State of California
California Environmental Protection Agency
California Air Resources Board
U.S. FOREST OFFSET PROJECT DATA REPORT
INITIAL REPORTING PERIOD - IMPROVED FOREST MANAGEMENT

U.S. FOREST OFFSET PROJECT DATA REPORT INITIAL REPORTING PERIOD - IMPROVED FOREST MANAGEMENT

OPR Staff Use Only	**Date Report Received:**	**OPR Tracking Number:**	**Date Report Reviewed:**	*OPR Staff Use Only*

*Entities submitting the project's first Offset Project Data Report must submit the information requested in both **Initial Reporting Period** and the **Annual Reporting** forms to the appropriate Offset Project Registry. For every reporting year thereafter, submit only the information requested in the Annual Reporting form.*

PART I. ENTITY SUBMITTING REPORT

Is this form being submitted by the Offset Project Operator (OPO) or by the Authorized Project Designee (APD)? *Note: The person completing this form should be an OPO/APD employee.*

☐ **OPO**
☒ **APD**

Name of Person Completing Form:		**Organization, if applicable:**
James D. Clark		NCRM, Inc.
Date Form Completed:	**Phone Number:**	**Email Address:**
05/02/2017	707-485-7211	jimclark@ncrm.com

PART II. OFFSET PROJECT INFORMATION

Offset Project Name:	**OPR Project ID#:**	**ARB Project ID#** (if known)**:**
Congaree River	ACR292	CAFR5242

Offset Project Commencement Date:	**First Reporting Period Start Date:**	**First Reporting Period End Date:**
October 21, 2015	October 21, 2015	June 30, 2016

Provide an explanation and justification for the commencement date. Specify the action(s) that identify the offset project commencement date.
The offset project commencement date is the date the Project was listed.

Optional: Provide the nearest town/city to the Project Area:
Philo, CA

PART III. OPO/APD INFORMATION

A. OPO

OPO Name:			**OPO's CITSS ID#:**
Congaree River, LLC, an Illinois LLC			CA 2 0 0 1
Mailing Address:	**City:**	**State:**	**Zip:**
53 W Jackson Blvd. Suite 530	Chicago	IL	60604
Contact Person:	**Phone Number:**	**Email Address:**	
Francis Beidler IV	312-922-3808	fbeidler@congaree.com	

B. APD (if applicable)

☐ **No APD/Not Applicable**

APD Name:			**APD's CITSS ID#:**
James D. Clark			CA 1 5 6 9
Mailing Address:	**City:**	**State:**	**Zip:**
PO Box 435	Calpella	CA	95418
Contact Person:	**Phone Number:**	**Email Address:**	
James D. Clark	707-485-7211	jimclark@ncrm.com	

PART IV. LAND OWNERSHIP

A. Is the Offset Project Operator (OPO) the owner in fee for the Project Area?
Further documentation is required for all projects. Submit as attachment labeled "Attachment A." See Part X of this OPDR document for more information.

☒ **Yes**
☐ **No**

If "no," explain how the entity identified as the OPO has the right to undertake and list the project.

B. Optional: List all Forest Owners. This includes owners in fee as well as third parties with existing property interests within the Project Area that affect the trees and standing timber located in the Project Area (e.g. mineral rights, timber rights, easements, rights of way, leases, etc.).

Congaree River LLC is the only Forest Owner with property interests within the Project Area that affect the trees and standing timber located on the Project Area.

C. Does the offset project occur on public or private lands?

If the project occurs on public lands, proceed to questions C1 and C2. Otherwise, skip to question D. Further documentation is required if project occurs on public lands. Submit copies of documentation demonstrating explicit approval of the project's management activities and baseline, as well as the public vetting process used; attachment should be labeled "Attachment B." See Part X of this document for more information.

☒ **Private**
☐ **Public**

1. **Describe the public process that was used to evaluate the forest management activities and policy decisions concerning the offset project.**
   N/A
2. **Describe the explicit approval process used by the public entity to initiate and maintain this offset project, including the offset project's management activities and baseline.**
   N/A

D. Does the project employ a Qualified Conservation Easement (QCE)?

If employing a QCE, proceed to questions D1, D2, and D3. Otherwise, skip to question E. Supporting documentation for a QCE is required. Submit as attachment labeled "Attachment C." See Part X of this document for more information.

☐ **QCE**
☐ **Public Ownership**

1. **Date that the QCE was recorded.**
   N/A
2. **Optional:** Is the project located in a state that requires third-party beneficiaries to sign the easement (i.e., to "accept and record that acceptance"), such as Arizona, Pennsylvania, or West Virginia? ☐ **Yes** ☐ **No**
3. **Provide the terms within the easement that affect forest management.**
   N/A

E. Does the offset project occur on any of the following categories of land? (check all that apply)

☐ **Land that is owned by, or subject to, an ownership of possessory interest of a Tribe**
☐ **Land that is "Indian lands" of a Tribe as defined by 25 U.S.C. §81(a)(1)**
☐ **Land that is owned by any person, entity, or Tribe, within the external borders of such Indian lands**
☒ **None of the above**

If "none of the above," skip to Part V. Otherwise, proceed to Optional questions E1 and E2. Further documentation is required for projects occurring on land listed in the first three categories. Submit supporting documents as attachments labeled "Attachment D." See Part X of this document for more information.

