2004 through 2011 is calculated by determining the total change in carbon stocks from 1/1/2004 to 12/31/2011, 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 2004 are those at the end of 2004.
2. The increment in onsite carbon stocks is calculated after applying the Inventory Confidence Deduction of 1.9%.
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 baseline⁷ 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 CO₂e sequestered by the Project.

⁷ 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: $QR_y = [(\Delta AC_{\text{onsite}} - \Delta BC_{\text{onsite}}) + (AC_{\text{wp}, y} - BC_{\text{wp}, y}) * 80\% + SE_y] * (1 - ACD) + N_{y-1}$

Where,

QR_y = Quantified GHG reductions and removals for year y

$\Delta AC_{\text{onsite}}$ = $(AC_{\text{onsite}, y})(1 - CD_y) - (AC_{\text{onsite}, y-1})(1 - CD_{y-1})$

Where,

$AC_{\text{onsite}, y}$ = Actual onsite carbon (CO₂e) as inventoried for year y

$AC_{\text{onsite}, y-1}$ = Actual onsite carbon (CO₂e) as inventoried for year y-1 (if y is the first year of the project, then the value for $AC_{\text{onsite}, y-1}$ 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.

$\Delta BC_{\text{onsite}}$ = $BC_{\text{onsite}, y} - BC_{\text{onsite}, y-1}$

Where,

$BC_{\text{onsite}, y}$ = Baseline onsite carbon (CO₂e) as estimated for year y

$BC_{\text{onsite}, y-1}$ = Baseline onsite carbon (CO₂e) as estimated for year y-1 (if y is the first year of the project, then the value for $BC_{\text{onsite}, y-1}$ will be zero)

$AC_{\text{wp}, y}$ = Actual carbon in wood products produced in year y that is projected to remain stored for at least 100 years (i.e. $WP_{\text{total}, y}$ derived for actual harvest volumes following the guidance in Appendix C)

$BC_{\text{wp}, y}$ = Averaged annual baseline carbon in wood products that would have remained stored for at least 100 years (i.e. $WP_{\text{total}, y}$ 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.

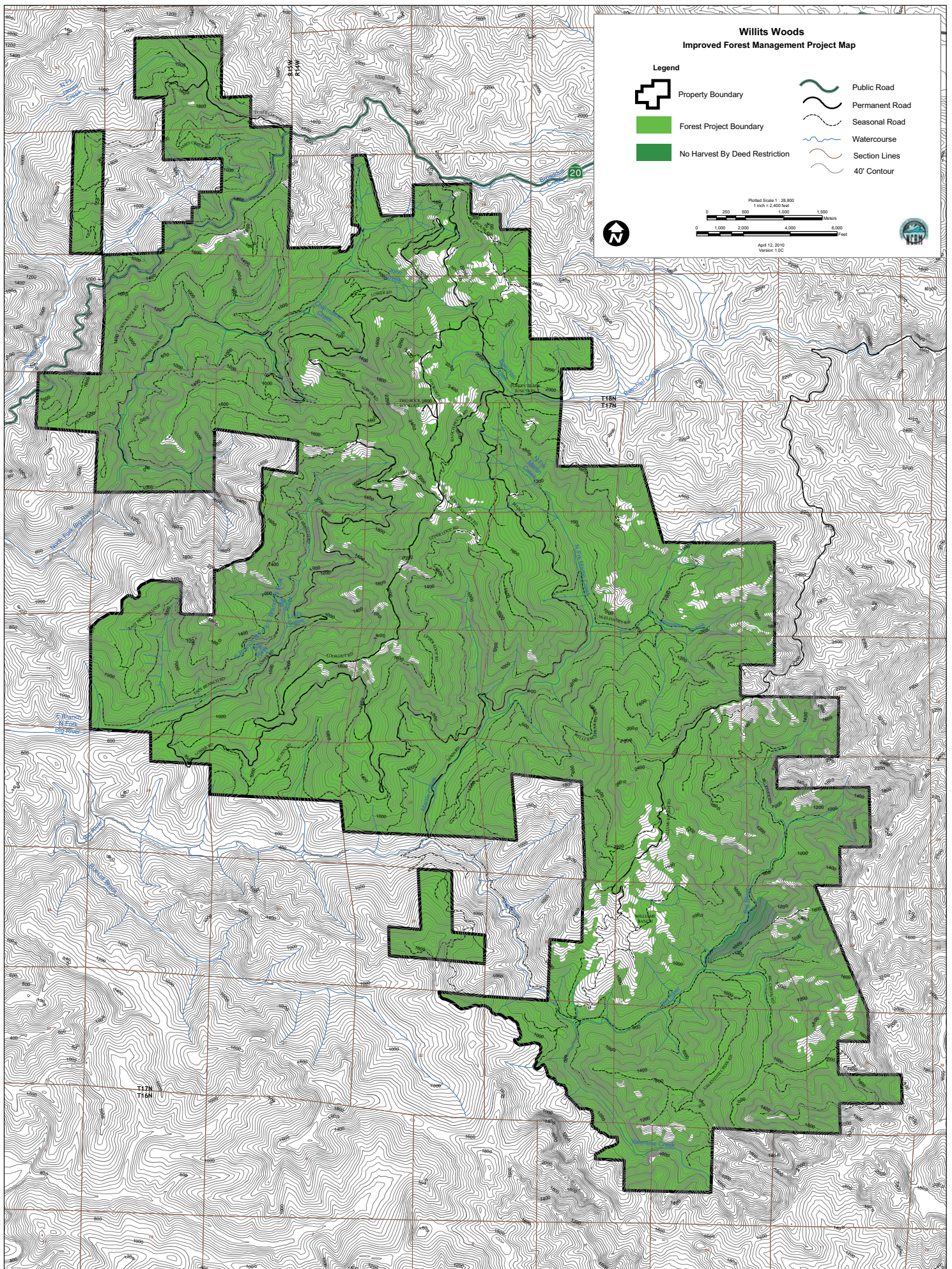
The Forest Project Calculation Worksheet included as Attachment J shows the Project's calculated additionality for the reporting period 1/1/2004 to 12/31/2011 allocated to each vintage from 2004 through 2011. All values are in Mg CO₂e.

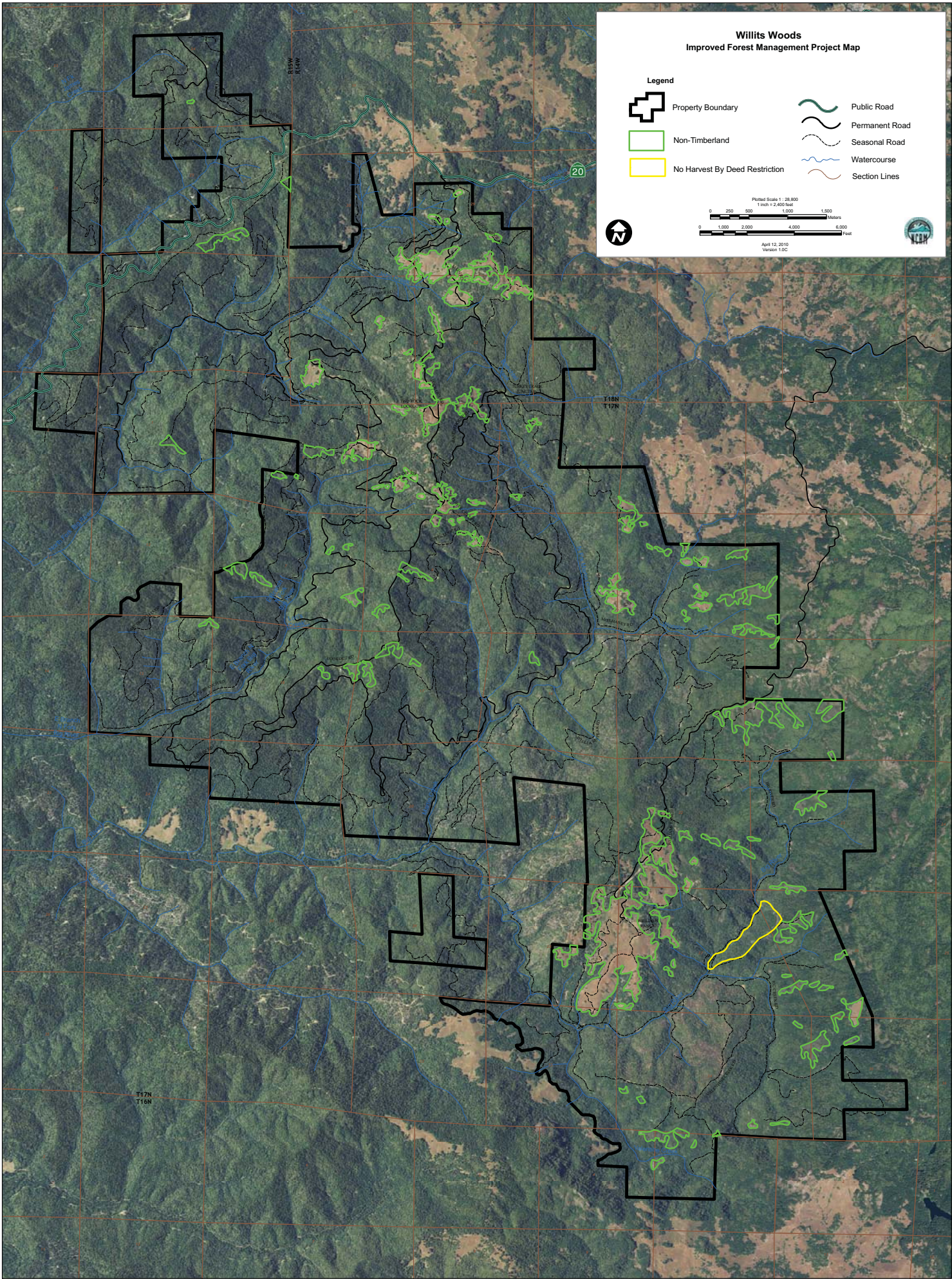
For vintages 2004 through 2011, the Willits Woods Improved Forest Management Project generates 791,266 CRTs.

13. Attachments

- Attachment A. Maps of the Project Area.
 - 1. Topography with major watercourses including Township, Section and Range.
 - 2. Orthophoto of Project Area.
- Attachment B. Cruise design document and maps.
- Attachment C. Modeling Plan.
- Attachment D. Statistical review document by Howard Stauffer.
- Attachment E. A demonstration that the growth and harvesting regime assumed for the baseline is financially feasible following the requirements of Section 6.2.1.2.
- Attachment F. Documentation of any and all legal constraints affecting forest management activities on the Project Area.
- Attachment G. Verification Protocol Crosswalk.
- Attachment H. FIA biomass equation documentation.
- Attachment I. Site Index Study.
- Attachment J. Forest Project Calculation Worksheet (Provided by CAR)

Attachment A





Attachment B

Coastal Ridges 2008 Inventory Specification

April 28, 2008

The cruise shall include the Willits Woods and Gualala River Forest Tracts for a total of approximately 32,200 acres.

The emphasis of the cruise is to develop timber stand and stock tables at the ownership level, and allow for growth and yield projections to be performed.

The cruise will be based on a systematic sample of the ownership, and will not include stratification. The cruise design will install approximately 500 plots on a square systematic plot grid 25.4 chains on a side (1,675 feet).

Coastal will work to improve or provide ATV and or four-wheel drive access to the extent feasible.

Plot Documentation and Location: Cruiser will be supplied with maps that show the locations of the plots and plot numbers, air photos (which must be returned to Coastal), and a list of coordinates for plot centers (UTM).

It is the cruiser's responsibility to accurately locate plots within the accuracy tolerances specified (one chain). Plots will be located via a combination of GPS take-off points established by Coastal, and field measurement (hip chain, or electronic device). Resource grade GPS equipment will be used to establish plot take-off points where cruise lines cross or are adjacent to traveled roads. Plot take-off points will be monumented with black and red striped flagging hung with glo-orange, and a metal tag listing the plot number, and the distance and direction to the plot. The timber cruiser will navigate from the take-off point to the plot in question using a hand compass, hip-chain or electronic distance device approved by Coastal. Where it is not possible or practical to establish a road take-off point for a given plot, the plot shall be located based on the last plot cruised on the cruise line. When navigating between plots, or between the take-off point and the plot, cruiser shall hang flags (glow lime green) at one-chain intervals. Flags shall be hung in such a manner that they assist relocation of cruise plots by check cruisers. Where cruise lines cross roads, cruiser shall hang a long flag with the distance and direction to the next plot, plot number of the next plot, date, and cruiser initials.

Plot centers will be documented with a 50p ferrule nail and vinyl flag with the plot number written in rain proof ink. A long vinyl flag (at least 24" in length) with the plot number, date, and cruiser initials written in rain proof ink shall be hung on trees stems or branches over, or nearly over the plot center. The plot number shall be painted on the nearest tree to plot center of sufficient size with orange spray paint. Flagging to establish plot center shall be glow lime green.

Cruise Report Format: Paper field data forms will follow the format of the sample card attached to the proposal letter From William Kliener dated January 15, 2008. The only exception is that the “Tree Defect%” column be replaced with “Merch. Height” and an additional column will be added for recording dib at 17.5 feet (Form Class). Cruiser shall fill out all appropriate information on cruise cards while in the field. All cruise cards produced within any day shall be completed and “proofed” by the cruiser the same day. Cruiser will be responsible for generating the cruise report, providing copies of the field data cards, and providing the cruise data in a digital format. Cruise reports shall be provided at the tract level.

Check Cruising: A minimum of fifteen percent of plots will be check cruised. Each plot check cruised will receive either a pass or fail grade. The basis for pass or fail will be individual plot measurements for a given plot as compared to the check cruiser. Plot data shall be proofed daily and provided to Coastal for check cruising within 3 days of cruising. Coastal will randomly select plots to be checked as plot data is received by cruiser. Check cruise reports should be provided to cruiser in a timely manner and no latter than 3 days from receipt of plot data from cruiser.

The following tolerances will be used to determine if a cruiser passes or fails the quality control check on any one plot:

Measurement	Tolerance, + / - of check measurement
Tree count on 1/5 th , and 1/50 th acre plots including snags	None.
Species	None.
Total height	±10% or 10' whichever is less, on each tree.
DBH	±1 for trees less than 24" DBH ±2 for trees 24" DBH or greater
Live crown ratio	20%.
Plot location	Within one chain of mapped location
Tree count on 1/250 th – acre plot	±30% within each species class

The cruiser’s work will be considered acceptable if the following is met:

1. The cruise design was followed
2. The plot card is correctly filled out
3. A minimum score of 88% is achieved using the Check Cruise Worksheet (the worksheet generates a score by evaluating all data on a plot and considers data that misses the cruise tolerances)

If 2 or more plots measured on the same day fail the check cruising criteria, then in addition to the failed plots, all plots measured on the day of measurement of the last failed plot will have to be remeasured in their entirety.

Sampling Method: To maintain consistency with past inventory efforts, including the ongoing remeasurement of permanent growth plots, all plots will be circular.

The cruise will consist of three nested circular plots:

1. 1/5th acre – Conifers 10.5” DBH and larger
2. 1/50th acre – Conifers 3.5” DBH to 10.4” DBH, and hardwoods 3.5” DBH and larger.
3. 1/250th acre – Conifers and hardwoods less than 3.5” DBH.

Data to be collected:

1. Tree number shall be recorded clockwise from north
2. Plot size
3. Species
4. DBH in 1” DBH classes
5. Crown position
6. Live crown ration (LCR) to the nearest 10%
7. Visible defect will be recorded by log position for all conifers which contain at least one 16.5’ x 6” dib log
8. Total height to the nearest foot, and merchantable height to a 6” top (dib) to the nearest foot*
9. Status Code
10. Conifer snag trees if they are at least 10.5” DBH and 20’ in height with height recorded to the nearest five feet**.
11. Hardwood snags at least 10.5” DBH and 20’ in height shall have DBH recorded
12. Form class will be measured on the first merchantable conifer tree of each species present on the plot, selected clockwise from north

*For the Willits Woods, hardwood total heights were recorded to the nearest 5 feet, and conifer total heights to the nearest foot were only recorded for the trees for which form class data was collected.

**Future inventories will collect snag data for trees greater or equal to 5” DBH which are at least 15’ tall.

Species Codes:

RW	Redwood	TO	Tanoak
DF	Douglas-fir	PM	Madrone
SP	Sugar Pine	BO	Black Oak
PP	Ponderosa Pine	WO	White Oak
GF	Grand Fir	LO	Live Oak
IC	Incense Cedar	BM	Bigleaf Maple
WH	Western Hemlock	CL	California Laurel
CX	Other Conifer	HX	Other Hardwood
NM	Nutmeg		

Diameter at Breast Height:

Measure DBH at 4.5 feet above ground on the uphill side of tree. On leaning or pistol butt trees, measure 4.5 feet along the stem, not vertical distance. For redwood sprouts growing on top of stumps, and for other trees where there is no good ground level to measure from, figure where a faller would cut the tree, and measure DBH 3.5 feet above that stump height.

Diameter class ranges from 0.5" below the midpoint of the class, and 0.4" above the midpoint. As an example, the 10" DH class runs from 9.5" to 10.4".

Crown Position:

Record the crown position of each tree as:

Code	Definition
P	<u>Predominant</u> : Trees with crowns completely above the general level of the main canopy receiving full light from above and from all sides.
D	<u>Dominant</u> : Trees with crowns extending above the general level of the main canopy of even-aged stands or, in uneven-aged stands, above the crowns of the tree's immediate neighbors, and receiving full light from above and partly from the sides.
C	<u>Codominant</u> : Trees with crowns forming the general level of the main canopy in even-aged stands or, in uneven-aged stands, the main canopy of the tree's immediate neighbors, receiving full light from above and comparatively little from the sides.
I	<u>Intermediate</u> : Trees with crowns extending into the lower portion of the main canopy of even-aged stands or, in uneven-aged stands, into the lower portion of the canopy formed by the tree's immediate neighbors, but shorter in height than the codominants. They receive little direct light from above and none from the sides.
S	<u>Suppressed</u> : Trees of varying levels of vigor that have their crowns completely overtopped by the crowns of one or more neighboring trees.

Live Crown Ratio:

Estimate live crown ratio, in percent, on all trees on the plot. Visually estimate the percentage of the total length of the tree bole that is covered by live crown, to the nearest 10 percent. In trees with uneven crown length, average the two most different sides of the tree.

Visible Defect:

Estimate visible defect for all merchantable conifer trees by 16-foot log segment. A merchantable conifer tree is any tree that will make at least one 16.5' x 6" dib log.

Total Height:

Measure total height to the nearest foot for all conifers on the plot, and to the nearest five feet for all hardwoods. Merchantable conifers shall have merchantable height to a 6" top (dib) recorded.

Trees with broken tops will have the condition of the top noted (broken, broken and recovered, dead). In those instances where breakage occurs above 6" dib, no further information is required. For trees where breakage occurs below 6" dib, cruiser shall record appropriate visible defect codes to reflect loss of tree volume >6" dib.

Form Class:

For each tree measured for form class, DBH and the scaling diameter at the top of the first log should be measured to the nearest inch. The top of the first log shall be at a point 17.5 feet above upper ground line. Measurements shall be made with a Relaskop or Criterion RD1000. Bark thickness at the top of the first log shall be estimated by the cruiser.