1. **Optional:** Does a limited waiver of sovereign immunity between ARB and the governing body of the Tribe exist? ☐ **Yes** ☐ **No**
2. **Optional:** Provide a description of land ownership within the Project Area.
   N/A

PART V. OFFSET PROJECT AREA

Maps depicting specific elements of the Project Area are required for all projects.
Submit supporting documentation as attachments labeled "Attachment E." See Part X of this document for more information.

Latitude of Offset Project Location:	Longitude of Offset Project Location:	Project Area Total Acreage:
38.9942	-123.5391	5,440.15

A. Identify the assessment area (or assessment areas, if project crosses more than one) that contain Project Area lands and list the acreage of project lands within each assessment area.
See Addendum to OPDR for the Initial Reporting Period V.A.

B. Identify and describe the governing jurisdiction(s) applicable to the Project Area.
See Addendum to OPDR for the Initial Reporting Period V.B.

C. Describe how the Project Area was determined.
See Addendum to OPDR for the Initial Reporting Period V.C..

D. Describe the existing land cover, and land use of the Project Area.
See Addendum to OPDR for the Initial Reporting Period V.D.

E. Describe the forest vegetation types within the Project Area boundary.
See Addendum to OPDR for the Initial Reporting Period V.E.

F. Describe the site classes within the Project Area boundary.
See Addendum to OPDR for the Initial Reporting Period V.F.

G. Describe the land pressures and climate zone/classification applicable to the Project Area.
See Addendum to OPDR for the Initial Reporting Period V.G.

H. Describe the historical land uses, current zoning, and projected land use within the Project Area and surrounding areas.
See Addendum to OPDR for the Initial Reporting Period V.H.

I. Describe the forest conditions within the Project Area, including species composition, age class distribution, and management history.
See Addendum to OPDR for the Initial Reporting Period V.I.

PART VI. OFFSET PROJECT ELIGIBILITY

A. Does the Project Area have a canopy cover that is greater than 10 percent?
Supporting documentation is required. Submit as attachment labeled "Attachment F." See Part X of this document for more information.
See Addendum to OPDR for the Initial Reporting Period VI.A.

☒ **Yes** ☐ **No**

B. Optional: Are the associated project lands currently in compliance with all local, state, and federal regulatory requirements?

☒ **Yes** ☐ **No**

Optional: If no, provide an explanation of the non-compliance.
N/A

C. Does the entity submitting this report declare that the offset project has not and does not employ broadcast fertilization?

☒ **Yes** ☐ **No**

D. Indicate how the offset project meets the definition of Natural Forest Management per Table 3.2 in the U.S. Forest protocol:

1. Native species:

a) Does the project consist of at least 95% native species based on the estimated sum of carbon in the standing live carbon pool? Improved Forest Management Projects are assessed using estimates of basal area per acre.
If "no," proceed to question 1b. Otherwise, skip to question D2.
See Addendum to OPDR for the Initial Reporting Period VI.D.1(a).

☒ **Yes** ☐ **No**

b) Describe how the project will meet this requirement.
N/A

2. Composition of native species:

a) Does the Project Area naturally consist of a mixed species distribution where no single species' prevalence, measured as the percent of basal area of all live trees in the Project Area, exceeds the percentage value of standing live carbon shown under the heading 'Species Diversity Index' in the Assessment Area Data File?
If "no," proceed to questions 2b and 2c. Otherwise skip to question D3.
See Addendum to OPDR for the Initial Reporting Period VI.D.2(a).

☒ **Yes** ☐ **No**

b) Explain how the project will demonstrate a trend toward achieving the Species Diversity Index of native species and meet this requirement within 25 years.
N/A

c) If the Project Area does not naturally consist of a mixed species distribution: Will or have you provided a written statement from the government agency in charge of forestry regulation in the state where the project is located stipulating that the Project site is not capable of meeting the requirement of mixed species distribution?

☐ **Yes** ☐ **No** ☒ **N/A**

3. Distribution of age classes/sustainable management:

a) Indicate how the project will meet the requirement for sustainable management if regeneration or commercial harvesting is either planned or initiated within the Project Area demonstrating sustainable long-term harvesting practices. This applies to all forest landholdings of the Forest Owner(s)
(check one of the boxes).

☐ **Not applicable; no commercial harvesting is occurring within the Project Area.**
☐ **Third party certification under the Forest Stewardship Council, Sustainable Forestry Initiative, or Tree Farm System, whose certification standards require adherence to and verification of harvest levels which can be permanently sustained over time.**
☐ **Adherence to a renewable long-term management plan that demonstrates harvest levels which can be permanently sustained over time and that is sanctioned and monitored by a state or federal agency.**
☒ **Employ uneven-aged silvicultural practices and maintain canopy retention averaging at least 40% across the forest, as measured on any 20 acres within the entire forestland owned by the Forest Owner, including land within and outside of the Project Area (areas impacted by Significant Disturbance may be excluded**

from this test).

See Addendum to OPDR for the Initial Reporting Period VI.D.3(a).

b) On a watershed scale up to 10,000 acres (or the Project Area, whichever is smaller), projects must maintain, or make progress toward maintaining, a maximum of 40% of the project's forest lands in ages that are less than 20 years old. (Areas impacted by Significant Disturbance are exempt from this test until 20 years after reforestation of such areas.) Does the acreage within this project meet this requirement?

If "no," proceed to question 3c. Otherwise, skip to question D4.

☒ Yes ☐ No

See Addendum to OPDR for the Initial Reporting Period VI.D.3(b).

c) If the project does not meet the age class requirement at this time, explain how the project intends to demonstrate progress to meet this requirement over time; such that forest lands in ages less than 20 years old are reduced and make up no more than 40% of the Project Area.

N/A

4. Structural elements (standing and lying dead wood):
How does the project ensure that structural elements are retained in sufficient quantities throughout the project life?

See Addendum to OPDR for the Initial Reporting Period VI.D.4.

E. Describe the management activities that will result in increased carbon stocks in the Project Area, compared to the baseline.

See Addendum to OPDR for the Initial Reporting Period VI.E.

F. Is this project being implemented and conducted as the result of any law, statute, regulation, court order, or other legally binding mandate?
If "yes," explain:

☐ Yes ☒ No

N/A

G. Does the offset project take place on land that was part of a previously listed and registered Forest Offset Project?

This question is applicable to both voluntary and compliance markets. If "yes" proceed to questions G1 and G2. Otherwise, skip to Part VII.

☐ Yes ☒ No

1. Optional: Was the previous Forest Offset Project terminated due to an Unintentional Reversal?

☐ Yes ☒ No

2. Optional: Has this project transitioned to the Compliance Offset Protocol U.S. Forest Projects after previously being listed as an early action offset project?

☐ Yes ☒ No

PART VII. CARBON STOCK INVENTORY

A. Provide a description of the inventory methodology used to quantify carbon stocks for each required carbon pool in the forest project's offset boundary. The inventory methodology must describe the information required in Appendix A.3 of either the Compliance Offset Protocol U.S. Forest Projects, October 20, 2011 or the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014.

IFM-1 Standing Live:

See Addendum to OPDR for the Initial Reporting Period VII.A.

IFM-3 Standing Dead:

See Addendum to OPDR for the Initial Reporting Period VII.A.

IFM-6 Soil (if applicable):

See Addendum to OPDR for the Initial Reporting Period VII.A.

IFM-7 Carbon in in-use forest products:

See Addendum to OPDR for the Initial Reporting Period VII.A.

IFM-8 Forest product carbon in landfills (if applicable):

See Addendum to OPDR for the Initial Reporting Period VII.A.

IFM- 9 Biological emissions from site preparation:

See Addendum to OPDR for the Initial Reporting Period VII.A.

IFM-14 Biological emissions/removals from change in harvesting on forestland outside project area:

See Addendum to OPDR for the Initial Reporting Period VII.A.

IFM-17 Biological emissions from decomposition of forest products:

See Addendum to OPDR for the Initial Reporting Period VII.A.

B. Describe the calculation methodologies used to determine metric tons per acre for each of the carbon pools included in the Offset Project Data Report.

IFM-1 Standing Live:
See Addendum to OPDR for the Initial Reporting Period VII.B.

IFM-3 Standing Dead:
See Addendum to OPDR for the Initial Reporting Period VII.B.

IFM-6 Soil (if applicable):
See Addendum to OPDR for the Initial Reporting Period VII.B.

IFM-7 Carbon in in-use forest products:
See Addendum to OPDR for the Initial Reporting Period VII.B.

IFM-8 Forest product carbon in landfills (if applicable):
See Addendum to OPDR for the Initial Reporting Period VII.B.

IFM- 9 Biological emissions from site preparation:
See Addendum to OPDR for the Initial Reporting Period VII.B.

IFM-14 Biological emissions/removals from change in harvesting on forestland outside project area:
See Addendum to OPDR for the Initial Reporting Period VII.B.

IFM-17 Biological emissions from decomposition of forest products:
See Addendum to OPDR for the Initial Reporting Period VII.B.

C. Provide a summary of the inventory of carbon stocks for each carbon pool (or approach used, if inventory is not applicable).

IFM-1 Standing Live:
See Addendum to OPDR for the Initial Reporting Period VII.C.

IFM-3 Standing Dead:
See Addendum to OPDR for the Initial Reporting Period VII.C.

IFM-6 Soil (if applicable):
See Addendum to OPDR for the Initial Reporting Period VII.C.

IFM-7 Carbon in in-use forest products:
See Addendum to OPDR for the Initial Reporting Period VII.C.

IFM-8 Forest product carbon in landfills (if applicable):
See Addendum to OPDR for the Initial Reporting Period VII.C.

IFM- 9 Biological emissions from site preparation:
See Addendum to OPDR for the Initial Reporting Period VII.C.

IFM-14 Biological emissions/removals from change in harvesting on forestland outside project area:
See Addendum to OPDR for the Initial Reporting Period VII.C.

IFM-17 Biological emissions from decomposition of forest products:
See Addendum to OPDR for the Initial Reporting Period VII.C.

D. Provide a summary of inventory confidence statistics.
See Addendum to OPDR for the Initial Reporting Period VII.D.

E. Provide the calculation of the offset project's reversal risk rating and contribution to the Forest Buffer Account.
See Addendum to OPDR for the Initial Reporting Period VII.E.

PART VIII. OFFSET PROJECT BASELINE

A. Required for ALL Improved Forest Management Projects

1. **Describe the project's modeling plan, following the requirements and methods in Appendix B, Section B.3 of the U.S. Forest protocol.**
   Please see the Modeling Plan included as Attachment M.