Status Codes:

BT	Broken top
FT	Forked top
RL	Recovered leader
DT	Dead top
SN	Snag

Remarks/Diagram:

Record descriptive information for a particular tree, notes about measurements, or other observations.

Draw a map of the location of the plot relative to known landmarks such as roads and streams, and directions to the plot.

Coastal Ridges Cruise Instruction Supplement:

Plot Grid Installation:

The plot grid is a systematic grid with a random start. An initial systematic grid was overlaid over Coastal Ridges' property and adjusted to "fit" the ownership boundary configuration. It was determined that the Northwestern portion of the grid could be shifted up to 125 feet North and 300 feet West and still remain on the property. A random number between 0 and 125 for the Northern shift, and a second random number between 0 and 300 for the Western shift were chosen to determine the final location of the Northwestern grid anchor. The plot grid was anchored to this randomly selected point in the Northwestern portion of Coastal Ridges' ownership on the Willits Woods which became plot 1. The grid was then expanded systematically across all of Coastal's timberlands including the Gualala River Forest.

Plots were measured where they fell on the systematic grid regardless of roads or watercourses. The one chain plot location tolerance was a check-cruise standard designed to emphasize the importance of installing the plots on the systematic grid with a high degree of accuracy. Check cruising found that plots were installed within the one chain tolerance.

Tools used:

Tree heights were measured using laser hypsometers, DBH was measured with steel diameter tapes, plot diameters were determined utilizing steel tapes while correcting for slope. Slope was determined with a Relaskop or clinometer.

Special Instructions:

Trees with irregularities at DBH were measured just below the irregularity. For trees with a fork near DBH, the tree was treated as two trees if the fork occurred below DBH, and as a single tree if the fork occurred above DBH. As the plots are fixed area plots, trees are considered on the plot if the center of the tree is within the fixed plot radius.

The reference for determining if a tree is off or on the plot is the point where the tree meets the ground. Trees leaning away from plot center are on the plot in question if the center of the base of the tree, and not the tree's DBH is within the plot radius.

Coastal Ridges 2008 Inventory Check Cruise Procedure

August 22, 2008

The Coastal Ridges 2008 timber cruise was broken into two parts. The cruise began in the Gualala River Forest block with three to four cruise teams operating per day. Upon completion of cruising on the Gualala River Forest, the cruise teams moved to the Willits Woods. Copies of daily plot cards were provided the following morning from Western Timber Service for selection of check cruise plots. All check cruising was conducted within three days of cruising by Western Timber Service.

On the Garcia River Forest, one plot from each cruise team was selected per day for check cruising during the initial weeks of the cruise. This resulted in between 3 and 4 plots being selected per day. Plots to be check cruised were selected using random number tables provided by Howard Stauffer. The random number tables provided one or two random numbers for a range of potential number of plots cruised in a day. Depending on the number of plots cruised by a given crew on a given day or series of days, the random number table was consulted and the appropriate plot or plots were selected for check cruising.

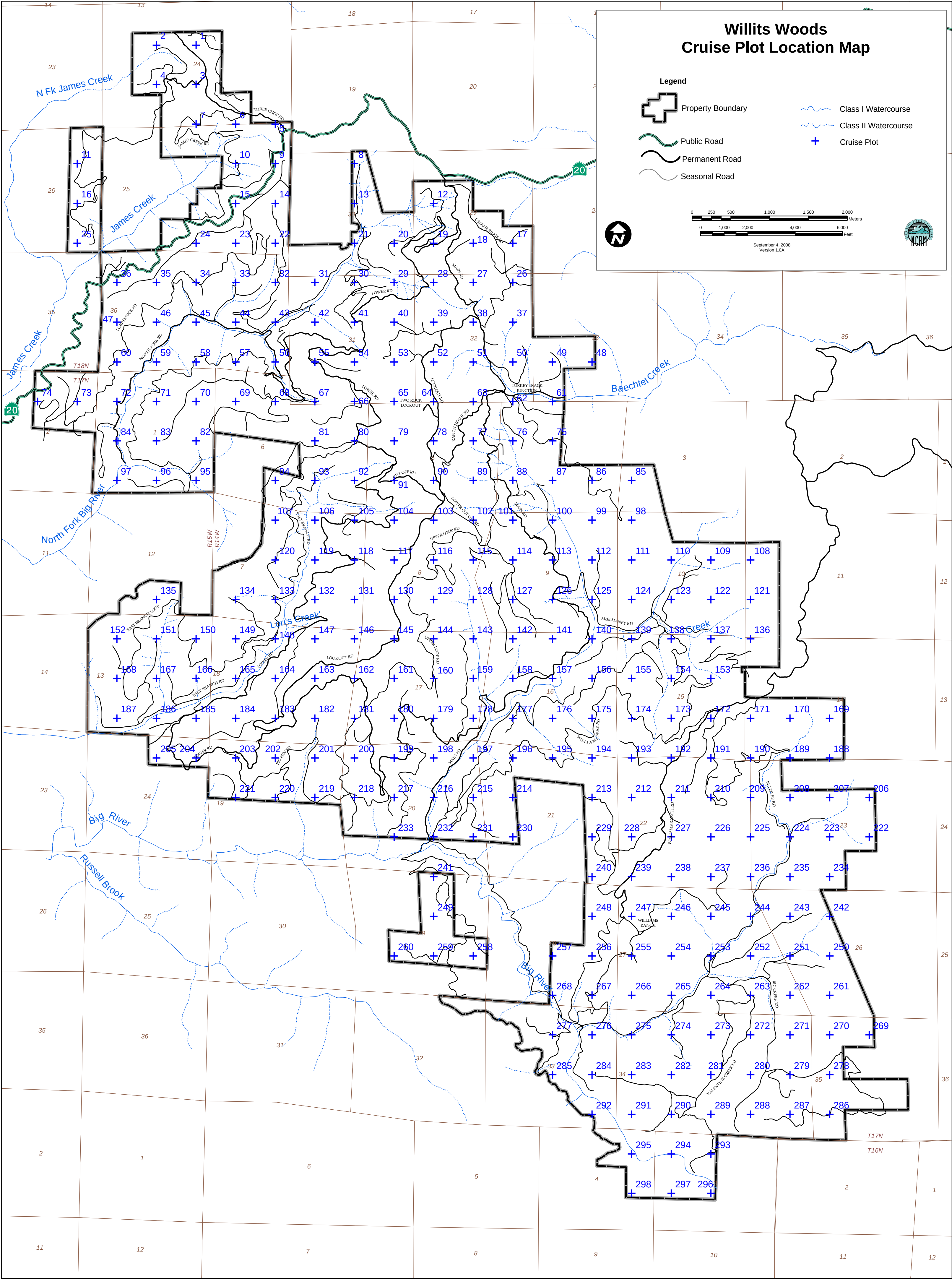
Of the 216 cruise plots on the Gualala River Forest, 62 plots were selected for check cruising, or approximately 29%. Three of the selected plots were not cruised due to the presence of illegal marijuana operations in the vicinity of the plots. The 59 check cruise plots represent approximately 27% of the 216 cruise plots on the Gualala River Forest. This check cruise percentage is higher than the target 15% check cruise target due to our desire to ensure that all crews were following the cruise protocol, and that accurate data was being collected.

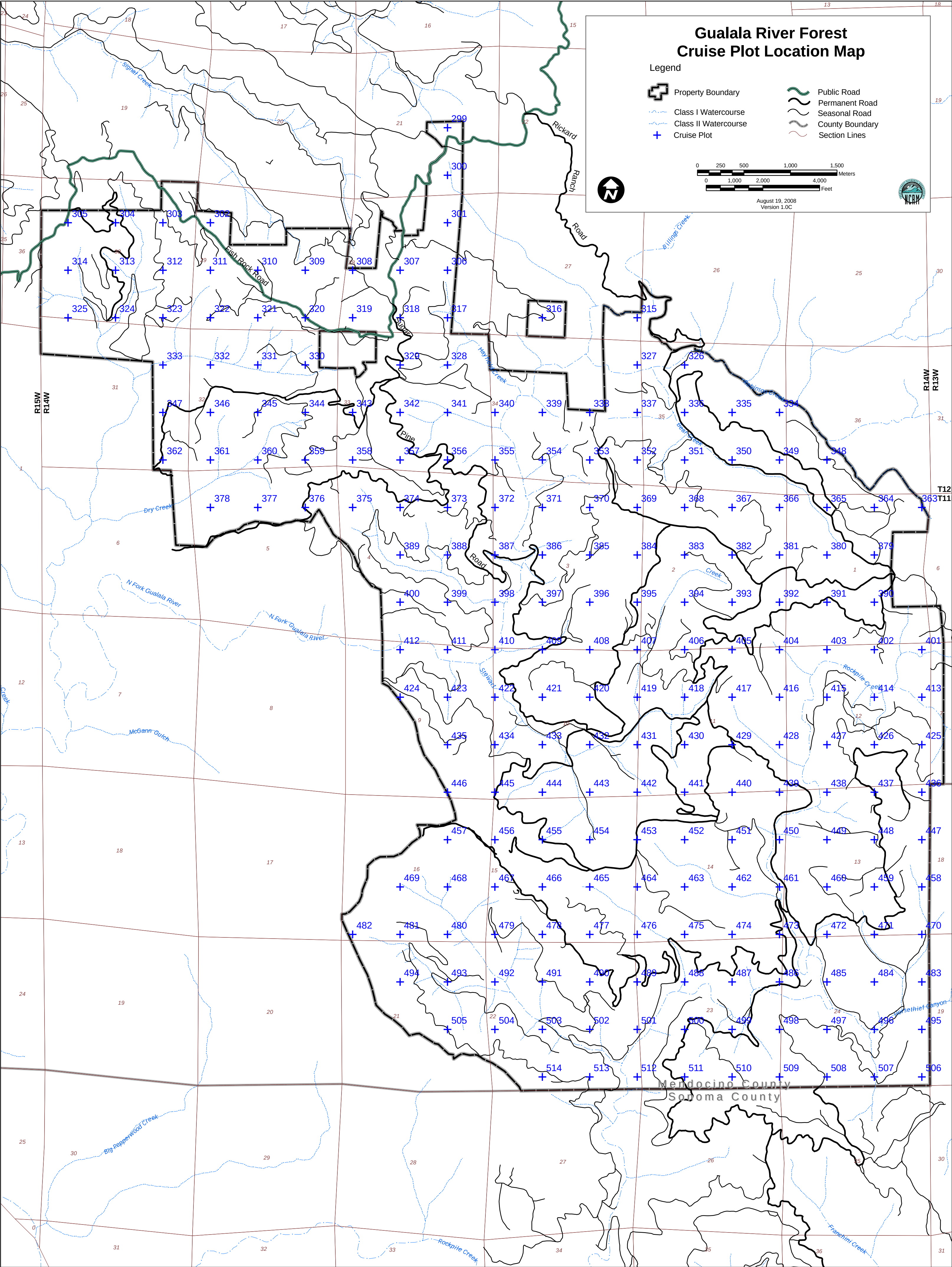
Early check cruise results showed that additional work was needed to ensure that total heights were properly recorded. Subsequent check cruise results showed that total height data was within check cruise tolerance. As cruising concluded on the Gualala River Forest, the percentage of check cruise plots selected from each cruise team was reduced to approximately 15% as per the check cruise protocol.

The intention was to continue the check cruise intensity in the Willits Woods tract at the 15% target; however, due to check cruise staffing changes during the Willits Woods portion of the cruise, the selection protocol was revised. Due to wildfires on other portions of the ownership, staff utilized for check cruising on the Gualala River Forest was unavailable for the first three weeks of the Willits Woods cruise.

In the Willits Woods, one plot per cruise team per day was randomly selected for check cruising. This resulted in 61 plots being selected for check cruising. Of the 61 selected plots, 36 plots or approximately 12% were ultimately cruised. The selection of the 36 plots was based on accessibility with the most accessible plots being cruised by the available check cruisers. Plots were in no way selected based on tree count or volume per acre.

Overall, 95 check cruise plots were installed for a check cruise intensity of 18.5%.





Attachment C

Coastal Ridges LLC. Willits Woods Modeling Plan

By Jim Clark, RPF #2528

Revised November 08, 2011

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Visual CRYPTOS:

Prior to the recent development of FORSEE, the procedure for modeling individual plots using CRYPTOS, and tracking the resulting inventory, harvest, and growth was problematic due to the fact that the original CRYPTOS user interface is antiquated. The previous CRYPTOS interface was extremely difficult to manage in extended runs with many plots, while implementing various silvicultural prescriptions, multiple ingrowth files, and calibrations. To resolve these problems, Coastal Forestlands contracted with Jan Derksen, Ph.D. for the development of a timber growth and harvest modeling tool, which allows for management of the required complexity in a user-friendly manner, and for the comparison of various 100 year modeling scenarios. This tool has evolved over the years, and is currently referred to by the author as Visual CRYPTOS (VC). VC was previously named the CRYPTOS Emulator, which is listed in CAR's Forest Project Protocol, Version 3.2 as an approved model. During development of the revised CAR Forest Project Protocol, I submitted written comments pointing out that the CRYPTOS Emulator had been renamed Visual CRYPTOS, but CAR did not correct the reference in the list of approved growth and yield models.

Both the CRYPTOS Emulator and Visual CRYPTOS are substantively identical CRYPTOS based models. VC provides a user interface that facilitates complex growth and harvest modeling, the basis for the modeling relies entirely on the original CRYPTOS growth and harvest source code, which has been integrated into the VC model. Elsewhere in this document the discussion of CRYPTOS refers to results obtained using CRYPTOS, with VC as the user interface.

VC has at its core the Fortran CRYPTOS version 6 engine translated into Pascal. To the fullest extent possible VC is an exact duplicate of the original CRYPTOS. As VC is able to read CRYPTOS stand, calibration, and ingrowth files a direct comparison between CRYPTOS and VC is possible by running both programs on exactly the same stand files, with the same calibration, and the same ingrowth files, and then comparing the results.

A great many verification tests have been performed: on low, medium, and high inventory plots with various species mixes. Results of runs performed with the Fortran CRYPTOS version 6 were exactly the same as runs performed with VC after correction of two irregularities that were found to exist in the original CRYPTOS code that surfaced in the testing trials. These have been reported to Dr. Lee Wensel at U.C. Berkeley. The first irregularity is the assignment of the Douglas-fir site index to other conifers even when a

site index value for other conifers is supplied in the stand file. The program always uses the user-supplied site index for other conifers to grow tanoak and other hardwoods, while the user supplied site index for tanoak is applied to red alder.

The second irregularity has to do with the fact that the diameter growth subroutine assigns, for diameter growth purposes, the site index for other conifers rather than the site index value for tanoak to the OH species (other hardwoods category) even when the site index for other conifers is 0, which it almost always is. The result is **no diameter growth** for OH. The problem is caused by the use of KSP rather than ISP in the following Fortran line found in SUBROUTINE DGRO5 in the *r-dgro5.for* file: IF (ISP.EQ.4.OR.KSP.EQ.6)K=3. After correction of this bug, the behavior of CRYPTOS and VC were exactly the same on a large set of trial stands.

VC allows users to load and maintain in a database:

1. The entire set of cruise plots for the ownership.
2. A program script used to drive the model logic.

To simplify the process of assigning silvicultural treatments to individual plots, a means for testing stand parameters such as basal area, or point count stocking has been developed and implemented through a series of commands contained in a scripting language. The introduction of testing of basal area, or point count stocking, etc., and acting on the outcome has allowed for the application of more intelligent silvicultural prescriptions. This more sophisticated harvesting strategy is compatible with CRYPTOS in that even though each plot receives a different prescription, the harvest actions performed are ordinary CRYPTOS harvest actions.

During a VC run, the program records each step (harvest, growth, or ingrowth) performed, and produces a list of the steps stored under the run name for later inspection. A run is performed by applying to each plot its assigned harvest prescription, growth routine, and inclusion of ingrowth.

Growth and Yield Modeling:

The growth and yield modeling described in this document is performed on an individual plot basis using the Visual CRYPTOS model, and is based on the following:

Plot Data:

The modeling presented in this document is based on 500 cruise plots installed in the spring and summer of 2008 across Coastal Ridges' timberlands (including both the Gualala River Forest and the Willits Woods). The 2008 plot data has been adjusted 1/1/2004 which for all intents and purposes represents the Project stocks as of the 12/22/2003 project start date. These plots were installed systematically across the timbered portion of Coastal Ridges' property. The Willits Woods contains 286 plots installed as part of the 2008 inventory.

Prior to the 2008 cruise, Coastal Ridges relied on a cruise installed by Pioneer Resources, LLC ("Pioneer") in 1999 and 2000 under the guidance of Olympic Resource Management, Inc. The Pioneer cruise was designed to develop a strata based volume estimates for the entire Pioneer property, including property not owned by Coastal (approximately 78,000 acres). The inventory was completed in two phases, the first in the summer and fall of 1999 and the second in the summer and fall of 2000. Data collection procedures varied slightly between the phases.

The Pioneer cruise installed 1,279 plots across the Willits Woods. In 1999 sampling took place on a systematic grid consisting of cruise lines running north and south located at approximately one-mile intervals. Plots were located at 2.5 chain intervals along those lines. All plots in the 1999 inventory were measurement plots. A variable radius plot utilizing a 20-factor prism and a 1/250th acre sub-plot were measured at each plot center.

The 2000 cruise was not installed systematically across the entire property as was the 1999 cruise, but was installed in specific strata with the intent of improving the confidence level of the data by strata and geographic area. Plots were installed 5 chains apart on cruise lines 10 chains apart. A variable radius plot utilizing a 20 factor prism measured conifers 4.5 inches DBH and larger, hardwoods 4.5 inches DBH and larger were measured on a 1/100th plot, and a 1/250th acre sub-plot was measured for all trees less than 4.5 inches DBH. Data was collected by direct measurement or estimation; plots were either "measurement" or "count" plots. For the measurement plots, every other conifer tree on the variable radius plot was directly

measured for DBH and total height, with the remainder of the tree measurements being estimated. All tree measurements on the 1/100th acre and 1/250th acre sub-plots were estimated regardless of whether or not the variable radius plot was a measure or count plot. For the count variable radius plots, species and group code were recorded, and DBH was estimated.

Data from the 1999/2000 cruise was used to estimate some tree data in 2004 as described below. This cruise was also used for the purpose of comparing the 1999/200 Pioneer cruise data grown forward to the Coastal Ridges' 2008 cruise date.

In addition to data based on these two cruises, data has also been obtained from a series of 90 permanent plots Coastal Ridges maintains across its ownership. These plots were initially installed and measured in 1994 with the majority being measured in late 1994 and early 1995. In 2007 and 2008, 86 of these permanent plots were remeasured. Of these 86 plots, 67 had been previously re-measured between 2000 and 2003. Data from these permanent plots has been used for the purpose of adjusting the 2008 inventory to 1/1/2004, and for the calculation of CRYPTOS basal area calibration factors as described below.