2. **Describe and estimate the project's baseline onsite carbon stocks. Explain any annual changes in baseline carbon stocks over time.**
   A graph of the baseline onsite carbon stocks, labeled "Attachment G," must be portrayed depicting time on the x-axis and metric tons CO2-e on the y-axis. Include a written characterization describing any annual change in baseline carbon stocks over time. See Part X of this document for more information. A diagram of the baseline incorporating all required carbon stocks, labeled "Attachment H," is also required.
   This information is contained in the Modeling plan included as Attachment M.

3. **Optional:** Identify the approved growth model that will be used for the project.
   FORSEE

4. **Harvest Planning**
   a. **Is harvesting planned in the Project Area?** ☒ **Yes** ☐ **No**
   If "yes," proceed to question 4b. Otherwise, skip to question A5.

   b. **Optional:** Does the project use a harvest schedule model? ☐ **Yes** ☒ **No**
   If "yes," proceed to question 4c. Otherwise, skip to question A5.

   c. **Optional:** Explain how you are addressing age class and stratification as part of your harvest scheduling?
   N/A

5. **Provide an estimate of carbon that will be stored long-term in harvested wood products in the baseline.**
See Addendum to OPDR for the Initial Reporting Period VIII.A.5.

6. **Provide a projection of baseline and actual harvesting volumes from the Project Area over 100 years.**
A projection may be provided in an attachment, labeled "Attachment I". Include a narrative with a clear explanation of how the OPO/APD arrived at the baseline and actual harvest volumes is determined

B. Required for Improved Forest Management Projects on Private Lands ONLY

1. **Provide the initial above ground standing live carbon stock (per acre) for the project.**
187.20

2. **Provide the Common Practice statistic (per acre) associated with the Project Area.**
173.03

3. **Summarize how the Project's initial above-ground standing live carbon stock compares to Common Practice.**
At the Project's commencement date of 10/21/2015, the Project's initial above-ground standing live carbon stocks were above the Common Practice statistic listed above.
Are the initial above-ground standing live carbon stocks above or below Common Practice? ☒ **Above** ☐ **Below**

If below Common Practice, what is the High Stocking Reference for the Project Area? Describe the Project Area's live tree carbon stocks over the previous 10 years.
Further documentation is required if project is below Common Practice. Submit supporting documents as attachments labeled "Attachment J." See Part X of this document for more information. An affidavit must be submitted testifying that the inventory depicted over the past 10 years is reasonably accurate.
N/A

4. **Optional:** Does the Forest Owner(s) and its affiliate(s) own land in fee or hold timber rights on land outside the Project Area? ☒ **Yes** ☐ **No**
If "no," skip to question B.5.

Optional: If "yes" does the Protocol require the use of a weighted average carbon stock on lands in the same Logical Management Unit (LMU, as defined in Section 6.2.1.1)? ☐ **Yes** ☒ **No**
If "no," skip to question B.5.

Optional: If "yes," is inventory data available for the LMU or will the OPO use a stratified vegetation analysis? ☐ **Data available for LMU** ☐ **Stratified Vegetation Analysis**
If "no," skip to question B.5.

Optional: Identify the Minimum Baseline Level for above-ground standing live carbon stocks for the Project Area:

5. **Provide a description of any and all legal constraints affecting forest management activities in the Project Area. Include documentation of legal constraints and a description of each constraint (referring to Section 6.2.1.2); for each constraint provide a narrative that constraint has on forest management.**
Submit supporting documents as attachment labeled "Attachment K". See Part X of this reporting document for more information.
This information is contained in the Modeling plan included as Attachment M.

6. **Provide a description of the modeling techniques used to simulate the effect of any constraints on carbon stocks.**
This information is contained in the Modeling plan included as Attachment M.
Optional: Provide a description of the modeling techniques used to simulate forest management activities that may affect carbon stocks.

7. **How does the OPO demonstrate financial feasibility of the growth and harvesting regime assumed for the baseline?** (check one of the boxes)
☒ **Conducting 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, using regional norms or documented costs and returns for the project area or other properties in the Forest Project's Assessment Area**
☐ **Providing 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**
Supporting documentation is required. Submit as attachment labeled "Attachment L." See Part X of this listing document for

more information.
See Addendum to OPDR for the Initial Reporting Period VIII.B.7.

C. Required for Improved Forest Management Projects on Public Lands ONLY

1. **Provide a projection of future changes to Project Area forest carbon stocks extrapolating from historical trends.**
   N/A

2. **Explain how current public policy affects onsite carbon stocks and how the baseline modeling incorporates constraints imposed by all applicable statutes, regulations, policies, plans, and activity-based funding.**
   N/A

3. **Have carbon stocks in the Project Area been increasing or declining over the preceding ten-year period?** ☐ Increasing ☐ Declining

PART IX. OTHER OFFSET PROGRAMS

A. Have any GHG reductions or GHG removal enhancements associated with the Project Lands ever been listed or registered with, or otherwise claimed by, another registry or program, or sold to a third party prior to listing? *If "yes," identify the registry or program and provide details on the issued credits below.*	☐ Yes ☒ No
B. Have any lands within the Project Area ever been listed or registered with an offset project registry or program in the past? *If "yes," identify the registry or program and provide details on the issued credits below.*	☐ Yes ☒ No
C. Have greenhouse gas emission reductions or removal enhancements associated with lands within the Project Area been credited or claimed for the purpose of greenhouse gas mitigation or reduction goals, whether in a voluntary or regulatory context? *If "yes," identify the goal(s) and provide details on the reductions and removal enhancements (under "Number of Credits Issued") below.*	☐ Yes ☒ No

Registry / Program / Goal(s):	Reporting Period(s):	Vintage(s):	Number of Credits Issued:
N/A	N/A	N/A	N/A

PART X. ATTACHMENTS

A. **If the answer to Part IV.A is "yes," provide documentation (e.g., deed of trust, title report, etc.) showing the OPO's ownership interest in the property and its interest in the trees and standing timber on the property. If the answer to Part IV.A is "no," provide documentation supporting the explanation of the OPO's right to undertake and list the project.**

B. **If the answer to Part IV.C is "public," provide documentation demonstrating explicit approval of the offset project's management activities and baseline including any public vetting processes necessary to evaluate management and policy decisions concerning the offset project. If the project is a private lands project, mark "N/A" in the box below. The OPO may provide an "Attachment B" page with a "This Page Left Intentionally Blank - Private Lands Project" notation on the page.** ☒ N/A

C. **If a Qualified Conservation Easement (QCE) has been recorded, provide a copy. The information contained in this form and the documents attached to it will be submitted to ARB so submitting a copy of the QCE as an attachment to this document fulfills the requirement in 9.1.1.1(18)(a) of the U.S. Forest protocol to provide ARB with a copy.**
☒ N/A

D. **If the project is located on one of the categories of Tribal land listed in Part IV.E, provide documentation demonstrating that the land within the Project Area is owned by a tribe or private entity. Also provide documentation that demonstrates the existence of a limited waiver of sovereign immunity between ARB and the governing body of the Tribe entered into pursuant to section 95975(l) of the Cap-and-Trade Regulation.** ☒ N/A

E. **Attach map(s) of the Project Area including:**
1. **Public and private roads**
2. **Towns**
3. **Major watercourses (4th order or greater), water bodies, and watersheds**
4. **Topography**
5. **Townships, ranges, and sections or latitude and longitude**
6. **Existing land cover and land use (optional)**
7. **Forest vegetation types (optional)**
8. **Site classes (optional)**
9. **Land pressures and climate zone / classification (optional)**
10. **Historical land uses, current zoning, and projected land use within the Project Area (optional)**
11. **A georeferenced shape file (or other electronic file that can be read in a geographic information system) that clearly identifies the Project Area and boundaries.** *Note that the georeferenced shape file may constitute the required*

map if it includes the required map information listed above.

F. **Provide supporting documentation demonstrating that the offset project takes places on land that has greater than 10 percent tree canopy cover.**

G. **Attach a graph portraying the baseline onsite carbon stocks with time depicted on the x-axis and metric tons CO_2e depicted on the y-axis.**

H. **Attach a diagram of the final baseline incorporating all required carbon stocks.**

I. **Provide a projection of baseline and actual harvesting volumes from the Project Area over 100 years.**

J. **For IFM projects on private lands ONLY: If the Project Area's initial above-ground standing live carbon stocks are below Common Practice, submit an affidavit testifying that the inventory depicted over the past 10 years (used to determine the High Stocking Reference for the Project Area) is reasonably accurate. Also include a summary of volume harvested over the past 10 years.** ☒ **N/A**

K. **For IFM projects on private lands ONLY: Attach supporting documentation identifying the legal constraints within the Project Area. A 'constraints' table with the following categories may be provided for simplicity with the following information: narrative of legal constraint, identification of specific governing law guiding the constraint, acreage, silviculture method, retention strategy.** ☐ **N/A**

L. **For projects on private lands ONLY: Provide a description and supporting evidence, if applicable, that the growth and harvesting regime assumed for the baseline is financially feasible based on the qualifications in Section 6.2.1.3 of the Protocol.** ☐ **N/A**

PART XI. OPO/APD SIGNATURE

Note: The person signing this Initial Reporting Period report should be the same person signing the accompanying U.S. Forest Offset Project Data Report Annual Reporting Period – All Project Types report.

In signing this form, I certify under penalty of perjury of the laws of California that the information contained in this form is true, accurate, and complete. I further certify that I am an Account Representative of the Offset Project Operator (OPO).

SIGNATURE: 	**PRINTED NAME:** James D. Clark
TITLE: APD	**DATE:** 05/02/2017

Background for U.S. Forest Offset Project Data Report Initial Reporting Period – Improved Forest Management

Section 95976(d) of the Cap-and-Trade Regulation specifies reporting requirements for offset projects participating in the Compliance Offset Program. Offset Project Operators (OPO) or Authorized Project Designees (APD) are required to submit an Offset Project Data Report (OPDR) within four months of the end of each (annual) Reporting Period. The Compliance Offset Protocol U.S. Forest Projects, October 20, 2011 and Compliance Offset Protocol U.S. Forest Projects, November 14, 2014 both require additional information to be included with the initial OPDR. This form is designed to help OPOs and APDs provide the extra information required for an initial OPDR by U.S. Forest offset projects. The information in this form is submitted to the approved Offset Project Registry that is listing the offset project and should also be provided to the ARB-accredited verification body that will be verifying the Offset Project Data Report.