Updating the Inventory:

As timber management activities take place on the Willits Woods Project Area or disturbance such as fire or mortality resulting from pathogens or other factors occurs, cruise plots installed in 2008 will be relocated and remeasured within areas that have been harvested, treated for hardwood reduction, or subject to other disturbance. By 2020, all of the plots installed in 2008 will have been remeasured regardless of whether or not the plot had been harvested, treated for hardwood reduction, or subject to other disturbance. On this basis, Coastal Ridges will maintain a forest inventory system that will meet the inventory specifications and requirements contained in Appendix E of the Forest Project Design Document, 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.
2. Existing inventory plots will be updated using Visual CRYPTOS or 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. Inventory updates following harvest or disturbance will be re-measured within 12 months of the harvest or disturbance.

Volume Calculations:

Board foot volume calculations utilize the standard CRYPTOS volume equations taken from Bulletin 1907, by Krumland and Wensel (1983). Reported volumes are in board feet Scribner Scale for all conifers 6.5 inches DBH and larger to a 6" merchantable top. Cubic foot volume equations contained within CRYPTOS are used for the calculation of wood products cubic foot volumes delivered to the mill.

Biomass Calculations:

Biomass calculations utilized in the modeling are described in detail in the Forest Project Design Document (PDD). The PDD lists all of the species specific volume and biomass equations utilized; however, the growth and yield model CRYPTOS has a limited number of species which can be modeled. The baseline modeling described herein utilizes the following formulas for the calculation of cubic foot volumes and biomass:

Species	Bole Cubic Ft Volume	Bark Biomass	Live Crown Biomass
Redwood	Equation 24	Equation 17 if DBH >39.37 otherwise Equation 13	Equation 10
Douglas-fir	Equation 3	Equation 8	Equation 6
Other Conifer (Knobcone pine)	Equation 16	Equation 14	Equation 11
Tanoak	Equation 34	None	None
Other Hardwood (Madrone)	Equation 40	None	None

A comparison of current Project carbon stocks calculated using the complete species specific equations listed in the PDD to carbon stocks calculated using the formulas above results in less than seven tenths of a percent difference in the calculated carbon stocks.

Adjusting the 2008 Inventory Data to 1/1/2004:

In order to adjust the 2008 plot data to 1/1/2004, diameter increment regression formulas were created from Coastal Ridges' permanent plot remeasurements between the second measurement in 2000 to 2003 and the

third measurement in 2007 to 2008. This data was taken from 67 of the 90 remeasured permanent plots. As plot measurements were not necessarily made at the same time of the year, each plot is considered to have its own growth period. The growth period of a plot is the difference between the current measurement and the last measurement rounded to the nearest tenth of a year. The permanent plots utilized to create the diameter increment regressions have growth periods ranging from 3.2 to 7.8 years.

For each tree in the remeasurement dataset, average annual diameter increment over the remeasurement period was calculated. Average annual diameter increment by one-inch diameter class was calculated by species, and a regression equation was created for each species from the summary data.

As Coastal Ridges' 2008 inventory was installed in the middle of the 2008 growing season, a growth adjustment of 4.5 years is applied to the 2008 data in order to approximate the 1/1/2004 inventory date. The annual diameter regression equations were applied to the 2008 dataset for a 4.5 year period in order to estimate the tree diameters in 2004. Trees in the 1" to 2" class were reduced in increment by 0.05" per year for a 4.5 year period, as sufficient increment data does not exist for this diameter class range. Trees recorded in 2008 that were less than 1" DBH were not included in the 2004 dataset.

Tree heights in 2004 were estimated by applying diameter to height regressions developed from the 1999 and 2000 Pioneer cruise data. This allowed for estimated total heights to be calculated for the 2004 dataset.

There has been no conifer timber harvesting since 2004; however, approximately 991 acres of the timbered portion of the property have been treated with herbicides to kill hardwoods since Coastal Ridges acquired the property in 2003. This treatment occurred in October 2006. The area treated contains mainly standing dead hardwoods.

In order to ensure that the plot data as of 1/1/2004 reflected these hardwood treatments, the plot data was adjusted in the following way. All recorded dead hardwoods on plots within areas treated for hardwood reduction were added back into the 1/1/2004 dataset as live trees.

In addition to the treatment of hardwoods, a small portion of the Willits Woods Tract burned during the 2008 Mendocino Lightning Complex. Two fires were started by the lightning storm. The first fire burned approximately 2 acres in the northern portion of the ownership adjacent to the Two Rock Lookout. A second fire approximately 423 acres in size burned in the southern portion of the tract adjacent to the headwaters of Big River. Both of these fires were characterized primarily as slow burning ground fires that crept through the understory. These fires did not consume a significant

portion of vegetation in the 3.5" DBH and larger diameter classes. The burned areas were cruised after the fires had been suppressed. The cruise plots indicate that very little of the measured trees were burned. Accordingly, no adjustment to the 2008 plot data has been made to account for the 2008 fires.

Standing Dead Adjustments

Standing dead trees measured in 2008 were not grown backwards, but were assumed to be standing dead in 2004. This assumes that the standing dead pool has been static since 2004. Although the standing dead pool measured in 2008 is assumed to be the same as that present in 2004, in order to be conservative in the calculation of the baseline, those standing dead hardwood trees with decay class 0 or 1 were added back into the 2004 dataset as live trees as these trees were most likely alive in 2004. The assumption is made that the estimated standing dead pool in 2008 represents the best estimate of the standing dead pool in 2004. Even though a few trees recorded as standing dead in 2008 are added to the 2004 dataset as live trees, it is reasonable for these trees to be used to estimate the standing dead pool in 2004, as well as estimate live trees which may have died during the period from 2004 to 2008.

The Project's inventory includes standing dead trees 10.5" DBH and larger and $\geq 20'$ in height. In order to predict carbon in standing dead trees as required by the Protocol, carbon in trees 15' to 19' in height and $\geq 10.5"$ DBH, as well as carbon in trees $\geq 5"$ DBH and $< 10.5"$ DBH and $\geq 15'$ in height that was not sampled in 2008 must be estimated. The standing dead carbon that was not sampled in 2008 is estimated from the standing dead data that was sampled in 2008.

For the Willits Woods, 9% of the above-ground standing dead carbon measured in 2008 or 0.014 Mg C per acre on average is in the 20-30' height range, and 91% or 0.140 Mg C per acre is in the 31' and larger height range. It is assumed that the amount of carbon in the 15'-19' category is less than that measured in the 20'-30' range. In order to be conservative, the carbon in the 15'-19' height category is estimated as being the same as that of the 20'-30' height range. This results in an estimate of 0.014 Mg C per acre for above-ground standing dead carbon in trees $\geq 10.5"$ DBH and 15'-19' in height. Total above-ground standing dead carbon $\geq 10.5"$ DBH and $\geq 15'$ in height is then 0.169 Mg C per acre on average for the Willits Woods Project.

Above-ground standing dead carbon for trees $\geq 5"$ DBH and $< 10.5"$ DBH will be estimated by calculating the relative proportion of above-ground live

carbon per acre in the 5"-10" DBH class to above-ground live carbon per acre 10.5" DBH and larger (11" class and larger), and applying the same relative proportion to the estimate of standing dead 10.5" DBH and larger calculated above.

Trees ≥ 5 " DBH and < 10.5 " DBH represent 23% of the total above-ground live carbon per acre for the Willits Woods Project as of 1/1/2011. Based on the estimate of 0.169 Mg C per acre in above-ground standing dead 10.5" DBH and larger estimated above, this equates to 0.051 Mg C of standing dead in trees ≥ 5 " DBH and < 10.5 " DBH $[(0.169 \text{ Mg C}/0.77)-0.169 \text{ Mg C}]$.

Total above-ground standing dead carbon ≥ 5 " DBH and at least 15' in height is then estimated at 0.220 Mg C per acre for the Willits Woods Project.

The total above and below-ground carbon in standing dead trees is estimated by calculating the ratio of total standing dead carbon to above-ground standing dead carbon for the 2008 sampled standing dead trees (≥ 10.5 " DBH and 20' in height). The 2008 sample estimated the above-ground carbon at 0.155 Mg C per acre, and the total above and below-ground carbon at 0.206 Mg C per acre, or a ratio of 132.9%. Using this expansion, the estimated above and below-ground estimate of standing dead estimate is 0.292 Mg C per acre.

Future inventory updates will record standing dead trees ≥ 5 inches DBH and at least 15' in height.

Projecting the 2008 Inventory Data to 12/31/2010:

The 2008 plot data was grown in CRYPTOS with calibration for two and a half years to estimate the inventory as of 12/31/2010.

Calibration:

CRYPTOS computes increments in basal area and height for each individual tree in a stand list. Increments are based, among other factors, on current dbh, height, live crown, position of the crown of the individual tree in the canopy, and basal area per acre of the stand.

CRYPTOS' growth increments can be calibrated, that is, adjusted for local conditions. By comparing local growth measurements with growth increments predicted by CRYPTOS for the same trees in the same stands, a basal area growth calibration factor can be computed. CRYPTOS allows both basal area growth and height growth to be calibrated.

Tree measurements from the 67remeasured permanent plots has been used to develop CRYPTOS basal area calibrations for conifers and tanoak. These calibrations were created by dividing the measured basal area growth over a given time period for a given tree by the CRYPTOS predicted basal area growth for the same tree over the same time period. If a tree's remeasured DBH was less than its previously measured DBH, it was assumed to be measurement error, and all such trees were therefore excluded from the analysis.

Successive measurements of trees on these 67 permanent plots show that CRYPTOS underestimates diameter growth rates for larger trees and overestimates diameter growth on smaller diameter trees on Coastal Ridges' property.

Table 1 shows the CRYPTOS basal area calibrations derived from a comparison of the first permanent plot remeasurement (2000-2003) and the most recent remeasurement (2007-2008). This analysis includes all trees 3.5 inches DBH and larger that were measured at the time of the first remeasurement.

Table 1: Basal Area Calibration Factors

DBH Class	Basal Area Calibration Factor			
	Redwood	Douglas-fir	Sugar P	Tanoak
0-5	0.27	0.76	0.49	1.50
6-10	0.68	0.91	1.22	1.61
11-15	0.78	1.05	1.77	2.11
16-20	1.07	1.56	2.13	2.24
21+	1.86	1.88	2.85	1.50
Average	0.88	1.09	1.90	1.65

DBH Class	Sample Size			
	Redwood	Douglas-fir	Sugar Pine	Tanoak
0-5	13	28	2	50
6-10	31	54	4	70
11-15	128	111	26	18
16-20	62	33	18	3
21+	14	10	5	2
Total	248	236	55	143

These calibration factors will be utilized for the first two periods of the 100-year baseline modeling scenario, and during future inventory updates utilizing the VC model to estimate stand growth. It is felt that calibration of the baseline is at least appropriate for the first two periods until conifer stocks increase. The frequent harvests projected in the baseline have the effect of minimizing potential inaccuracies of the growth model as growth is checked every 10 years by harvest. Coastal Ridges will continue to develop appropriate calibration factors based upon remeasurement of its permanent plots over time. The use of updated calibration factors will be fully described as a part of future forest project verifications. Since project carbon stocks will be updated by ongoing inventory, any potential impacts associated with the accuracy of applying calibration will be minimized over the life of the project.

Utilizing these calibration factors within the VC model, the Pioneer 1999/2000 cruise data was grown forward to and compared with Coastal Ridges' 2008 cruise results. The projected volume based on the 1999/2000 cruise is within a few percentage points of the volume reported by the 2008 cruise.

Ingrowth:

The amount of ingrowth added to each plot during each decade of the planning period is calculated from several factors. The maximum number of ingrowth trees added is determined by the silvicultural prescription under which the plot is being harvested. The species composition of ingrowth is determined by calculating the species composition of the pre-harvest plot by basal area, and then adjusting the percentage of redwood seedlings to a minimum of 25% percent. Adding ingrowth at the same rates as the pre-harvest species composition of the plots results in the species composition of the property shifting from approximately 43% redwood in 2010 to less than 30% redwood species composition at the end of the 100 year planning period. Increasing the component of redwood ingrowth to a minimum of 25 percent maintains the current level of redwood stocking throughout the baseline and project modeling scenarios. This is consistent with what has been observed between the 1999/2000 inventory and the 2008 inventory, where the percentage of redwood shows an increasing trend.

Table 2: Regeneration (Ingrowth) Assumptions

Prescription	Regeneration Assumption
Selection	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 45 seedlings per acre. Hardwood regeneration is 8 seedlings per acre.
Selection (WLPZ)	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration varies from 10 to 20 seedlings per acre. Hardwood regeneration is 3 seedlings per acre.
Transition	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 60 seedlings per acre. Hardwood regeneration is 10 seedlings per acre.
Group Opening	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 100 seedlings per acre. Hardwood regeneration is 18 seedlings per acre.
Rehabilitation	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 100 seedlings per acre. Hardwood regeneration is 18 seedlings per acre.
Non-Commercial (Release)	As these stands are well stocked prior to harvest, only a minimal amount of natural regeneration is assumed for this treatment. Conifer regeneration is 8 seedlings per acre. Hardwood regeneration is 3 seedlings per acre.
Even-Aged	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 50 seedlings per acre. Hardwood regeneration is 10 seedlings per acre.

Each decade ingrowth in the form of 10-year old trees was added to the CRYPTOS stand description as per the regeneration assumptions shown in Table 2 above. This addition was done before the harvest and before further growth. These ingrowth assumptions are based on an analysis of the inventory data, comparisons with other data sources and professional experience. These 10-year old trees are assumed to be 2.0 inches in diameter, and 15 feet tall for conifers, and 1.5 inches in diameter, and 12 feet tall for hardwoods.

Site Index:

In order to conduct growth modeling for the property, it was necessary to develop an estimate of average 50-year base age site index by species for each project area. Redwood site index is Wensel and Krumland 50-year breast height age, and Douglas-fir is King 50-year breast height age.

Site index is derived from data collected as part of a site index study conducted on Coastal Ridges' lands in late 1996 and early 1997. The study was based on a methodology agreed to by the California Department of Forestry and Fire Protection. The site tree study involved the collection of site tree data from plots systematically installed on Coastal Forestlands' approximate 70,000 acres of timberland. The methodology involved searching for candidate trees in a systematic manner on each sample plot in order to minimize bias. The final site tree sampling protocol as well as correspondence between NCRM and Tim Robards (CDF biometrician at the time) are included in Attachment I of the PDD. These correspondences indicate that CDF approved of the sample design, as well as the selection of sample plots.

The average site index by species for the property is shown in Table 3 below and is detailed in a report in Attachment I of the Forest Project Design Document. Only the site indices for trees twenty-five years or older were used in the calculation of site index for the purpose of growth and yield modeling.

The following 50-year base age average site indices were used during the growth and yield analysis:

Table 3: Site Index by Ownership Block

Willits Woods	
Species	Site Index
Douglas-fir	120
Redwood	119

Project Acreage:

The Willits Woods Forest Improved Forest Management Project (the "Willits Woods Project") is comprised of 18,008 acres of timberland on the larger 19,008 acre ownership block. The topographic map included in Attachment A of the Project Design Document shows the Project Area boundary.

Baseline Modeling:

The baseline modeling utilizes the above-described 2004 plot dataset, and an unevenaged management harvesting strategy employing selection and transition combined with small group openings not exceeding 2.5 acres in size. Portions of Coastal Ridges' 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. Since 2003, Coastal Ridges has treated approximately 2,041 acres of its ownership (991 acres on the Project Area) for the purpose of reducing hardwood stocking (primarily tanoak), and releasing existing conifer regeneration. The baseline harvest scenario assumes a continuation of this intensive hardwood reduction program.

The baseline modeling scenario assumes that Coastal Ridges would demonstrate Maximum Sustained Production of High Quality Timber Products (MSP) through Option "A". Under the baseline scenario Coastal's stands will not contain sufficient basal area per acre of conifer trees 18" and larger to satisfy MSP using Option "C" during the early decades of the planning period; however, by the 5th decade of the baseline scenario, MSP could be demonstrated by either Option "A" or Option "C".

At the Project's initiation on 12/22/2003 there were no approved Timber Harvest Plans (THPs) on the Project Area. Since 2006, Coastal Ridges has obtained approval of fifteen THPs on the Project Area, which cover approximately 40% of the timberstands available for harvest during the first decade. Per section 6.2.1.2 of the protocol, the baseline harvest scenario must be modeled to reflect the silvicultural treatments associated with these approved THPs.

Coastal Ridges also obtained approval of an Option A document in 2006 which documented the manner by which sustained yield would be demonstrated on the Gualala River Forest. The Option A describes the silvicultural parameters to be employed and sets limits on conifer harvests. A specific limitation of the Option A is that no more than 68% of conifer growth may be harvested during the first decade of the planning period. Given this constraint, and the fact that the approved THPs incorporate approximately 40% of the allowable harvest in the first decade, the baseline modeling has been modified such that 40% of the Project Area harvest during the first decade will be constrained by the 68% of growth harvest limit.

In general, the baseline modeling employs the same silvicultural constraints described in Coastal's approved Option A document with the exception of

heavier hardwood reduction, slightly increased WLPZ harvesting more in line with the minimums of the rules, as well as the application of some group selection. Coastal Ridges' Option A document describes that the minimum conifer basal area retention levels will be increased beyond the minimum levels prescribed by the Forest Practice Rules over the 100-year planning period for the various silvicultural prescriptions. For example, the minimum conifer basal area retention for selection silviculture is increased from 75 square feet per acre to 120 square feet per acre, or 45 square feet per acre more than the minimum of the rules. This increased basal area retention which increases from the second period through the seventh period results in significantly higher basal area and stocking levels, and in turn increased growth potential, by the end of the 100-year planning period under the approved Option A harvest scenario. The baseline modeling described herein does not incorporate this increase in basal area retention through the 100-year planning period..

Under a baseline harvest scenario where timber stands are cut to the minimums of the forest practice rules, the baseline scenario would harvest approximately 84% of the conifer growth in the first decade of the 100-year baseline modeling period; however, the baseline scenario presented below incorporates a reduction in the harvest during the first decade to account for the 68% harvest limit on the approved THPs. The baseline scenario harvests 78% of the projected conifer growth during the first decade, which equates to 40% of the area being harvested at no more than 68% of growth, and 60% of the area being harvested at no more than 84% of growth. Harvests are modeled to the minimum of the Forest Practice Rules for the remaining nine decades of the baseline analysis.

Baseline Harvest Strategy:

The group-selection harvest strategy results in the eventual harvest in small groups of those areas of the property located outside of WLPZs within an 80-year period. Once a plot is harvested as either a small group, or under a rehabilitation prescription, the plot is grown for 20 years without harvest, subsequent silvicultural treatments are transition, or selection prior to the plot being harvested under a group selection treatment in 80 years. Plots, which are harvested utilizing selection prior to their first group selection treatment, must continue under selection following the 20-year period of no harvest.

Silvicultural treatments under the baseline scenario in the first decade of the 100-year planning period are dominated by transition harvests (42%), rehabilitation of understocked areas (24%), and release of well stocked conifer stands through hardwood control (6%). Only a limited number of

small group openings (2%) are created in the first period, as the level of hardwood reduction under rehabilitation treatments is extensive.

Beginning in the second decade, approximately 12% on average of the property outside of WLPZ areas is harvested as small groups each decade. Plots were selected for harvest based on conifer stocking level, with those plots with the highest stocking levels being harvested as small groups first.

Silvicultural prescriptions on individual THPs are designed to best accommodate local timber stand conditions, while complying with the Forest Practice Rules. 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 3a-3c below illustrate the silviculture decision matrix upon which the growth and yield modeling is based. Harvesting under selection-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 (Guldin 1991). 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.

General Harvest Constraints:

Harvest on Coastal Ridges' ownership 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 Willits Woods 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. Based on the size of the timber found on the Willits Woods, the sustained yield rules referred to as 'Option A' rules are used to meet sustained yield requirements. The pertinent rules include the following:

- 14 CCR 913.11(a): 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;
- 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;

Attachment F contains a detailed list of legal constraints affecting forest management activities on the Project Area. The method by which the Forest Practice Rule constraints listed above as well as other legally binding constraints is described in the following sections.

Coastal Ridges is also committed to restoring riparian function, and has instituted a 25' no-harvest zone on either side of all class I watercourses. No-harvest zones have also been established around all Northern Spotted Owl (NSO) activity sites.

These constraints are modeled by calculating the acreage of each identified constraint, to determine the combined constrained acreage. The plot data is run with a 100-year no-harvest regime with average carbon stocks leveling off at 140 Mg C per acre after the fifth decade. It is assumed that NSO activity centers would migrate over time, and that some level of minimal harvest would be allowed after the fifth decade. The yield stream from this reduced harvest is weighted by the constrained acreage and combined with the baseline harvest regime weighted by the unconstrained acreage to determine the final baseline carbon stocks through the 100-year analysis period.

Class I no Harvest Zone:

Utilizing Coastal Ridges GIS, it is estimated that 111 acres are located within 25' of either side of a class I watercourse.

Harvesting WLPZ Plots:

Utilizing Coastal's GIS the locations of the 284 plots in relation to class I and II WLPZs were determined. There are 15 plots located within class I or II WLPZs. This represents 5.3% of the plots. These plots are harvested using the selection silvicultural prescription depending on basal area stocking (please see tables 4a-4c below). 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 given the basal area retention standards applied in the model.

Northern Spotted Owl:

NSO activity centers are given a 1,000 foot no harvest buffer. There are approximately 639 acres of no-harvest NSO buffers associated with the Willits Woods.

Hardwood Harvest:

Coastal's hardwood reduction program calls for the manipulation of hardwood stocking levels through commercial harvest, manual or mechanical treatments, or basal herbicide treatments as appropriate.

Non-Commercial Treatments:

Portions of Coastal's timberlands exist in a condition that does not permit current commercial timber harvest. These stands are composed of advanced conifer regeneration with varying levels of hardwood competition. The stands with the heaviest hardwood component are targeted for a "Release" treatment during the first decade of the planning period. Stands with lesser amounts of hardwood competition, or those stands where the hardwood component is too small to treat economically, no treatment is modeled in the baseline growth and yield analysis; however, Coastal may at its discretion undertake stand improvement treatments in these non-commercial stands. Non-commercial treatments may include hardwood reduction treatments and pre-commercial thinning of conifers.

No Harvest Area:

In sections 27 and 26, T17N, R14W MDB&M, there exists an approximate 60 acre area for which timber harvesting is prohibited by deed restriction. The deed describes the restricted area as approximately 80 acres; however the area depicted on the map, Exhibit "D" of the recorded document, represents a 60-acre area. This 60-acre area has been treated as a no-harvest area in the baseline analysis.

Small Tree Mortality Adjustment:

Mortality of conifer and hardwood trees between 1" to 3" DBH beyond any mortality applied by CRYPTOS is modeled in the baseline harvest scenario by reducing the number of trees per acre in each decade of the 100-year analysis. Plots with >3000 TPA in trees 1" to 3" DBH have 85% of the trees

per acre removed; plots with between 2000 to 3000 TPA have 75% of the trees per acre removed; and plots with between 1000 to 2000 TPA have 60% of the trees per acre removed.

This mortality adjustment is designed to more accurately reflect small tree mortality on plots with excessive numbers of small trees. Past observations of CRYPTOS growth and harvest with regard to plots with excessive numbers of small trees indicate that CRYPTOS does not realistically reduce tree numbers over time. This small tree mortality assumption also serves to account for logging damage in areas subject to high small tree stocking.

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 Coastal

Prescription		Description
Uneven-Aged Management		
	Single Tree Selection	The goal of this prescription is to create and maintain, multistoried, uneven-aged stands with varied diameter classes.
	Single Tree Selection (WLPZ)	The goal of this prescription is to create and maintain dense, multistoried, uneven-aged stands with varied diameter classes.
	Group Selection	The goal of this prescription is to create and maintain, multistoried, uneven-aged stands with varied diameter classes. Groups are 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.
	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.
Even-Aged Management		
	Even-aged	The goal of this prescription is to perform the final step in rotating the stand that proceeded the current stand. Successive harvests will utilize uneven-aged silviculture.
	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.
	Hardwood Release	The goal of this prescription is to improve growth in stands that are primarily experiencing excessive hardwood competition, and that are also well stocked with conifer seedlings. Successive harvests will utilize uneven-aged silviculture.

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

Prescription		Pre-Harvest Conifer Basal Area (Square Feet per Acre)		Other Pre-Harvest Considerations
		Lower Limit	Upper Limit	
Uneven-Aged Management				
	Single Tree Selection	125	None	
	Single Tree Selection Low Stocking (WLPZ)	150	225	
	Single Tree Selection Medium Stocking (WLPZ)	225	275	
	Single Tree Selection High Stocking (WLPZ)	275	None	
	Group Selection	125	None	
	Transition	50	125	
	Commercial Thinning	50	125	
Even-Aged Management				
	Even-aged	15	60	Greater than 50% of conifer basal area in trees larger than 18” DBH
	Rehabilitation	0	50	Less than 300 point count
	Hardwood Release	0	50	

Table 4c: Post-harvest Stocking by Silvicultural Prescription

Prescription		Stocking Considerations	Conifer Basal Area Retention (sq. ft. per acre)	Hardwood Basal Area Retention (sq. ft. per acre)	Time to Next Treatment
Uneven-Aged Management					
	Single Tree Selection	All age, evenly distributed	>75	8	At Least 10 Years
	Single Tree Selection Low Stocking (WLPZ)	All age, evenly distributed	>140	30	At Least 10 Years
	Single Tree Selection Medium Stocking (WLPZ)	All age, evenly distributed	>175	25	At Least 10 Years
	Single Tree Selection High Stocking (WLPZ)	All age, evenly distributed	>225	20	At Least 10 Years
	Group Selection	Less than 20% of stand in group openings	>75	5	At Least 10 Years
	Transition	Less than 20% of stand in group openings, at least 15 sq. ft. >12" DBH	>50	8	Selection within 10-20 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"	8	Selection within 10-20 Years
Even-Aged Management					
	Even-aged	Retain/recruit 2-3 snags per acre	>8	8	Selection within 20-40 Years
	Rehabilitation	Retain/recruit 2-3 snags per acre	>8 where conifer >8 pre-harvest	8	Selection within 30-40 Years
	Hardwood Release	No Commercial Conifer Harvest	No Commercial Conifer Harvest	8	Selection within 20-40 Years

Growth and Yield Analysis:

The baseline growth and yield analysis was modeled using the VC model utilizing the above described harvest strategy. The calibration factors shown in Table 1 were applied during the first two decades of the 100-year planning period. The maximum retention diameter was set at 18.5” for the first decade, and was increased by two inches per decade until the 4th decade and was thereafter held at 24.5 inches for the remainder of the planning period. 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 per Acre Conifer Growth and Yield through the Planning Horizon

Elapsed Time (year)	Beginning Inventory (board feet)	Average Decadal Growth (board feet)	Average Decadal Harvest (board feet)	Ending Inventory (board feet)
10	6,338	607	487	7,545
20	7,545	784	642	8,967
30	8,967	790	572	11,144
40	11,144	804	783	11,358
50	11,358	799	708	12,266
60	12,266	803	755	12,743
70	12,743	824	691	14,074
80	14,074	829	850	13,868
90	13,868	837	767	14,570
100	14,570	847	826	14,781
Average		792	708	

Table 5b: Average per Acre Total Live Carbon Growth and Yield through the Planning Horizon

Elapsed Time (year)	Beginning Inventory (Mg Carbon)	Average Decadal Growth (Mg Carbon)	Average Decadal Harvest (Mg Carbon)	Ending Inventory (Mg Carbon)
10	38.13	2.34	3.40	27.44
20	27.44	2.09	1.98	28.56
30	28.56	1.83	1.51	31.77
40	31.77	1.77	1.84	31.17
50	31.17	1.74	1.57	32.84
60	32.84	1.74	1.60	34.22
70	34.22	1.77	1.43	37.65
80	37.65	1.77	1.80	37.35
90	37.35	1.77	1.56	39.49
100	39.49	1.77	1.74	39.83
Average		1.86	1.84	

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	71	81	80	88	87	90	91	97	95	99	99
Hardwood	77	23	19	17	14	15	16	18	19	20	20
Total	149	104	99	106	101	104	107	116	114	119	120

Table 7 presents the estimated percentage of each silvicultural prescription modeled by decade for the entire baseline modeling analysis.

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

Decade	Silviculture						
	Selection	Transition	Group Select	Rehabilitation	Release	Even-aged	No Harvest
1	18%	42%	2%	24%	6%	1%	6%
2	17%	39%	13%	0%	13%	0%	18%
3	43%	18%	14%	0%	0%	0%	25%
4	40%	22%	10%	0%	0%	0%	29%
5	50%	14%	11%	0%	0%	0%	25%
6	67%	0%	12%	0%	0%	0%	21%
7	67%	0%	10%	0%	0%	0%	23%
8	64%	0%	14%	0%	0%	0%	22%
9	68%	0%	8%	0%	0%	0%	24%
10	64%	0%	13%	0%	0%	0%	23%

The growth and yield modeling presented here includes variations of seven silvicultural prescriptions: Selection, Group openings associated with selection or transition, Transition, Rehabilitation, Even-aged, Release, and Non-Commercial. These reflect the principle silvicultural prescriptions currently being applied on Coastal Ridges' timberlands. The application of these silvicultural prescriptions is guided by the stocking standards contained in Forest Practice Rules.

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.

Baseline Carbon Stocks

The baseline modeling scenario defined in this document follows the guidelines presented in section 6.2 of the Forest Project Protocol, Version 3.2.

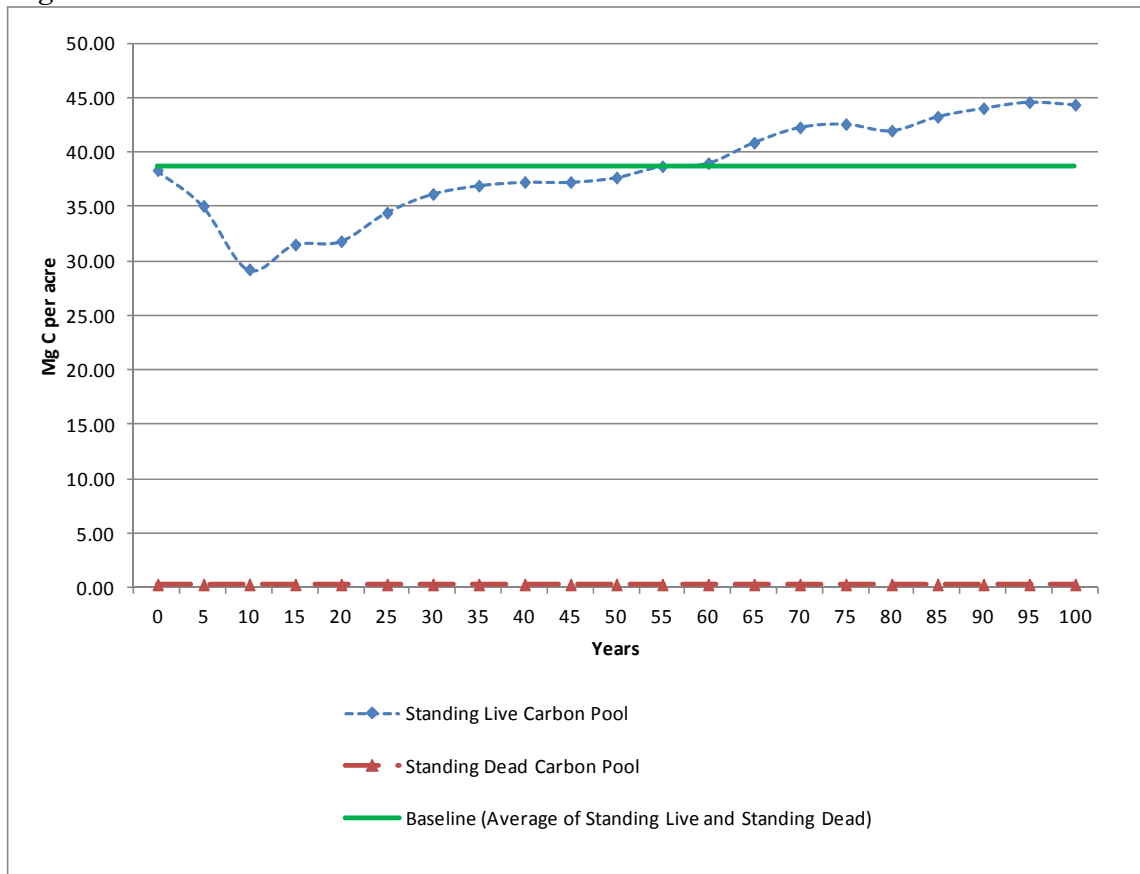
Key components of the calculated baseline are as follows:

1. Initial Project live carbon stocks are below 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: Average Baseline Carbon Stocks per acre Generated by the Baseline Harvest Scenario.

Elapsed Time	Standing Live Mg C/acre	Standing Dead Mg C/acre	Total Mg C/acre
0	38.33	0.29	38.62
5	35.06	0.29	35.35
10	29.22	0.29	29.51
15	31.50	0.29	31.79
20	31.81	0.29	32.10
25	34.42	0.29	34.72
30	36.14	0.29	36.43
35	36.91	0.29	37.20
40	37.24	0.29	37.53
45	37.24	0.29	37.53
50	37.66	0.29	37.95
55	38.69	0.29	38.98
60	38.97	0.29	39.27
65	40.86	0.29	41.15
70	42.26	0.29	42.55
75	42.56	0.29	42.86
80	41.96	0.29	42.26
85	43.24	0.29	43.53
90	44.01	0.29	44.31
95	44.57	0.29	44.86
100	44.34	0.29	44.63
Average	38.43	0.29	38.72

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.

Wood Products	Mg C/ acre	Total Mg CO2e
Average Wood Products In-use	0.240	15,871
Average Wood Products Landfill	0.155	10,247
Average Wood Products Prior to Delivery to a Mill	1.41	93,133

Literature Cited

- Guldin, James M., 1991. Uneven-Aged BDq Regulation of Sierra Nevada Mixed Conifers. *Journal of Forestry*, Vol. 6, No. 2, p. 27-32.
- Oliver, W.W., J.L. Lindquist, and R.O. Strothman. 1994. Young-growth redwood stands respond well to various thinning intensities. *West. J. Appl. For.* 9(4): 106-112.

Attachment D

Analysis Report
Updated Coastal Ridges Timber Inventory
November 1, 2011
Howard Stauffer

Introduction

This report summarizes the analysis results of the updated Coastal Ridges timber inventory, November 1, 2011, based upon the 500 plots installed across Coastal Ridges' timberlands in 2008, with 284 plots in the Willits Woods tract and 216 plots in the Gualala River Forest tract. The plots were installed in a stratified systematic sample survey design, with fixed area plots positioned on a square grid system, with random start, overlaying the entire harvestable portion of the CR timberlands. Summary statistics in this report are based upon a confidence level of 90% for the standing live and standing dead carbon pools. Stratified random sampling formulas were used for the CR timberlands statistics (Cochran, 1977). Simple random sampling formulas were used for the Willits Woods and Gualala River Forest strata statistics. It was unnecessary to use finite population correction factors (fpcf's) since they were all approximately equal to 1 (0.996858, 0.996846, and 0.996874 for the CR timberlands, Willits Woods, and Gualala River Forest, respectively, with negligible sampling fractions 0.003142, 0.003126, and 0.003140, all less than 1%).

Summary

I. Carbon Statistics

a) CR Timberlands:

For the CR timberlands, the summary live carbon statistics, with 90% confidence, were as follows: the mean metric tons per acre estimate was 54.27 with sampling error 2.75 (5.1%) and confidence interval [51.52, 57.01].

b) Willits Woods tract:

For the Willits Woods tract, the summary live carbon statistics, with 90% confidence, were as follows: the mean metric tons per acre estimate was 56.62 with sampling error 3.94 (7.0 %) and confidence interval = [52.68, 60.56].

c) Gualala River Forest tract:

For the Gualala River Forest tract, the summary live carbon statistics, with 90% confidence, were as follows: the mean metric tons per acre estimate was 51.20 with sampling error 3.71 (7.2%) and confidence interval [47.50, 54.91].

Summary statistics with 90% confidence are listed in Table 1 and Graphs 1-2, in the Appendix. Stratified random sampling and simple random sampling (SRS) formulas are provided in Figures 1-2 in the Appendix (Cochran 1977, Freese 1962). Analysis details are provided in the attached document Minitab Analysis Details.

II. References

Cochran, W.G. 1977. Sampling Techniques. Joseph Wiley and Sons, New York.

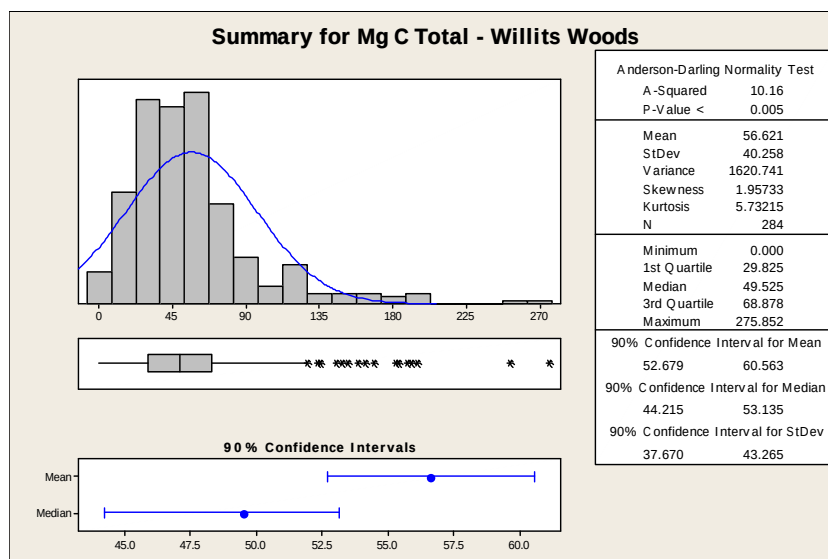
Freese Frank. 1962. Elementary Forest Sampling. United States Department of Agriculture, Agriculture Handbook, No. 232.