The information to be provided in this form closely mirrors information provided in the application for listing a U.S. Forest offset project. OPOs and APDs may wish to copy the information in their project's application for listing to the extent that the information provided at the time of that application has not changed.

Where to Submit Information Contained in This Form

Please complete the information on the form using your computer. Then print, sign, and scan the form. The completed and signed information and all supporting documentation should be submitted to the appropriate Offset Project Registry.

Copies of this form can be downloaded from the ARB website at:
http://www.arb.ca.gov/cc/capandtrade/offsets/forms/forms.htm

Detailed Instructions for U.S. Forest Offset Project Data Report Initial Reporting Period – Improved Forest Management

This form is protected with restricted editing to facilitate completing the form. If the applicant wishes to unprotect the form, the password is "form".

Part I. Entity Submitting Report:

- Indicate whether the Offset Project Operator (OPO) or Authorized Project Designee (APD) is submitting the Offset Project Data Report.
- List the name, organization, phone number, and email address of the person submitting the information. This person should be an employee of the OPO or APD, whichever entity is making the submission. The person submitting the information need not be the same person as the contact person listed for the OPO or APD in Part III and also need not be the person signing the form in Part XI.
- The person submitting the information should indicate the date the form is completed.

Part II. Offset Project Information:

- Provide the name for the offset project. Also provide the project's identification number from the approved Offset Project Registry listing the project. The ARB project identification number may also be provided if known.
- Indicate the offset project commencement date and the start and end dates of the first reporting period. Unlike with the listing form, approximations are no longer acceptable for these dates since precise dates should be known.
- Project commencement for an Improved Forest Management Project must be linked to a discrete, verifiable action that delineates a change in practice that increases sequestration and/or decreases emissions relative to the forest project's baseline. This date could be triggered by the transfer of property ownership, recordation of a conservation easement on the Project Area, or when submitting the offset project listing information.

Part III. OPO/APD Information:

- Enter contact information for the OPO and APD submitting the report. Every offset project will have an OPO. If an offset project does not have an APD, please mark the box indicating the Offset Project does not have an APD and leave the remaining fields blank.

- For both the OPO and, if applicable, the APD, enter the entity's name, its mailing address, and the name, phone number, and email address of a contact person for the entity. Also include its CITSS ID number. The CITSS ID is six characters in length, with two letters followed by four numbers (e.g., "CA1234"). **DO NOT PROVIDE THE CONFIDENTIAL CITSS ACCOUNT NUMBER**, which begins with the CITSS ID number followed by a hyphen and more numbers.

Part IV. Land Ownership:

- This part includes questions regarding land ownership and property interests.
- Further documentation is required based on the responses to some questions. See Part X of this report for more information on the precise requirements.

Part V. Offset Project Area:

- This part asks for qualitative descriptions of the offset Project Area.
- Maps are required to complement the descriptions provided in this part. See Part X of this report for more information on the precise requirements.
- The Project Area should be determined following the requirements of Section 4 of the U.S. Forest protocol.
- Assessment areas shall be determined by referencing the Assessment Area Data File available at: http://www.arb.ca.gov/cc/capandtrade/protocols/usforestprojects.htm

Part VI. Offset Project Eligibility:

- The questions in this part are designed to facilitate the determination of project eligibility for Improved Forest Management Projects.
- Further documentation is required based on the responses to some questions. See Part X of this report for more information on the precise requirements.
- Details on the eligibility requirements for Improved Forest Management Projects can be found in Sections 2.1.2, 3.1, and 3.8 of the U.S. Forest protocol.
- Details on the Natural Forest Management criteria can be found in Table 3.2 in the U.S. Forest protocol.

Part VII. Carbon Stock Inventory:

- Projects are required to have completed a full carbon stock inventory for the initial Offset Project Data Report. Unlike the inventory provided at the time of listing, a general description of the project's inventory methods with preliminary best estimates is no longer sufficient to meet the regulatory requirements. If the project's inventory methodology changed between the time of listing and submission of the initial OPDR, this change should be reported as a change to the information submitted at project listing when submitting the first OPDR.
- Section 6.2 of either the Compliance Offset Protocol U.S. Forest Projects, October 20, 2011 or the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014 outlines the approved quantification methodologies for Improved Forest Management Projects. Further details on completing a forest project carbon inventory can be found in Appendix A of the Protocol. (There are some differences in section 6.2 and Appendix A between the two versions.)
- Follow the steps in Appendix D of the U.S. Forest protocol to quantify the project's reversal risk rating.
- The project's expected contribution to the Forest Buffer Account is determined annually based upon the project's risk of reversal and is calculated by multiplying the project specific reversal risk rating by the total net GHG reductions/removals achieved by the project. Unlike the listing application, for this OPDR an approximation of the contribution to the Forest Buffer Account is not acceptable.

Part VIII. Offset Project Baseline:

- For this OPDR, unlike the project listing application, projects are required to have a finalized baseline. A modeling plan with preliminary best estimates is no longer sufficient to meet the regulatory requirements. If the project's modeling plan or baseline estimates changed between the time of listing and submission of the initial OPDR, this change should be reported as a change to the information submitted at project listing when submitting the first OPDR.
- Note that IFM projects located on public land must present documentation demonstrating explicit approval of the offset project's management activities and baseline. These projects may report changes to the baseline within the initial OPDR if the changes have gone through a public review process and meet the Protocol requirements regarding explicit approval of the project's baseline.
- This part is divided into three sections: questions required for all Improved Forest Management Projects; questions for Improved Forest Management Projects on private lands; and questions for Improved Forest Management Projects on public lands. Answer the questions applicable to the project.