Appendix

Table 1. Summary Conifer Statistics for the Coastal Ridges Inventory, with 90% Confidence

<u>Area</u>	<u>Mean Estimate Mg Carbon per Acre</u>	<u>Sampling Error</u>	<u>Percentage Error</u>	<u>Confidence Intervals of the Mean</u>
CR Timberlands	54.27	2.75	5.1%	[51.52,57.01]
Willits Woods	56.62	3.94	7.0%	[52.68, 60.56]
Gualala River Forest	51.20	3.71	7.2%	[47.50, 54.91]

Graph 1. Descriptive Statistics: Willits Woods Tract



Graph 2. Descriptive Statistics: Gualala River Forest

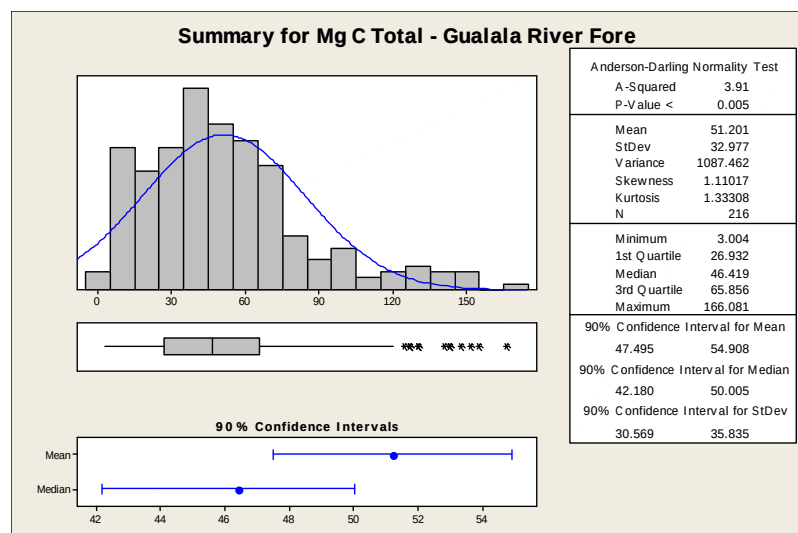


Figure 1. Simple Random Sampling Formulas

The formulas used for the simple random sampling estimates for each stratum h were as follows:

$$\text{Mean estimate} = \bar{y}_{h} = \sum_i y_i / n_h$$

$$\text{Standard deviation estimate} = s_h = \sqrt{(1 - n_h / N_h) * (\sum_i (y_i - \bar{y}_{h})^2 / (n_h - 1))}$$

$$\text{Standard error estimate} = se_h = s_h / \sqrt{n_h}$$

where

N_h = area in stratum h ,

y_i = measurement for sample plot i in stratum h ,

n_h = sample size for stratum h ,

s_h = standard deviation estimate for stratum h , and

se_h = standard error estimate for stratum h .

The finite population correction factors $(1 - n_h / N_h)$ were omitted in the calculations since they were approximately equal to 1, with sampling fractions n_h / N_h all less than 1%.

Figure 2. Stratified Random Sampling Formulas

The formulas used for the stratified random sampling estimates were as follows:

$$\text{Mean estimate} = \bar{y} = \sum (N_h/N) * \bar{y}_h$$

$$\text{Standard error estimate} = se = (1/N) * \sqrt{\sum [N_h^2 * (1 - n_h/N_h) * s_h^2 / n_h]}$$

where

N_h = area in stratum h ,
 N = total area in CR timberlands,
 $\bar{y}_h$ = mean estimate for stratum h ,
 n_h = sample size for stratum h , and
 s_h = standard deviation estimate for stratum h .

The finite population correction factors $(1 - n_h/N_h)$ were omitted in the calculations since they were approximately equal to 1, with sampling fractions n_h/N_h all less than 1%.

Attachment E

Coastal Ridges Willits Woods Improved Forest Management Project

This analysis is provided per section 6.2.1.2 (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 financial feasibility. If herbicide treatments, tree planting and logging costs were significantly increased, the analysis would still demonstrate that the baseline growth and harvest is financially feasible. Delivered log values are below trended values based on Board of Equalization values, yet still demonstrate financial feasibility.

Model Inputs:

Discount Rate	10.0%
Inflation	0.0%
Real price appreciation for delivered log values	0.5%
Yield Tax	2.9% MBF

Production Costs:

Item	Cost per acre	Quantity ¹	Total Cost	Cost per MBF
THP Preparation	\$110	17,258	\$ 1,898,380	\$23.40
Logging Supervision				\$7.00
Property Management				\$7.00
Logging and Hauling				\$285.00
Total				\$322.40

Herbicide Treatment of Hardwoods:

Period	Cost per acre	% of Acres Treated	Total Cost	Cost per MBF
1	\$ 125.00	100%	\$2,157,250	\$26.59
2	\$ 125.00	33%	\$711,893	\$6.44
3	\$ 125.00	33%	\$711,893	\$7.04
4	\$ 125.00	33%	\$711,893	\$5.21
5	\$ 125.00	33%	\$711,893	\$5.63
6	\$ 125.00	33%	\$711,893	\$5.26
7	\$ 125.00	33%	\$711,893	\$5.26
8	\$ 125.00	33%	\$711,893	\$5.00
9	\$ 125.00	33%	\$711,893	\$4.95
10	\$ 125.00	33%	\$711,893	\$5.07

Tree Planting: (\$1 per tree cost)

Period	Cost per acre	% of Acres Treated	Total Cost	Cost per MBF
1	\$ 125.00	100%	\$2,157,250	\$26.59
2	\$ 100.00	25%	\$431,450	\$3.90
3	\$ 100.00	25%	\$431,450	\$4.27
4	\$ 100.00	25%	\$431,450	\$3.16
5	\$ 100.00	25%	\$431,450	\$3.41
6	\$ 100.00	25%	\$431,450	\$3.19
7	\$ 100.00	25%	\$431,450	\$3.18
8	\$ 100.00	25%	\$431,450	\$3.03
9	\$ 100.00	25%	\$431,450	\$3.00
10	\$ 100.00	25%	\$431,450	\$3.08

¹ Unconstrained timbered acreage.

**CALCULATION OF PRESENT NET VALUE
COASTAL RIDGES WILLITS WOODS TIMBERLANDS**

Assumptions: Harvest levels are based on Willits Woods Baseline Harvest Scenario

Logging sytem mix estimated as 80% tractor, 20% cable.

Production costs per MBF are estimates based upon logging system mix.

0.5% Real price appreciation applied to delivered log values.

All calculations in constant dollars without inflation.

Discount Rate 10.0% Real.

Year	Annual Harvest Volume				Delivered Log Values per MBF				Production Costs \$ / MBF	Herbicide Treatment \$ / MBF	Tree Planting \$ / MBF	Yield Taxes \$ / MBF	Net Value \$ / MBF	Total Net Value	Present Net Value
	RW MBF	DF MBF	Pine MBF	Totals MBF	RW \$ / MBF	DF \$ / MBF	Pine \$ / MBF	Camprun \$ / MBF							
2009	3,897	4,074	141	8,112	900.00	400.00	400.00	640.18	322.40	26.59	26.59	18.57	246.02	1,995,739	1,814,308
2010	3,897	4,074	141	8,112	904.50	402.00	402.00	643.38	322.40	26.59	26.59	18.66	249.13	2,020,952	1,670,208
2011	3,897	4,074	141	8,112	909.02	404.01	404.01	646.59	322.40	26.59	26.59	18.75	252.25	2,046,290	1,537,408
2012	3,897	4,074	141	8,112	913.57	406.03	406.03	649.83	322.40	26.59	26.59	18.84	255.39	2,071,756	1,415,037
2013	3,897	4,074	141	8,112	918.14	408.06	408.06	653.08	322.40	26.59	26.59	18.94	258.55	2,097,349	1,302,288
2014	3,897	4,074	141	8,112	922.73	410.10	410.10	656.34	322.40	26.59	26.59	19.03	261.72	2,123,069	1,198,417
2015	3,897	4,074	141	8,112	927.34	412.15	412.15	659.62	322.40	26.59	26.59	19.13	264.90	2,148,919	1,102,735
2016	3,897	4,074	141	8,112	931.98	414.21	414.21	662.92	322.40	26.59	26.59	19.22	268.11	2,174,897	1,014,606
2017	3,897	4,074	141	8,112	936.64	416.28	416.28	666.24	322.40	26.59	26.59	19.32	271.33	2,201,005	933,441
2018	3,897	4,074	141	8,112	941.32	418.36	418.36	669.57	322.40	26.59	26.59	19.42	274.56	2,227,244	858,699
2019	3,758	7,068	223	11,049	946.03	420.46	420.46	599.21	322.40	6.44	3.90	17.38	249.08	2,752,012	964,563
2020	3,758	7,068	223	11,049	950.76	422.56	422.56	602.20	322.40	6.44	3.90	17.46	251.99	2,784,154	887,117
2021	3,758	7,068	223	11,049	955.51	424.67	424.67	605.21	322.40	6.44	3.90	17.55	254.91	2,816,457	815,827
2022	3,758	7,068	223	11,049	960.29	426.79	426.79	608.24	322.40	6.44	3.90	17.64	257.85	2,848,922	750,210
2023	3,758	7,068	223	11,049	965.09	428.93	428.93	611.28	322.40	6.44	3.90	17.73	260.80	2,881,549	689,820
2024	3,758	7,068	223	11,049	969.91	431.07	431.07	614.34	322.40	6.44	3.90	17.82	263.77	2,914,339	634,245
2025	3,758	7,068	223	11,049	974.76	433.23	433.23	617.41	322.40	6.44	3.90	17.90	266.75	2,947,293	583,106
2026	3,758	7,068	223	11,049	979.64	435.39	435.39	620.50	322.40	6.44	3.90	17.99	269.75	2,980,412	536,053
2027	3,758	7,068	223	11,049	984.54	437.57	437.57	623.60	322.40	6.44	3.90	18.08	272.76	3,013,696	492,763
2028	3,758	7,068	223	11,049	989.46	439.76	439.76	626.72	322.40	6.44	3.90	18.17	275.79	3,047,147	452,939
2029	3,258	6,727	131	10,116	994.41	441.96	441.96	619.89	322.40	7.04	4.27	17.98	268.21	2,713,163	366,631
2030	3,258	6,727	131	10,116	999.38	444.17	444.17	622.99	322.40	7.04	4.27	18.07	271.22	2,743,607	337,041
2031	3,258	6,727	131	10,116	1004.37	446.39	446.39	626.10	322.40	7.04	4.27	18.16	274.24	2,774,204	309,818
2032	3,258	6,727	131	10,116	1009.40	448.62	448.62	629.23	322.40	7.04	4.27	18.25	277.28	2,804,954	284,775
2033	3,258	6,727	131	10,116	1014.44	450.86	450.86	632.38	322.40	7.04	4.27	18.34	280.34	2,835,857	261,738
2034	3,258	6,727	131	10,116	1019.52	453.12	453.12	635.54	322.40	7.04	4.27	18.43	283.41	2,866,915	240,550
2035	3,258	6,727	131	10,116	1024.61	455.38	455.38	638.72	322.40	7.04	4.27	18.52	286.49	2,898,128	221,063
2036	3,258	6,727	131	10,116	1029.74	457.66	457.66	641.91	322.40	7.04	4.27	18.62	289.59	2,929,498	203,141
2037	3,258	6,727	131	10,116	1034.89	459.95	459.95	645.12	322.40	7.04	4.27	18.71	292.71	2,961,024	186,661
2038	3,258	6,727	131	10,116	1040.06	462.25	462.25	648.35	322.40	7.04	4.27	18.80	295.84	2,992,708	171,508
2039	5,327	8,248	79	13,654	1040.06	462.25	462.25	687.70	322.40	5.21	3.16	19.94	336.98	4,601,037	239,708
2040	5,327	8,248	79	13,654	1045.26	464.56	464.56	691.14	322.40	5.21	3.16	20.04	340.32	4,646,624	220,075
2041	5,327	8,248	79	13,654	1050.49	466.88	466.88	694.60	322.40	5.21	3.16	20.14	343.68	4,692,438	202,041
2042	5,327	8,248	79	13,654	1055.74	469.22	469.22	698.07	322.40	5.21	3.16	20.24	347.05	4,738,482	185,476
2043	5,327	8,248	79	13,654	1061.02	471.56	471.56	701.56	322.40	5.21	3.16	20.35	350.44	4,784,756	170,261
2044	5,327	8,248	79	13,654	1066.32	473.92	473.92	705.07	322.40	5.21	3.16	20.45	353.84	4,831,261	156,287
2045	5,327	8,248	79	13,654	1071.65	476.29	476.29	708.59	322.40	5.21	3.16	20.55	357.27	4,877,999	143,454
2046	5,327	8,248	79	13,654	1077.01	478.67	478.67	712.14	322.40	5.21	3.16	20.65	360.71	4,924,970	131,668
2047	5,327	8,248	79	13,654	1082.40	481.07	481.07	715.70	322.40	5.21	3.16	20.76	364.17	4,972,176	120,846
2048	5,327	8,248	79	13,654	1087.81	483.47	483.47	719.28	322.40	5.21	3.16	20.86	367.64	5,019,619	110,908
2049	5,282	7,317	52	12,651	1093.25	485.89	485.89	739.46	322.40	5.63	3.41	21.44	386.58	4,890,565	98,233
2050	5,282	7,317	52	12,651	1098.71	488.32	488.32	743.16	322.40	5.63	3.41	21.55	390.17	4,935,983	90,132
2051	5,282	7,317	52	12,651	1104.21	490.76	490.76	746.87	322.40	5.63	3.41	21.66	393.77	4,981,628	82,696
2052	5,282	7,317	52	12,651	1109.73	493.21	493.21	750.61	322.40	5.63	3.41	21.77	397.40	5,027,501	75,871
2053	5,282	7,317	52	12,651	1115.28	495.68	495.68	754.36	322.40	5.63	3.41	21.88	401.04	5,073,604	69,606
2054	5,282	7,317	52	12,651	1120.85	498.16	498.16	758.13	322.40	5.63	3.41	21.99	404.71	5,119,937	63,856
2055	5,282	7,317	52	12,651	1126.46	500.65	500.65	761.92	322.40	5.63	3.41	22.10	408.39	5,166,502	58,579
2056	5,282	7,317	52	12,651	1132.09	503.15	503.15	765.73	322.40	5.63	3.41	22.21	412.09	5,213,299	53,736
2057	5,282	7,317	52	12,651	1137.75	505.67	505.67	769.56	322.40	5.63	3.41	22.32	415.80	5,260,331	49,291
2058	5,282	7,317	52	12,651	1143.44	508.20	508.20	773.41	322.40	5.63	3.41	22.43	419.54	5,307,598	45,213
2059-2108															557,336
Total															25,161,994

Attachment F

Legal Constraints Affecting Forest Management Activities on the Project Area

- Z'Berg-Nejedly Forest Practice Act of 1973 (California Public Resources Code – Division 4, Chapter 8): Designed to protect, enhance & restore California's timberland.
- California Forest Practice Rules (Title 14, California Code of Regulations, Chapter 4): Regulations used to implement the Forest Practice Act that govern timber operations.
- California Timberland Productivity Act of 1982 (Gov.C. 51100 et seq.): The intent of this Act is to “*encourage investment in timberlands based on reasonable expectation of harvest*”, and to “*discourage premature or unnecessary conversion of timberland to urban and other uses*”.
- California Environmental Quality Act (CEQA) (Pub.Res.C. 21000 et seq.): statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.
- Porter-Cologne Water Quality Control Act (California Water Code, Division 7. Water Quality): This is the primary vehicle for implementation of California's responsibilities under the federal 1972 Clean Water Act.
- Clean Water Act of 1972 (33 U.S.C. §1251 et seq.): The Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.
- California Endangered Species Act (Fish & G.C. 2050 et seq.): Protects and Preserves all native species of fishes, amphibians, reptiles, birds, mammals, invertebrates, and plants, and their habitats, that are threatened with extinction.#
- Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884): The Act provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend.#

Attachment G

Willits Woods

Improved Forest Management Project

Verification Crosswalk

September 30, 2010

This document has been prepared as a mechanism for linking the Verification items listed in Tables 10.1(A) through 10.12 presented in Section 10 of the Forest Project Verification Protocol Version 3.2 to the relevant information in the Forest Project Design Document (FPDD), and the Modeling Plan (Verification Documents).

Table 10.1B Initial Eligibility Verification Items – Improved Forest Management Projects

Verification Items		Criteria Met
1. Project Definition	1.a Evidence is provided indicating the canopy cover exceeds 10%.	See page 13 of the FPDD.
	1.b No evidence exists for use of broadcast fertilization.	See page 4 of the FPDD.
2. Legal Requirement Test	2. Proof that a signed Regulatory Attestation form is on file with the Reserve.	The Project meets the legal requirement test for the reporting period. A signed Regulatory Attestation form will be submitted following successful verification of the Project.
3. Start Date	3. Identification of a discrete, verifiable action that delineates a change in practice relative to the project's baseline.	See the Project Submittal Form as well as pages 3-4 of the FPDD.
4. Project Implementation Agreement	4. Proof that a Project Implementation Agreement (PIA) between the forest owner and the Reserve has been signed and recorded in the county of interest.	The PIA will be signed and recorded following successful verification of the Project.
5. Project Location	5.a Project is located in the United States of America. 5.b Project is on private land, or 5.c If non-federal public lands, provide documentation showing approval by the government agency or agencies responsible, or 5.d If Tribal land, provide documentation that demonstrates that the land within the	See general Project Information on page 1 of the FPDD.

Table 10.1D Project Area Definition Verification Items

PROJECT AREA DEFINITION Verification Items		
Verification Items		Criteria Met
1. All	1. Proof that a description and maps of the geographic boundaries defining the project area are on file at the Reserve.	Maps of the Project Area are on file at the Reserve.

Table 10.1F Baseline Modeling Verification Items – Improved Forest Management Projects – Private Lands

Verification Items		Criteria Met
1. Inventory of On-Site Carbon Stocks	1. An inventory of the Project Area's carbon stocks in required and optional pools has been conducted in accordance with the requirements and guidance in Appendix A	See pages 7-9 of the FPDD.
2. Compare Initial Above-Ground Standing Live Carbon Stocks with the Minimum Baseline Level	2.a The baseline analysis utilizes the correct value for Common Practice and the Minimum Baseline Level (for above-ground standing live carbon stocks) associated with the Assessment Area(s) covered the Project Area. 2.b Initial above-ground standing live carbon stocks have been estimated correctly following the requirements and guidance in Appendix A.	See pages 14-15 of the FPDD. See pages 9-13 of the FPDD.
3. Baseline Carbon Stock Modeling	3. A 100-year forest management simulation of standing live carbon stocks has been conducted in accordance with the requirements and guidance in Section 6.2.1 and Appendix B.	See the Modeling Plan included as Attachment C of the FPDD.
4. Description of Forest Project Activities	4. A description has been provided of the management activities that will lead to increased carbon stocks in the Project Area compared to the baseline.	See page 16 of the FPDD.

Table 10.1J Baseline Carbon in Wood Products Verification Items – Improved Forest Management Projects

Verification Items		Criteria Met
1. Baseline Harvest Volume	1. The <i>average</i> volume of harvesting in each year of the baseline over 100 years has been derived from the growth and harvesting regime used to develop the baseline for onsite carbon stocks, following the requirements and guidance in Section 6.2.1 or 6.2.2, Section 6.2.3, Appendix B, and Appendix C.	See the Modeling Plan included as Attachment C of the FPDD, and pages 14-16 of the FPDD.
2. Long-Term Storage in Wood Products	2. The average amount of carbon expected to be transferred to wood products each year and stored over the long-term (100 years) has been calculated following the requirements and guidance of Section 6.2.3 and Appendix C.	See the Modeling Plan included as Attachment C of the FPDD, and pages 12-16 of the FPDD.

Table 10.2 Site Visit Verification Items

Verification Items		Criteria Met
1. Attestation of Title	1. Proof that a signed Attestation of Title is on file at the Reserve for the dates of the verification period. In addition to reviewing this form, the verification body must conduct a review to confirm ownership and claims to GHG reductions/removals that have occurred over the verification period.	The Project meets the attestations specified on the Attestation of Title form for the verification period. A signed Attestation of Title form will be submitted following successful verification of the Project.
2. Regulatory Compliance	2. Proof that a signed Attestation of Regulatory Compliance form is on file with the Reserve for the reporting period. In addition to reviewing this form, the verification body must perform a risk-based assessment to confirm the statements made by the Forest Owner in the Attestation of Regulatory Compliance form.	The Project meets the attestations specified on the Attestation of Regulatory Compliance form for the reporting period. A signed Attestation of Regulatory Compliance form will be submitted following successful verification of the Project.
3. Sustainable Harvesting Practices	3.a Commercial harvesting is neither planned nor ongoing within the Project Area, or 3.b At the time commercial harvesting is either planned or initiated within the Project Area, the Forest Owner meets sustainable harvest practices on all of its landholdings, as described in Section 3.10.1.	See pages 4-5 of the FPDD.
4. Change in Forest Owner Landholdings	4. If the Forest Owner has acquired additional forestlands outside of the Project Area, the Forest Owner must incorporate the newly acquired land in their demonstration of sustainable long-term harvesting practices within 5 years of the acquisition.	No additional forestlands outside of the Project Area have been acquired.
5. Maintenance of Standing Live Carbon Pool	5. No decrease has occurred in the Project Area's standing live carbon stocks over any ten-year consecutive period not accounted for by allowable exceptions.	Standing live carbon stocks have increased since the Project's start date in 12/22/2003.
6. Natural Forest Management	6. Natural Forest Management eligibility criteria in Section 3.10.2 have been and continue to be met.	See page 5 of the FPDD.
7. Estimates of Actual Onsite Carbon Stocks	7.a An inventory of the Project Area's carbon stocks in required and optional pools has been conducted in accordance with the requirements and guidance in Appendix A and Appendix B, or 7.b Inventory has been deferred until the second site-visit verification for Reforestation Projects.	See pages 9-13 of the FPDD.
8. Estimates of Actual Carbon in Harvested Wood Products	8. The amount of harvested wood that has been delivered to mills over the reporting period has been determined correctly, and the amount of carbon expected to be transferred to wood products and stored over the long-term (100 years) has been calculated correctly, per the requirements in Section 6 and the requirements and guidance in Appendix C.	See pages 12-13, and the modeling plan (Attachment C) in the FPDD.
9. Quantification of Primary Effect	9. Calculations for the Primary Effect are complete and accurate for both onsite carbon stocks and harvested wood products.	See pages 18-21 of the FPDD.
10. Quantification of Secondary Effects	10. Calculations for quantifying Secondary Effects are complete and accurate.	See pages 18-21 of the FPDD.

11. Reversal Determination	11. If a reversal has occurred, the type of reversal (avoidable or unavoidable) has been properly identified.	No reversal has occurred on the Project Area.
12. Reversal Risk Rating	12. Project's risk rating has been calculated following the requirements of Appendix D.	See page 17 of the FPDD.

Table 10.4 Natural Forest Management Verification Items

Verification Items		Criteria Met
1. Native Species	1. Completed inventory demonstrates that project consists of at least 95% native species. Must demonstrate continuous progress toward goal and criterion must be met within 50 years.	The Project meets this criterion currently. See page 5 of the FPDD.
2. Composition of Native Species	2.a Reforestation Projects: Documentation on planted mixture of species meets composition of native species goals. Project must show continuous progress and criteria must be met within 50 years.	NA
	2.b Improved Forest Management and Avoided Conversion Projects: Completed inventory demonstrates standing live carbon meets composition of native species goal. Project is not eligible, unless it is demonstrated that management activities will enable this goal to be achieved over the project life.	The Project meets this criterion currently. See page 5 of the FPDD.
3. Sustainability of Timber Resource	3.a Documentation showing that the forest, including entity lands outside project area, is currently under one of the following: 1. Third party certification under the Forest Stewardship Council or Sustainable Forestry Initiative/ Tree Farm System, or 2. A renewable long-term management plan sanctioned and monitored by a state or federal agency, or 3. For entities of 1000 acres or less, restricted to uneven-aged silvicultural practices and canopy retention averaging > 40% across the forest, as measured on any 20 acres within the entity area. Condition shall be met at all times during project and is assessed at each verification audit.	See page 5 of the FPDD.
	3.b Completed inventory demonstrates the project maintains, or makes progress toward maintaining, no more than 40 percent of their forested acres in ages less than 20 years. Project must show continuous progress and this criterion must be met within 25 years.	See page 5 of the FPDD.
4. Structural Elements (Lying and Standing Dead Wood)	4. Completed inventory work demonstrates that lying and standing dead wood is retained in sufficient quantities and for sufficient duration depending on whether portions of the project area have undergone salvage harvesting.	See page 5 of the FPDD.

Table 10.5 Inventory Methodology Verification Items

Verification/Evaluation Items		Criteria Met
1. a	1. Plot locations are established in such a way that the verification body can acquire independent data from within measurement area and compare with forest owner inventory reports.	Plots are well marked in the field. It should be possible to revisit the 2008 plot locations.
1.b	2.Inventory methodology document exists. Document is clear and forest owner can demonstrate implementation.	See Attachment B of the FPDD.
1.c	3.Forest vegetation is stratified (either before or post sampling) or forest owner can demonstrate a methodology that enables the verification body to compare inventory statistics to defined areas (polygons).	The project's timberstands are not stratified; however, the plots are well marked and can be revisited.
1.d	4.Updating process clearly defined in inventory methodology document and forest owner demonstrates adherence to methodology. Inventory, through update processes, is current.	Inventory updates are Described in the FPDD and Modeling Plan. The inventory is currently up to date.
1.e	5.Field observations or aerial photos/other remote sensing comparison to inventory reports demonstrate high correlation.	See DOQ map included as Attachment A in the FPDD.

As the Project Area is between 17,500 to 19,999 acres, the Verification Intensity Multiplier is 4 for this Project.

Table 10.7 Calculating the Verification Field Intensity for Project Area

Verification Multiplier	Item 1	Item 2	Item 3	Item 4	Item 5	Verification Field Intensity
from Table 10.6	From Table 10.5					
4	1	1	1	1	1	4

Based on the above calculated Verification Field Intensity of 4, 16 plots should be installed. The allocation of plots should be based on a random sample of the 286 sample plots installed in 2008.

Table 10.9 Additional Verification Items for Inventory Methodology and Implementation

Verification/Evaluation Items		Criteria Met
1. Other Verified Required and Optional Pools	1. Sampling methodologies for other reported pools adhere to the minimum required sampling criteria in Table A.2 of Appendix A, acceptable practices in forestry and have been implemented correctly.	See pages 7-9, and Attachment B of the FPDD.
2. Inventory Update Processes	2.a Forest Owner's inventory document describes methodology for updating inventory data resulting from growth, harvest, and disturbances. Methodology adheres to acceptable forestry practices.	Please see pages 8-9 of the FPDD and the Modeling Plan.
	2.b Harvest/Disturbance updates in inventory management system are implemented per the specified methodology and are representative of the harvest or disturbance.	Please see pages 8-9 of the FPDD and the Modeling Plan.

	2.c Growth is accounted for using an approved growth model or using a stand table projection, as described in Appendix B.	Please see the Modeling Plan.
3. Biomass Equations and Calculations	3.a The carbon tonnes per acre for a representative sample plot, computed using the Forest Owner's calculation tools, replicate output computed by the verification body. 3.b All conversions and expansions are accurate.	TBD

Table 10.10 Baseline Modeling Verification Items

Verification Items		Criteria Met
1. Document	1. A modeling document exists that contains the all the elements within this table.	The Modeling Document is attached as Attachment C to the FPDD.
2. Qualitative Characterization (Reforestation and Avoided Conversion only)	2. A sufficiently detailed qualitative characterization has been included in the modeling document that documents the general assumptions of the project's baseline. The qualitative assessment addresses the vegetative conditions and activities that would have occurred.	NA
3. Model Choice and Calibration	3a. The model used is an approved model.	See page 2 of the Modeling Plan.
	3.b The Forest Owner has provided a rationale for any model calibrations or an sufficient explanation of why calibrations were not incorporated.	Model calibrations are described on pages 7-8 of the Modeling Plan.
	3.c The Forest Owner has provided a description of the site indexes used for each species and a sufficient explanation of the source of the site index values used.	See page 6 of the FPDD and page 10 of the Modeling Plan.
4. Legal Constraints	4. A list of legal constraints is provided that includes an accurate description of the type and effect of each constraint on the ability to harvest trees and the area constrained.	Legal constraints and how they were modeled in the baseline are described on pages 12-18 of the Modeling Plan.
5. Financial Constraints	5.a A sufficient qualitative description is provided indicating that the harvesting activity modeled in the baseline is a financially viable activity. 5.b For Improved Forest Management projects, Forest Owner has provided either a financial analysis of the anticipated growth and harvesting regime that captures all relevant costs and returns, taking into consideration all legal, physical, and biological constraints; or has provided evidence that activities similar to the proposed baseline growth and harvesting regime have taken place on other properties within the Forest Project's Assessment Area within the past 15 years.	See the financial analysis included as Attachment F of the FPDD.
6. Silviculture Guidelines	6. The silviculture guidelines incorporated in the model demonstrate all legal constraints are applied in the model. The silviculture guidelines must include: i. A description of the trees retained by species group ii. The level of retention iii. Harvest frequency iv. Regeneration assumptions	See the Modeling Plan pages 8-10 and 12-18.

7. Modeling Guidelines	7.a Reforestation: Modeling is based on the qualitative characterization of the baseline and conducted per Section 6.1. 7.b Improved Forest Management: Modeling is conducted per Section 6.2. 7.c Avoided Conversion: Modeling is conducted per Section 6.3.	See pages 19-22 of the Modeling Plan.
8. Modeling Outputs	8.a The Forest Owner has provided reports that display periodic harvest, inventory, and growth estimates for the entire project area presented as total carbon tonnes and carbon tonnes per acre. 8.b Estimates are within the range of expected growth patterns for the Project Area.	See table 5b on page 19 of the Modeling Plan.

Table 10.11 Carbon in Harvested Wood Products Verification Items

Verification Items		Criteria Met
1. Carbon in Harvested Wood Delivered to Mills	1.a Amount of wood harvested that will be delivered to mills has been estimated and reported. 1.b The appropriate wood density factor has been applied and/or water weight subtracted to result in pounds of biomass with zero moisture content. 1.c Total dry weights for all harvested wood have been calculated. 1.d Total carbon weight has been computed. 1.e The total has been converted to metric tonnes of carbon.	See tables 5a and 5b on page 19 of the Modeling Plan, and pages 12-13 of the FPDD.
2. Account for Mill Efficiencies	2. The correct mill efficiency factors have been used to calculate total carbon transferred into wood products.	See page 14 of the FPDD.
3. Wood Product Classification	3.a The percentages of harvest by wood product class has been determined correctly with verified reports from the mill(s) where the project area's logs are sold; or by looking up default wood product classes for the project's assessment area; or if not available from either of these sources, by classifying all wood products as "miscellaneous."	See pages 12-13 of the FPDD.
4. Calculation of In-Use and Landfill Carbon Storage	4.a The average amount of carbon stored in in-use wood products over 100 years has been calculated correctly using the worksheets in Appendix C. 4.b The average amount of carbon stored in landfilled wood products over 100 years has been calculated correctly using the worksheets in Appendix C.	See Table 9 on page 22 of the Modeling Plan, and pages 12-13 of the FPDD.

5. Total Average Carbon Storage in Wood Products Over 100 Years	5. Total average carbon storage in wood products over 100 years for a given harvest volume has been calculated and reported.	See Table 9 on page 22 of the Modeling Plan.
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Table 10.12 Reversal Risk Rating Verification Items

Verification Items		Criteria Met (Correct Risk Factor Applied)
1. Financial Risk	1. Use of a Qualified Conservation Easement or Qualified Deed Restriction, occurrence on public lands, or use of a PIA alone.	See page 17 and Table 6 of the FPDD. All risk ratings are based on Appendix D of the Forest Project Protocol, Version 3.2.
2. Management Risk	2.a Management Risk I – Illegal removals of forest biomass. 2.b Management Risk II – Conversion of project area to alternative land uses. 2.c Management Risk III – Over-harvesting.	
3. Social Risk	3. Social Risk.	
4. Natural Disturbance Risk	4.a. Natural Disturbance Risk I – Wildfire 4.b. Natural Disturbance Risk II – Disease or insect outbreak. 4.c. Natural Disturbance Risk III – Other episodic catastrophic events.	
5. Completing the Risk Rating Analysis	5. Reversal risk rating calculated correctly using the formula in Appendix D.5.	See page 17 of the FPDD.

Attachment H

FIA Volume Equation documentation was updated 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.

Hardwood boardfoot ratio equations were corrected/clarified.

Questions – call or email Karen Waddell 503-808-2046 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 ($\geq 1"$ (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 $\geq 5"$ (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 $\geq 9"$ (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 $\geq 11"$ (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)

<u>Type of Volume</u>	<u>Calculated on trees with a DBH of:</u>	<u>Volume name in equations</u>
<u>All softwoods and hardwoods:</u>		
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
<u>Softwood sawlog volume:</u>		
Volume from a 1-foot stump to a 6-inch top	>= 9" (22.5cm)	CV6
<u>Hardwood sawlog volume:</u>		
Volume from a 1-foot stump to an 8-inch top	>= 11" (27.5cm)	CV8

BOARD FOOT VOLUME (square feet)

<u>Type of Volume</u>	<u>Calculated on trees with a DBH of:</u>	<u>Volume name in equations</u>
<u>Softwoods:</u>		
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
<u>Hardwoods:</u>		
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:

<u>RATIO</u>	<u>Used to convert:</u>
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					CA
		WOR	WWA	EOR	EWA		
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.

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

Softwood cubic volume equations

Equation 1

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

$$\text{CVTS} = 10^{**}\text{CVTSL} \quad (2)$$

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

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

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

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 DBH²

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

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

$$CVTS = \exp(CVTSL) \quad (2)$$

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

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

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

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 DBH²

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

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Equation 4

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

$$CVTS = \exp(CVTSL) \quad (2)$$

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

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

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

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 DBH²

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

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Equation 6

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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 DBH²

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

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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 DBH²

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

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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 DBH²

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

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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 DBH²

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

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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 DBH²

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

$$CVTSL = -2.575642 + 1.806775 \times \log(DBH) + 1.094665 \times \log(HT) \quad (1)$$

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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 DBH²

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

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

$$CVTS = 10^{**}CVTSL$$

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

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

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

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 DBH²

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

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

$$CVTS = 10^{CVTSL} \quad (2)$$

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

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

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

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 DBH²

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

$$CVTSL = -2.615591 + 1.847504 \times \log(DBH) + 1.085772 \times \log(HT) \quad (1)$$

$$CVTS = 10^{CVTSL}$$

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

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

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

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 DBH²

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

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Equation 17

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

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

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

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

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 DBH²

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

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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

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

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

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

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

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 DBH²

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

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

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

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

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

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

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) $BA = .005454154 \times DBH^2$

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

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Equation 24

$$CVTS = \exp(-6.2597 + 1.9967 \times \ln(DBH) + 0.9642 \times \ln(HT)) \quad (1)$$

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

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

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

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 x DBH²**

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

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

$$CV6 = RC6 \times CV4$$

IF CV6 > CV4 THEN CV6 = CV4

$$CUBUS = CV4 - CV6$$

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

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

$$RS616 = 10.0^{RS616L}$$

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

$$SV616 = RS616 \times CV6$$

$$SV632 = RS632 \times SV616$$

$$SCRIB = SV632$$

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

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

$$XINT6 = RI6 \times CV6$$

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

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

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

$$CVT = 0.00545415 \times (DBH)^2 \times (HT - 4.5) \times F \tag{2}$$

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

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

$$CV4 = \frac{\text{TARIF} \times (BA - 0.087266)}{0.912733} \tag{5}$$

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

$$CV8 = RC8 \times CV4 \tag{6}$$

$$CV4X = CV4$$

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

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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

$$CV8 = RC8 \times CV4 \quad (6)$$

$$CV4X = CV4$$

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

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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

$$CV8 = RC8 \times CV4 \quad (6)$$

$$CV4X = CV4$$

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 28

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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

$$CV8 = RC8 \times CV4 \quad (6)$$

$$CV4X = CV4$$

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 29

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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

$$CV8 = RC8 \times CV4 \quad (6)$$

$$CV4X = CV4$$

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 30

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

$$CVTS = 10^{**}CVTSL \quad (2)$$

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

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

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

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

$$CV8 = RC8 \times CV4 \quad (6)$$

$$CV4X = CV4$$

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 31

$$CVTS = 0.0016144 \times DBH^2 \times HT \quad (1)$$

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

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

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

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

$$CV8 = RC8 \times CV4 \quad (5)$$

$$CV4X = CV4$$

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 32

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

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

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

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 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 33

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

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

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

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 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 34

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

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

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

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 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 35