- A diagram and graph are required to complement the descriptions provided in this part. See Part X of this report for more information on the precise requirements.
- Section 6.2 of either the Compliance Offset Protocol U.S. Forest Projects, October 20, 2011 or the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014 outlines the approved quantification methodologies for Improved Forest Management Projects. Instructions for considering legal and financial constraints can be found in Sections 6.2.1.2 and 6.2.1.3, respectively. Further details on modeling carbon stocks can be found in Appendix B. (There are some differences in section 6.2 and Appendix B between the two versions.)
- ARB approved growth models can be found in Appendix B, Section B.1 of either the Compliance Offset Protocol U.S. Forest Projects, October 20, 2011 or the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014. (There are some differences in Appendix B between the two versions.)

Part IX. Other Offset Programs:

- Answer all questions. If the answer to any question is "yes," identify the registry or program and provide details on the issued credits in the space provided.

Part X. Attachments:

- Provide each attachment on a separate sheet of paper and submit along with the completed Initial Reporting Period-Offset Project Data Reporting Form.
- To aid with tracking each attachment, it is recommended that the attachments are labeled to correspond with the letter in Part X that they refer to (e.g. "Attachment B").
- When an attachment is not applicable to the project being listed, please select the "N/A" (Not Applicable) checkbox next to the requirement so that it is clear that the attachment was not inadvertently left off.

Part XI. OPO/APD Signature:

- The individual signing the document must be registered in CITSS as the OPO's Primary Account Representative or Alternate Account Representative for the entity submitting the information. The individual signing the document may be an APD employee and/or representative; but to sign the document, the individual must be an Account Representative on the OPO's CITSS account.
- Please provide the individual's signature, printed name, corporate title, and date signed.
- There are no attestations for this report. The attestations required for the Offset Project Data Report are included in the form U.S. Forest Offset Project Data Report Annual Reporting Period – All Project Types.

Please contact your Offset Project Registry with any questions regarding the OPDR.

Congaree River

ACR292, CAFR5242

Addendum to OPDR for the Initial Reporting Period Form

Under

Air Resources Board

Compliance Offset Protocol – U.S. Forest Projects

Adopted: November 14, 2014

Prepared May 2, 2017

Offset Project Operator	Authorized Project Designee
Congaree River LLC, an Illinois LLC **53 W Jackson Blvd., Suite 530** **Chicago, IL 60604** **(312) 922-3808**	**James D. Clark** **PO Box 435 Calpella, CA 95418** **(707) 485-7211**

Reporting Period

The reporting period for this Initial OPDR is from 10/21/2015 to 6/30/2016.

Protocol Version

Air Resources Board
Compliance Offset Protocol – U.S. forest Projects
Adopted: November 14, 2014

The OPDR and all other project documentation and reports that reference carbon stocks have been prepared and submitted by James D. Clark, California Registered Professional Forester (No. 2528).

Introduction

Congaree River is an Improved Forest Management (IFM) Project that is seeking registration under the California Air Resources Board Compliance Offset Protocol – U.S. Forest Projects Adopted: November 14, 2014. The Offset Project Operator is Congaree River, LLC, an Illinois LLC. The Project is approximately 5,440 acres in size, and is comprised of three properties or tracts, the Rancheria Northeast Tract, Rancheria Southwest Tract, and the Lawson Tract, all located in Mendocino County.

V.A.

The Project is located entirely within the Northern California Coast Supersection, and within the Coast Redwood/Douglas-fir Mixed Conifer Assessment Area, and Northern California Coast Mixed Oak Woodland Assessment Area. The Project area is classified as either site class II, III, or IV timberland. The Project Area distribution within the "Low" "Site Class" portion and "High" site portion of each of the above referenced Assessment Areas is as follows:

Supersection	Assessment Area	Site Class	Project Acres
Northern California Coast	Coast Redwood/Douglas-fir Mixed Conifer	High	2,671.80
		Low	2,456.63
	Northern California Coast Mixed Oak Woodland	N/A	311.72
Total			5,440.15

V.B.

The Project Area is subject to the governing jurisdiction of the County of Mendocino, the State of California, and the United States of America.

V.C.

The Project Area has been determined based on the best available data representing the legal description described in the Grant Deeds included as Attachment A. The Project Area boundary

is described and represented by the maps included as Attachment E, and the GIS data supplied in a geodatabase as a part of this Project submission. For the purpose of calculating GHG stocks, the Project Area acreage is taken from the GIS data provided with the OPDR.

V.D.

The existing land cover on the Congaree River Project Area is generally timberland with small areas of brush land, grasslands and rock outcroppings. It supports a healthy, diverse forest community comprised, predominantly, of coastal redwood and Douglas-fir, as the dominant conifer species, grand fir, nutmeg, western hemlock, and hardwoods, consisting of tan oak, Pacific madrone, live oak (interior, canyon, and coastal), California bay laurel, bigleaf maple, red alder, golden chinkapin; it is bordered by properties containing the same. Across the Project Area, the ecological community shifts with aspect, transitioning from Douglas-fir and redwood richly shaded areas and riparian areas to open oak woodland and grassland. Current uses of the Property generally include rural residential, recreation, ranching, farming, and timber production. The Congaree River Project Area 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.