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

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

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

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 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 36

$$CVTS = 0.0191453191 \times DBH^{2.40248} \times HT^{0.28060} \quad (1)$$

$$CV4 = 0.0053866353 \times DBH^{2.61268} \times HT^{0.31103} \quad (2)$$

$$CV8 = CV4 \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 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 37

$$CVTS = 0.0101786350 \times DBH^{2.22462} \times HT^{0.57561} \quad (1)$$

$$CV4 = 0.0034214162 \times DBH^{2.35347} \times HT^{0.69586} \quad (2)$$

$$CV8 = 0.0004236332 \times DBH^{2.10316} \times HT^{1.08584} \times FC^{0.40017} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$CVTS = 0.0070538108 \times DBH^{1.97437} \times HT^{-0.85034} \quad (1)$$

$$CV4 = 0.0036795695 \times DBH^{2.12635} \times HT^{0.83339} \quad (2)$$

$$CV8 = 0.0012478663 \times DBH^{2.68099} \times HT^{0.42441} \times FC^{0.28385} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$CVTS = 0.0125103008 \times DBH^{2.33089} \times HT^{0.46100} \quad (1)$$

$$CV4 = 0.0042324071 \times DBH^{2.53987} \times HT^{0.50591} \quad (2)$$

$$CV8 = 0.0036912408 \times DBH^{1.79732} \times HT^{0.83884} \times FC^{0.15958} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$CVTS = 0.0067322665 \times DBH^{1.96628} \times HT^{-0.83458} \quad (1)$$

$$CV4 = 0.0025616425 \times DBH^{1.99295} \times HT^{1.01532} \quad (2)$$

$$CV8 = 0.0006181530 \times DBH^{1.72635} \times HT^{1.26462} \times FC^{0.37868} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$CVTS = 0.0072695058 \times DBH^{2.14321} \times HT^{0.74220} \quad (1)$$

$$CV4 = 0.0024277027 \times DBH^{2.25575} \times HT^{0.87108} \quad (2)$$

$$CV8 = 0.0008281647 \times DBH^{2.10651} \times HT^{0.91215} \times FC^{0.32652} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$CVTS = 0.0097438611 \times DBH^{2.20527} \times HT^{0.61190} \quad (1)$$

$$CV4 = 0.0031670596 \times DBH^{2.32519} \times HT^{0.74348} \quad (2)$$

$$CV8 = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$CVTS = 0.0065261029 \times DBH^{2.31958} \times HT^{0.62528} \quad (1)$$

$$CV4 = 0.0024574847 \times DBH^{2.53284} \times HT^{0.60764} \quad (2)$$

$$CV8 = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$CVTS = 0.0136818837 \times DBH^{2.02989} \times HT^{0.63257} \quad (1)$$

$$CV4 = 0.0041192264 \times DBH^{2.14915} \times HT^{0.77843} \quad (2)$$

$$CV8 = 0.0006540144 \times DBH^{2.24437} \times HT^{0.81358} \times FC^{0.43381} \quad (3)$$

$$CVT = CVTS * RTS \quad (4)$$

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

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

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

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 DBH²
 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

$$\text{CUBUS} = \text{CV4} - \text{CV8} \quad (1)$$

$$\text{RC6} = 0.993 - 0.993 \times 0.62^{(\text{DBH}-6.0)} \quad (2)$$

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:

$$\text{CV4X} = \text{CVT} \times 0.99875 - \frac{43.336}{\text{DBH}^3} - \frac{124.717}{\text{DBH}^4} + \frac{0.193437 \times \text{HT}}{\text{DBH}^3} + \frac{479.83}{\text{DBH}^3 \times \text{HT}}$$

$$\text{TARIFX} = \frac{\text{CV8} \times 0.912733}{0.983 - 0.983 \times 0.65^{\text{DBH}-8.6} \times \text{BA} - 0.087266}$$

If TARIF or TARIFX are <0 then set them to .01

$$\text{CV6} = \text{RC6} \times \text{CV4X} \quad (3)$$

$$\text{B4} = \frac{\text{TARIFX}}{0.912733}$$

$$\text{RS616L} = 0.174439 + 0.117594 \times \log(\text{DBH}) \times \log(\text{B4}) - \frac{8.210585}{\text{DBH}^2} + 0.236693 \times \log(\text{B4}) - 0.00001345 \times (\text{B4})^2 - 0.00001937 \times \text{DBH}^2 \quad (4)$$

$$\text{RS616} = 10.0^{\text{RS616L}} \quad (5)$$

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

$$\text{RI6} = -2.904154 + 3.466328 \times \log(\text{DBH} \times \text{TARIFX}) - 0.02765985 \times \text{DBH} - 0.00008205 \times \text{TARIFX}^2 + \frac{11.29598}{\text{DBH}^2} \quad (6)$$

$$\text{XINT6} = \text{RI6} \times \text{CV6} \quad (7)$$

$$\text{RS616} = 0.990 - 0.58 \times (0.484^{\text{DBH}-9.5}) \quad (8)$$

$$\text{SV816} = \text{RS816} \times \text{SV616} \quad (9)$$

Calculated on hardwood species only:

$$\text{RI8} = 0.990 - 0.55 \times (0.485^{\text{DBH}-9.5}) \quad (10)$$

$$\text{XINT8} = \text{XINT6} \times \text{RI8} \quad (11)$$

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)

Willits Woods Project Design Document

HARDWOOD VOLUME EQUATION SOURCES

- Curtis, Robert O., Bruce, David, and Caryanne VanCoevinger. 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.**

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.

BIOMASS EQUATIONS AND PROCEDURES

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				CA
		WOR	WWA	EOR	EWA	
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	Subalpine 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

Code	Species	WOR	WWA	Halfstate		CA
				EOR	EWA	
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 (when DBH > 39.37)	17	17	17	17	17
211	Redwood (when DBH < = 39.37)	13	13	13	13	13
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				CA
		WOR	WWA	EOR	EWA	
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	Subalpine 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				CA
		WOR	WWA	EOR	EWA	
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				CA
		WOR	WWA	EOR	EWA	
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				CA
		WOR	WWA	EOR	EWA	
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		CA
				EOR	EWA	
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		EWA	CA
				EOR			
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 EQUATIONS

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

$$BB = \frac{\exp(2.1069 + 2.7271 \times \log(DBH))}{1000}$$

EQUATION 2

BIOPAK EQUATION 887

$$BB = 0.6 + 16.4 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 3

BIOPAK EQUATION 917

$$BB = 1.0 + 17.2 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 4

BIOPAK EQUATION 382

$$BB = \frac{\exp(1.47146 + 2.8421 \times \log(DBH))}{1000}$$

EQUATION 5

BIOPAK EQUATION 251

$$BB = \frac{\exp(2.79189 + 2.4313 \times \log(DBH))}{1000}$$

EQUATION 6

BIOPAK EQUATION 845

$$BB = 1.3 + 12.6 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 7

BIOPAK EQUATION 875

$$BB = 4.5 + 9.3 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 8

BIOPAK EQUATION 5

$$BB = \exp(-4.3103 + 2.4300 \times \log(DBH))$$

EQUATION 9

BIOPAK EQUATION 705

$$BB = \exp(-3.6263 + 1.34077 \times \log(DBH) + 0.8567 \times \log(HT))$$

EQUATION 10

BIOPAK EQUATION 391

$$BB = \frac{\exp(2.183174 + 2.6610 \times \log(DBH))}{1000}$$

EQUATION 11

BIOPAK EQUATION 899

$$BB = 1.2 + 11.2 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 12 (updated)

BIOPAK EQUATION 385

$$BB = \frac{\exp(-13.3146 + 2.8594 \times \log(DBH)) * 1000}{1000}$$

EQUATION 13

BIOPAK EQUATION 461

$$BB = 0.336 + 0.00058 \times DBH^2 \times HT$$

EQUATION 14

BIOPAK EQUATION 904

$$BB = 3.2 + 9.1 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 15

$$BB = \exp(-4.371 + 2.259 \times \log(DBH))$$

EQUATION 16

BIOPAK EQUATION 54

$$BB = \exp(-10.175 + 2.6333 \times \log(DBH \times \pi))$$

EQUATION 17

BIOPAK EQUATION 394

$$BB = \frac{\exp(7.189689 + 1.5837 \times \log(DBH))}{1000}$$

EQUATION 18

BIOPAK EQUATION 942

$$BB = 1.3 + 27.6 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 19

$$BB = 0.0$$

EQUATION 20

BIOPAK EQUATION 275

$$BB = \exp(-4.6424 + 2.4617 \times \log(DBH))$$

EQUATION 21

BIOPAK EQUATION 911

$$BB = 0.9 + 27.4 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 22

BIOPAK EQUATION 881

$$BB = 1.0 + 15.6 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 23

BIOPAK EQUATION 923

$$BB = 1.8 + 9.6 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 24

BIOPAK EQUATION 893

$$BB = 2.4 + 15.0 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 25

BIOPAK EQUATION 857

$$BB = 3.6 + 18.2 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 26

Weyerhaeuser Co Equation

$$BB = -0.025 + 0.00134 \times DBH^2 \times HT$$

EQUATION 27

$$BB = -1.2 + 29.1 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 28

BIOPAK EQUATION 930

$$BB = 1.2 + 15.5 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 29 (Bigleaf maple)

$$ADBH = \frac{(DBH - 0.21235)}{0.94782} \quad 1$$

$$OUTERVOL = 0.0000246916 \times (ADBH^{2.354347} (HT^{0.69586})) \quad 2$$

$$INNERVOL = 0.0000246916 \times (DBH^{2.354347} (HT^{0.69586})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 30 (California Black Oak)

$$ADBH = \frac{(DBH + 0.68133)}{0.95767} \quad 1$$

$$OUTERVOL = 0.0000386403 \times (ADBH^{2.12635} (HT^{0.83339})) \quad 2$$

$$INNERVOL = 0.0000386403 \times (DBH^{2.12635} (HT^{0.83339})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 31 (Canyon Live Oak)

$$ADBH = \frac{(DBH + 0.48584)}{0.96147} \quad 1$$

$$OUTERVOL = 0.0000248325 \times (ADBH^{2.32519} (HT^{0.74348})) \quad 2$$

$$INNERVOL = 0.0000248325 \times (DBH^{2.32519} (HT^{0.74348})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 32 (Golden Chinkapin)

$$ADBH = \frac{(DBH - 0.39534)}{0.90182} \quad 1$$

$$OUTERVOL = 0.000056884 \times (ADBH^{2.07202} (HT^{0.77467})) \quad 2$$

$$INNERVOL = 0.000056884 \times (DBH^{2.07202} (HT^{0.77467})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

EQUATION 33 (California Laurel)

$$ADBH = \frac{(DBH + 0.32491)}{0.96579} \quad 1$$

$$OUTERVOL = 0.0000237733 \times (ADBH^{2.05910} (HT^{1.05293})) \quad 2$$

$$INNERVOL = 0.0000237733 \times (DBH^{2.05910} (HT^{1.05293})) \quad 3$$

$$BB = (OUTERVOL - INNERVOL) \times 35.30 \times DENSFAC / 2.2046 \quad 4$$

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 EQUATIONS

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

$$BLB = 13.0 + 12.4 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 2

BIOPAK EQUATION 919

$$BLB = 3.6 + 44.2 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 3

BIOPAK EQUATION 28

$$BLB = \exp(-4.1817 + 2.3324 \times \log(DBH))$$

EQUATION 4

BIOPAK EQUATION 877

$$BLB = 16.8 + 14.4 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 5

BIOPAK EQUATION 847

$$BLB = 9.7 + 22.0 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 6

BIOPAK EQUATION 2

$$BLB = \exp(-3.6941 + 2.1382 \times \log(DBH))$$

EQUATION 7

BIOPAK EQUATION 702

$$BLB = \exp(-4.1068 + 1.5177 \times \log(DBH) + 1.0424 \times \log(HT))$$

EQUATION 8

$$BLB = \exp(-7.637 + 3.3648 \times \log(DBH))$$

EQUATION 9

BIOPAK EQUATION 901

$$BLB = 9.5 + 16.8 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 10

BIOPAK EQUATION 459

$$BLB = 0.199 + 0.00381 \times DBH^2 \times HT$$

EQUATION 11

BIOPAK EQUATION 907

$$BLB = 7.8 + 12.3 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 12

$$BLB = \exp(-4.570 + 2.271 \times \log(DBH))$$

EQUATION 13

BIOPAK EQUATION 51

$$BLB = \exp(-7.2775 + 2.3337 \times \log(DBH \times \pi))$$

EQUATION 14

BIOPAK EQUATION 944

$$BLB = 1.7 + 26.2 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 15

BIOPAK EQUATION 932

$$BLB = 2.5 + 36.8 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 16

$$BLB = \exp(-4.5648 + 2.6232 \times \log(DBH)) - BF$$

$$\text{where: } BF = (\exp(-4.5648 + 2.6232 \times \log(DBH))) \times \frac{1}{(2.7638 + 0.062 \times DBH^{1.3364})}$$

EQUATION 17

$$BLB = \exp(-5.2581 + 2.6045 \times \log(DBH))$$

EQUATION 18

BIOPAK EQUATION 883

$$BLB = 4.5 + 22.7 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 19

BIOPAK EQUATION 925

$$BLB = 5.3 + 9.7 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 20

BIOPAK EQUATION 895

$$BLB = 20.4 + 7.7 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 21

BIOPAK EQUATION 446

$$BLB = 0.626 + 0.00079 \times DBH^2 \times HT$$

EQUATION 22

BIOPAK EQUATION 859

$$BLB = 12.6 + 23.5 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 23

Weyerhaeuser Co Equation

$$BLB = 0.047 + 0.00413 \times DBH^2 \times HT$$

EQUATION 24

BIOPAK EQUATION 913

$$BLB = 4.2 + 17.4 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 25

BIOPAK EQUATION 950

$$BLB = -0.6 + 45.1 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

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

Attachment I

Average Site Index - Entire Ownership

Species	Avg Site Index	Sample Size
Douglas-fir	118	157
Redwood	114	80
Sugar-Pine	116	104

Property Wide Site Index for trees >24:

Species	Site Index	Sample Size
Douglas-fir	113	118
Redwood	111	62
Sugar-Pine	107	82

Property Wide Site Index for trees <25:

Species	Site Index	Sample Size
Douglas-fir	126	39
Redwood	129	18
Sugar-Pine	152	22

Willits Woods Average Site

Species	Site Index	Sample Size
Douglas-fir	126	80
Redwood	123	47

Average Site Index for trees >24:

Species	Site Index	Sample Size
Douglas-fir	120	62
Redwood	119	31

Average Site Index for trees <25:

Species	Site Index	Sample Size
Douglas-fir	139	18
Redwood	128	16

Longview Average Site

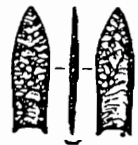
Species	Site Index	Sample Size
Douglas-fir	110	77
Redwood	103	33
Sugar-Pine	116	104

Average Site Index for trees >24:

Species	Site Index	Sample Size
Douglas-fir	106	56
Redwood	102	31
Sugar-Pine	107	82

Average Site Index for trees <25:

Species	Site Index	Sample Size
Douglas-fir	117	21
Redwood	133	2
Sugar-Pine	152	22



March 4, 1997

Mr. Tim Robards
California Department of Forestry and Fire Protection
1416 Ninth St., Room 1516-4
Sacramento, California 94244-2460

Re: CFL Site Tree Study

Dear Mr. Robards,

The collection of field data for this project is complete. Attached please find a listing of all the site trees collected as a part of this project. Also please find my calculation of site index dated 2/12/97. I have also attached a copy of the letter by Mr. Glen Zane of MB&G, detailing their conclusions regarding the site tree study.

Data Summary:

The site trees measured have been entered into an Access database, from which the data can be manipulated or sorted to provide desired calculations. The site tree data is available in digital format for calculation or modeling purposes, and will be provided if requested.

Site tree data can be summarized in different manners to reflect different analysis requirements. The attached table presents the site index calculation for the entire property, for the Willits Woods and Longview Fiber separately, while also calculating a site index with all trees, and differentiating between trees twenty five years of age and older, and those younger than twenty five. It is understood that final calculation of site index will be performed by Mason, Bruce, and Girard, Inc..

Discussion of Site Tree Measurements and Results.

The site tree protocols agreed to by the CDF require that trees be selected within a plot not exceeding 2 acres in size, located in a systematic manner across the entire ownership. Within the plot, dominant and codominant trees meeting the selection criteria were required to be selected as site trees. In general, if the trees show evidence of consistent growth, without suppression, they are required to be selected. In both site tree studies conducted on CFL lands (current study and 1995 study) several issues have become apparent that have never been fully resolved. First, due to the harvest history of CFL



stands, most of the older candidate site trees are codominants or intermediate trees from previous stands. Current protocols require that emphasis be given towards selecting trees as close to the Index Age (50 years) as possible. Unfortunately, many of the trees approaching this age are of low vigor, or are of questionable status. A portion of CFL's older site tree candidate trees were likely codominant or intermediate trees in the native stand. For a variety of reasons these older trees have been retained in the stand, and the timber site potential they express may be below actual as they have not truly grown at full potential throughout their life span. As a case in point, in both site studies the average timber site index calculated for both Douglas-fir and redwood increases as site tree age decreases. It is likely that the younger site trees measured are expressing full growth potential, and may be acting as true dominants. Given the composition of CFL's timber stands, these younger trees may present the best evidence as to actual timber site potential.

During discussions with you, the issue of minimum site tree age was discussed at length. It was your position that site trees should be no less than 25 years of age. The dominant argument presented in favor of this notion is the fact that a majority of the sample trees in the original site tree studies were older than 25 years of age. While this may be a correct statement, the data sets of original studies do contain trees less than 25 old, and these trees were used to construct height/age curves beginning at ages less than 25 years of age (breast high age). While differences between site index curves may be small at young ages, it does not seem logical to exclude young trees from our calculated average.

Most of the historic site tree studies were derived from stands with significantly different characteristics than the CFL lands. For example, most of the stands sampled to construct the original studies were single aged, and did not have recent harvest activity or hardwood competition. For the most part, trees measured were dominant trees. In both of the CFL studies to date site trees available for measurement are mostly codominant trees, in multi-aged stands, with varying levels of harvest activity and hardwood competition.

Estimating timber site index on CFL is a challenging task, as the stand conditions differ significantly from stands used historically to model site. The methods employed in historic studies to measure site potential are difficult to apply to CFL's lands. This fact became very clear to all of us when we were working with you to adopt protocols for this round of plots. For example, on CFL you cannot measure the largest 20% of the trees present and assume



that you have captured the dominant trees on site, as has been done in other site tree studies. Instead, we have built protocols that roughly follow the "classic" approach while allowing us to pay attention to dominance of individual trees. The growth of the young dominants measured is the best available, and may be our best indicator of timber site potential. The estimate of site provided by the current study while unbiased, may be unduly conservative due to the general pressure to "find" site trees on plots where only marginal codominant trees exist.

All other factors aside, I feel that the inclusion of all trees measured that are fifteen years of age or older in our site tree study is reasonable.

Do not hesitate to call if you have any further questions.

Sincerely,

Mark D. Edwards

Registered Professional Forester #2039

cc: Coastal Forestlands, LTD.



NORTH COAST RESOURCE MANAGEMENT

P.O. Box 509 Redwood Valley, CA 95470-0509 707-485-7211

Forestry-Archaeology-Computer Consulting



#27

January 10, 1997

Mr. Tim Robards
California Department of Forestry and Fire Protection
1416 Ninth St., Room 1516-4
Sacramento, California 94244-2460

Re: CFL Site Tree Protocols

Dear Mr. Robards,

Pursuant to our telephone conversations yesterday, and as per your letter dated 1/9/97, attached please find the "final" site tree protocols that we propose for the upcoming CFL site tree study. I believe that these revised protocols incorporate the revisions requested in your 1/9/97 letter.

Site Tree Plot Location

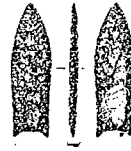
All site tree plots will be installed on CFL grid locations. Prior to starting field activities 198 site tree plot locations have been established on a systematic manner across the entire property. In general, plots were located at every thirty fifth key plot location throughout the ownership. Adjustments to this spacing were required to ensure that plots sampled only strata used for modeling purposes- CH33, HC33, HWDCON, RCRH, and CONHWD. No plots will be installed on non-modeled strata - SG, HARDWOOD, and NONVEG.

It is anticipated that not all of the 198 plots will be reachable due to time or access problems. For reasons of access, no plots are allotted to the Brandt Tract. This study will install at least 180 site tree plots out of the 198 plots indicated on the site tree plot map. In addition, no less than 90% of the plots allotted within either the Willits Woods or Longview Tracts will be installed.

Following the installation of the 180 minimum plots, additional plots will be installed if required within specific strata to ensure adequate sampling. The location of plots added to provide for appropriate strata sampling will be reviewed with CDF staff prior to their installation.

Plot Installation

At each plot location a 167 foot radius plot will be installed. Plots will be installed at key plot locations and fully monumented as per CFL's timber



cruise key plot standards. Each plot will be divided into four quadrants (NE (0°-89°), SE (90°-179°), SW (180°-269°), & NW (270°-359°)) with the NW quadrant sampled initially for site trees. The protocols below call for locating up to five site trees per species, per plot. If less than five measurable site trees per species are encountered in the first quadrant (NE), then the second quadrant may be entered (SE). In turn, the third quadrant (SW) and then the fourth quadrant (NW) may be visited to obtain up to five site trees per species. The number of site trees to be chosen is cumulative through the four quadrants. That is, up to five site trees per species will be selected, beginning in the NE quadrant, and progressing in a clockwise manner through the other three quadrants. All candidate trees will be identified within the individual quadrant, and trees meeting all of the site tree selection criteria will be measured. In instances where excess site trees are available following review of the entire quadrant, only that number of trees required to meet the "five" limitation shall be selected as site trees. In this instance, priority will be given to trees with:

- 1) the largest DBH
- 2) DBH age nearest Index age (50 years)
- 3) All other factors being the same, the first tree encountered (lowest azimuth).

Data for site trees not chosen due to the "five" limitation shall be retained on the plot card, and the reason for not choosing these candidate trees shall be noted.

Individual site trees selected will be numbered with an appropriate tag at DBH, as well as paint marked with "ST" on two sides to indicate their status as site trees. The approximate location of each site tree will be shown on a field map, and for each site tree the approximate distance and azimuth from plot center will be recorded. Next, the plot center will be mapped, and its location recorded via GPS (2 meter accuracy)

Site Tree Selection Criteria

Candidate site trees must meet the following guidelines:

- 1) All trees selected must be either dominant or codominant trees, and must have maintained this crown position throughout their life.
- 2) They must display a past history of uniform and consistent leader growth.
- 3) They must have a full, healthy crown, or nearly so.



- 4) Analysis of radial increment for candidate trees must indicate that the candidate tree has not been suppressed in its past.
- 5) Trees should not be selected that show signs of damage or disease, are residual type old-growth, or are "wolf" trees.
- 6) Site trees must be chosen as close to the index age as possible (50 years). Priority shall be given to selecting site trees 25 years of age or older, and no site trees will be selected with a breast high age less than fifteen years. When selecting between candidate trees meeting 1-4 above, and exhibiting otherwise similar characteristics, preference will be given to the tree nearest the index age. Up to five site trees 25 years or older at breast height will be selected. Site trees between 15 and 25 years of age will be collected only after trees older than 25 are collected. If five site trees older than 25 are found on the plot, any trees between 15 and 25 years of age may be measured and included on the plot card as supplemental data.
- 7) Site trees must be located within plot boundaries.

Douglas-fir Site Index Sampling

At each location identify candidate site trees prior to beginning final selection. Candidate site trees meeting all the criteria set out above, shall be selected whenever possible from trees of the largest 20% by DBH present in the plot. In the event no suitable site trees exist in the plot from within the largest 20%, smaller trees may be selected. At each plot record data from up to five Douglas-fir site trees, only if they comply with all of provisions 1-6 above. No Douglas-fir site trees shall be selected that are joined at their butt. For each site tree selected, record the plot information as indicated below.

Redwood Site Index Sampling

At each location identify candidate trees within the plot area prior to beginning final selection. Candidate site trees meeting all the criteria set out above, shall be selected whenever possible from trees of the largest 20% by DBH present in the plot, and shall be selected primarily from dominant sprouts. In the event insufficient dominant sprouts exist on the plot, site trees may be selected from codominant trees within the largest 20% of trees present. At each plot record up to five site trees, only if they comply with all of provisions 1-6 above.



Sugar Pine Site Index Sampling

Sugar Pine site trees shall be measured as a part of this site tree project. The Douglas-fir Sampling procedures shall be followed for this species.

Field Procedures

All data will be recorded on the "Site Tree Form" provided. Grid intersect points are to be located by GPS, and mapped and located on the ground as per the CFL timber cruise manual. Previously prepared maps showing CFL inventory grid intersect points for plots to be sampled will be provided to field crews. Site tree plots will be a 167 foot radius plot centered on preselected grid intersect points.

For each plot record the following data:

- 1) Crew Members
- 2) Date
- 3) Line start and reference tree information.
- 4) Locate plot at grid point and record appropriate plot number on card.
- 5) GPS plot center (2m accuracy). If offsets to plot center are required, note offsets on plot card.
- 6) Comments - access, etc.
- 7) Map location of plot and approximate location of site tree.

At each plot, install plot as follows, and record the following data:

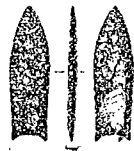
- 8) Proceed from plot center due north for up to 167 feet and cover the plot area by moving clockwise through the NE quadrant, and into additional quadrants if required as is described above. Refer to Site Trees Selection Criteria above to determine if the potential site trees encountered meet site tree criteria.
- 9) Upon locating a potential site tree, using your increment borer, extract an increment core from a boring taken at breast height. Examine the increment core to determine whether the tree shows signs of having been suppressed. If the tree shows signs of having been suppressed, exclude that tree from your sample and continue the site tree search. If the tree does not show signs of suppression, determine and record the breast height age of the site tree, and the five and ten year increment (in 1/20th inch) from the increment core.



NORTH COAST RESOURCE MANAGEMENT

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- 10) Number each site tree sequentially in the plot. Each site tree will have a two part number - the plot number followed by a "-" and the tree number.
- 11) Record the azimuth and approximate distance from the plot center to the site tree.
- 12) Record the species of the site tree.
- 13) Record the DBH to the nearest 1/10th inch.
- 14) Measure and record total height of the site tree to the nearest two feet.
- 15) Estimate and record the live crown ratio of the site tree to the nearest 5 percent.
- 16) Record if the tree is dominant or codominant.
- 17) For each tree, at DBH place an aluminum tack and tag containing the plot intersect and tree number (the two part number described in #10 above). Tie flagging around the tree just above the aluminum tag. Paint the letters "ST" for site tree on the bole of the site tree just below the aluminum tag, and facing plot center.

I hope that you will look these over if you have time. You should receive the plot map early next week. Do not hesitate to contact me if you have additional comments. I would appreciate it if you would send me a memo indicating your approval of the site tree protocols above.

Sincerely,

Mark D. Edwards
RPF #2039

STATE OF CALIFORNIA-THE RESOURCES AGENCY

PETE WILSON, Governor

DEPARTMENT OF FORESTRY AND FIRE PROTECTION

1416 Ninth Street
Sacramento California 95814
(916) 657-4778

#28



R 27

Mr. Mark Edwards
North Coast Resource Management
P.O. Box 509
Redwood Valley, CA 95470

January 13, 1997

Dear Mr. Edwards,

Thank you for the final site tree sampling protocols dated January 10, 1997. Most of the concerns that I have discussed with you in previous memos and conversations are incorporated as revisions in the final protocol. It is my understanding that all 198 plots will be visited. CDF believes, for reasons stated in earlier correspondence, that an unbiased sampling protocol shall consider only trees at least 25 years old for site trees. Given the two items above, this protocol is believed by CDF to be an unbiased sampling protocol to quantify the site productivity of CFL's property.

Sincerely,

A handwritten signature in dark ink, appearing to read 'Tim A. Robards'.

Timothy A. Robards
Forest Biometrician
RPF 2521

STATE OF CALIFORNIA-THE RESOURCES AGENCY

PETE WILSON, Governor

DEPARTMENT OF FORESTRY AND FIRE PROTECTION

1416 Ninth Street
Sacramento California 95814
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R 27

Mr. Mark Edwards
North Coast Resource Management
P.O. Box 509
Redwood Valley, CA 95470

January 27, 1997

Dear Mr. Edwards,

I received a fax from Jim Mehrwein at Mason, Bruce, and Girard on Friday, January 24, 1997. I also spoke with Mr. Mehrwein this morning for some additional clarification. The plots were selected moving from north to south, when at the bottom of a column the column to the east was moved to and then the count proceeded north. This pattern was continued across the property. This accounts for why there is no pattern to the plot numbers as they are sequential from west to east. Mr. Mehrwein states that only grid points and timber strata were used when plots were allocated.

Given the information provided by Mr. Mehrwein, the plot locations should provide an unbiased sample.

Sincerely,

A handwritten signature in cursive script, appearing to read "Timothy A. Robards".

Timothy A. Robards
Forest Biometrician
RPF 2521

Attachment J

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 Period Data entered for end of each Period; Period 2, each Period = 12 months		after	Initial Data at Start Date	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017			
Calc Row	Calculating GHG Reductions/Removals for Onsite Carbon Stocks - All Project Types																			
1	Actual Onsite Carbon Stocks (tonnes CO ₂ e)		2,552,274	2,695,565	2,846,902	3,006,735	3,175,542	3,353,826	3,542,119	3,740,983	3,951,013									
2	Confidence Deduction		1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%	1.9%									
3	Adjusted Actual Onsite Carbon Stocks (adjusted for confidence deduction) (tonnes CO ₂ e)		2,503,780	2,644,350	2,792,811	2,949,607	3,115,206	3,290,103	3,474,819	3,669,905	3,875,943	-	-	-	-	-	-			
4	Increment in Actual Onsite Carbon Stocks (tonnes CO ₂ e)			140,569	148,461	156,796	165,599	174,896	184,716	195,086	206,039	-	-	-	-	-	-			
5	Baseline Onsite Carbon Stocks (tonnes CO ₂ e)		2,558,969	2,558,969	2,558,969	2,558,969	2,558,969	2,558,969	2,558,969	2,558,969	2,558,969									
6	Increment in Baseline Onsite Carbon Stocks (tonnes CO ₂ e)			-	-	-	-	-	-	-	-	-	-	-	-	-	-			
7	Quantified GHG Reductions / Removals for Onsite Carbon Stocks (tonnes CO ₂ e)		(55,188)	140,569	148,461	156,796	165,599	174,896	184,716	195,086	206,039	-	-	-	-	-	-			
Calc Row	Calculating Carbon Stored in Wood Products Including Market Effects and Leakage - All Project Types																			
8	Actual Carbon in Trees Harvested for Wood Products in (tonnes CO ₂ e)			-																
9	Baseline Carbon in Trees Harvested for Wood Products (tonnes CO ₂ e)			93,133	93,133	93,133	93,133	93,133	93,133	93,133	93,133									
10	Actual Carbon in Harvested Wood Delivered to Mills (tonnes CO ₂ e)			-																
11	Baseline Carbon in Harvested Wood Delivered to Mills (tonnes CO ₂ e)			51,185	51,185	51,185	51,185	51,185	51,185	51,185	51,185									
12	Actual Carbon Stored Long-term in Wood Products (tonnes CO ₂ e) - Excl Landfill		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
13	Actual Carbon Stored Long-term in Wood Products (tonnes CO ₂ e) - Incl Landfill		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
14	Baseline Carbon Stored Long-term in Wood Products (tonnes CO ₂ e) - Excl Landfill		0	15,871	15,871	15,871	15,871	15,871	15,871	15,871	15,871	0	0	0	0	0	0			
15	Baseline Carbon Stored Long-term in Wood Products (tonnes CO ₂ e) - Incl Landfill		0	26,118	26,118	26,118	26,118	26,118	26,118	26,118	26,118	0	0	0	0	0	0			
16	Diff Between Actual and Baseline Carbon in Harvested Wood (tonnes CO ₂ e) - Excl Landfill		0	(15,871)	(15,871)	(15,871)	(15,871)	(15,871)	(15,871)	(15,871)	(15,871)	0	0	0	0	0	0			
17	Difference Between Actual and Baseline Carbon in Harvested Wood (tonnes CO ₂ e) - Incl Landfill		0	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	0	0	0	0	0	0			
18	Difference in Actual and Baseline Carbon Stored in Wood Products (tonnes CO ₂ e) - Landfill Adj		0	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	(26,118)	0	0	0	0	0	0			
19	GHG Reductions / Removals for Carbon Stored in Wood Products (tonnes CO ₂ e) w/ mkt response		0	(20,894)	(20,894)	(20,894)	(20,894)	(20,894)	(20,894)	(20,894)	(20,894)	0	0	0	0	0	0			
Calc Row	Calculation Other Secondary Effects - Reforestation Projects																			
20	Mobile Combustion Emission Factor (average tonnes CO ₂ e per acre)																			
21	Initial Site Prep Acres in Project Area (Acres)											-								
22	One-time combustion emissions associated with machinery use in site preparation (CO ₂ e tonnes)			-	-	-	-	-	-	-	-	-	-	-	-	-	-			
23	Leakage Risk Percentage for Leakage from Shifting Cropland and Grazing Activities (%)			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
24	Secondary Effect emissions due to shifting cropland or grazing activities (tonnes CO ₂ e)			-	-	-	-	-	-	-	-	-	-	-	-	-	-			
25	Other Secondary Effect Emissions for Reforestation Projects (tonnes CO ₂ e)			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			
Calc Row	Calculating Other Secondary Effects - Improved Forest Management Projects																			
26	Difference Between Actual and Baseline Carbon in Harvested Wood (tonnes CO ₂ e)		-	(93,133)	(93,133)	(93,133)	(93,133)	(93,133)	(93,133)	(93,133)	(93,133)	-	-	-	-	-	-			
27	Other Secondary Effects Emissions (shifting activities/materials) IFM Projects (tonnes CO ₂ e)		-	(18,627)	(18,627)	(18,627)	(18,627)	(18,627)	(18,627)	(18,627)	(18,627)	-	-	-	-	-	-			
Calc Row	Determining the Uncertainty Discount Factor and Calculating Other Secondary Effects - Avoided Conversion Projects																			
28	Appraised Fair Market Value of Anticipated Alternative Land Use of Project Area (000\$)																			
29	Appraised Fair Market Value of the Current Forested Land use of Project Area (000\$)																			
30	Avoided Conversion Discount Factor			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%			
31	Quantified GHG Reductions / Removals for Onsite Carbon Stocks (tonnes CO ₂ e)			140,569	148,461	156,796	165,599	174,896	184,716	195,086	206,039	-	-	-	-	-	-			
32	Other Secondary Effect Emissions for Avoided Conversion Projects (tonnes CO ₂ e)			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA			
Calc Row	Quantified GHG Reductions and Removals																			
33	Annual GHG Reductions/Removals Net of Discounts and Secondary Effects (tonnes CO ₂ e)		-55,188	101,048	108,940	117,275	126,078	135,376	145,195	155,565	166,518	0	0	0	0	0	0			
34	Cumulative GHG Reductions/Removals; not incl.neg. carryover or reversals (tonnes CO ₂ e)		0	101,048	209,989	327,264	453,342	588,718	733,913	889,478	1,055,996	1,055,996	1,055,996	1,055,996	1,055,996	1,055,996	1,055,996			
35	Cumulative Negative Carryover from Prior Year (tonnes CO ₂ e)			-55,188	0	0	0	0	0	0	0	0	0	0	0	0	0			
36	CRTs Issued - Net of Negative Carryover, bef. Buffer or adjust for Reversals (tonnes CO ₂ e)		0	45,859	108,940	117,275	126,078	135,375	145,194	155,565	166,517	0	0	0	0	0	0			
Calc Row	Calculation of Buffer Pool Contribution																			
37	Project Specific Reversal Risk Rating		20.9%	20.9%	20.9%	20.9%	20.9%	20.9%	20.9%	20.9%	20.9%									
38	Buffer Pool Contributions (CRTs)		-	9,602	22,809	24,554	26,397	28,343	30,399	32,570	34,863	-	-	-	-	-	-			
Calc Row	Accounting for Reversals																			
39	Annual Reversals (tonnes CO ₂ e)			-	-	-	-	-	-	-	-	-	-	-	-	-	-			
40	Total "Avoidable Reversals" to be compensated by the Forest Owner (tonnes CO ₂ e)						-	-												
41	"Unavoidable Reversals" compensated by the Reservefrom the Buffer Pool (tonnes CO ₂ e)			-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Calc Row	Compensating for Avoidable Reversals																			
42	"Avoidable Reversals" compensated by retirement of CRTs in the Forest Owners Reserve Account (tonnes CO ₂ e)																			
43	"Avoidable Reversals" compensated by retirement of CRTs issued to other Forest Projects Registered with the Reserve (tonnes CO ₂ e)																			
44	Carryover "Avoidable Reversals" which need to be compensated by Forest Owner (tonnes CO ₂ e)			-	-	-	-	-	-	-	-	-	-	-	-	-	-			
Calc Row	CRTs Issued to Account Holder																			
45	Annual CRTs Issued to Account Holder		-	36,257	86,131	92,721	99,681	107,032	114,795	122,995	131,654	-	-	-	-	-	-			
46	Cumulative CRTs Issued to Account Holder		-	36,257	122,388	215,109	314,790	421,822	536,617	659,612	791,266	791,266	791,266	791,266	791,266	791,266	791,266			

Notes	Equation(s) Reference (FPP)	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	$AC_{\text{onsite}, y}$
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	$AC_{\text{onsite}, y} \times (1-CD_y)$
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	$\Delta AC_{\text{onsite}}$
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	$BC_{\text{onsite}, y}$
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	$\Delta BC_{\text{onsite}}$
In the initial data at Start Date, the difference between the actual and baseline carbon stocks. For 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	$\Delta AC_{\text{onsite}} - \Delta BC_{\text{onsite}}$
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	$AC_{\text{hv}, n}$
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	$BC_{\text{hv}, n}$
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 calculated over a 100-year time period for the actual project.	C.1	$WP_{\text{in-use}, y}$
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 calculated over a 100-year time period for the actual project.	C.2, C.3	$WP_{\text{total}, y}$
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 calculated over a 100-year time period for the baseline.	C.1	$WP_{\text{in-use}, y}$
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 calculated over a 100-year time period for the baseline.	C.2, C.3	$WP_{\text{total}, y}$
Calculated from lines 10 and 12.	6.1	$AC_{\text{wp}, y} - BC_{\text{wp}, y}$
Calculated from lines 11 and 13.	6.1	$AC_{\text{wp}, y} - BC_{\text{wp}, y}$
Difference between actual and baseline carbon stored long-term in wood products in each year. May be negative. If total <i>cumulative</i> actual harvested volumes exceed total <i>cumulative</i> baseline harvested volumes (through previous period), then calculation will <i>exclude</i> carbon in landfills. If total cumulative actual harvested volumes are less than total cumulative baseline harvested volumes (through previous period), then this calculation will <i>include</i> carbon in landfills.	C.2, 6.1	$AC_{\text{wp}, y} - BC_{\text{wp}, y}$
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	$(AC_{\text{wp}, y} - BC_{\text{wp}, y}) * 80\%$
Mobile combustion emission factor from Table 6.1 in the FPP. Units are Average tonnes CO ₂ e 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	$AC_{\text{hv}, n} - BC_{\text{hv}, n}$
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 equal to 0.	6.11	ACD
Difference between the increments in actual and baseline onsite carbon stocks from above. (Copied from Row 7)	6.12	$\Delta AC_{\text{onsite}} - \Delta BC_{\text{onsite}}$
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 multiplying 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.		