V.E.

The following Wildlife Habitat Relationship (WHR) vegetation types occur on the Congaree River Project Area:

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, red alder, California laurel, and other California hardwoods. On most site redwood would dominate if vegetation succession were allowed to proceed naturally.

V.F.

The entire Project Area is classified as low to high site class timberland. Please see the Modeling Plan included as Attachment M for a more detailed description of the determination of site index.

V.G.

The Congaree River 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. 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 Congaree River 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. Temperatures range from an average low of 37 degrees F to an average high of 91 degrees F. Average annual rainfall for the property is approximately 50 inches per year.

V.H.

There is a long history of human occupation and use within the Project Area. Historic land use began in the late 1800's with homesteading activities on and near the Project Area. These uses included ranching, farming, and timber harvesting.

Congaree River LLC purchased the majority of the Project Area in 1983. Over time, additional adjacent properties were acquired, and in some cases lands were traded, until reaching to the

current property configuration. The Project Area contains several legal parcels that could be sold individually. The Congaree River property is primarily zoned Timber Production (TP) and Range Land (RL). The permitted uses on TP and RL land are timber production, row crops (including vineyard) and one single-family residence per legal parcel.

Current uses of the Property generally include rural residential, recreation, ranching, farming, and timber production. These uses are expected to continue into the foreseeable future.

V.I.

The Congaree River Project Area is characterized by a mix of predominantly redwood, Douglas-fir, and tanoak, and hardwoods, consisting of Pacific madrone, bigleaf maple, live oak, California bay laurel, and other native hardwoods and conifers.

Several age classes of timber stands exist across the Project Area as the result of past land management activities with age classes ranging from 100 years to 1 year. Timber harvesting on the Project Area occurs from time to time. Currently, there are no active timber harvest plans on the Project Area.

VI.A.

The Congaree River Project Area meets condition 1 under section 2.1.2 (page 10) of the Compliance Offset Protocol by maintaining greater than 10% tree canopy cover. Compliance is substantiated by the Orthophoto map of the Project site, that may be found in Attachment F, clearly showing canopy closure for the Project Area greater than 10% and, also, by modeling conducted in FORSEE based on the 2015 inventory, which indicated over 100% overlapping canopy for most stands.

VI.D.1.(a)

Approximately 100% of the Project's biomass is in native species, and thus the Project meets the 95% criteria for carbon in native species. Regeneration activities proposed under the Project will utilize only native species.

VI.D.2.

(a) The Congaree River Project Area is characterized by a mix of predominantly redwood, tanoak, and Douglas-fir, and hardwoods, consisting of Pacific madrone, bigleaf maple, live oak, California bay laurel, and other native hardwoods and conifers. It is estimated that, as of 6/30/16, the Project Area is composed of approximately 31% Douglas-fir, 31% redwood, 28% tanoak, 5% pacific madrone, and 5% other hardwoods by basal area. The Congaree River project owner intends to manage to reduce the hardwoods and increase conifer stocking, ensuring that the Project continues to meet the requirements for composition of native species under Table 3.2 (page 20) of the Compliance Offset Protocol by maintaining species' basal area percentage below 60%, the Species Diversity Index from the Assessment Area Data File.

VI.D.3.

(a) Commercial harvesting is planned within the Project Area; however, no commercial harvest activity has been planned during the initial reporting period. The Congaree River Project will employ natural forest management practices as described in items VI.D.1, VI.D.2, VI.D.3(b), and VI.D.4 as well as sustainable harvesting practices when it elects to conduct commercial harvesting in the future. The Congaree River Project meets condition 3 under Section 3.8.1 of the Compliance Offset Protocol by employing uneven-aged silvicultural practices and maintaning canopy cover averaging at least 40 percent across the entire forestland owned by the Forest Owner in the Same

Assessment Area covered by the Project Area.

(b) The project proposes to employ primarily 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.

VI.D.4.

The Congaree River project does not remove incidental lying dead wood as a part of its stand management activities. It is expected that the accumulation of lying dead wood will be commensurate with recruitment from standing dead trees. The Congaree River project 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. The Congaree River project does not currently, nor does it intend in the future to actively pursue salvage operations on its timberlands. Congaree River project has a policy of allowing standing dead trees to remain and recruiting large specimen trees across its ownership as components of its overall timber management strategy.

The Congaree River Project Area has not recently 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 0.87 Mg C per acre and 1.35% of standing live carbon stocks in standing dead wood. The project will continue to make progress towards the above mentioned standing dead wood target.

VI.E.

The OPO intends to allow conifer stocking levels to develop on the Project Area in excess of

those defined by the baseline analysis which projects carbon stocks levels over time following a harvest scenario which implements the minimum requirements of the California Forest Practice Rules as well as other financial and legal constraints. When timber harvesting is initiated on the Project Area, the OPO intends to balance harvest with growth such that conifer board foot volume is maintained or increased over time, excepting those portions of the Project Area which may in the future experience a Significant Disturbance.

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 the specific terms of the Forest Project Protocol will guide carbon stock levels over time.

VII.A.

IFM-1 Standing Live:

Standing live carbon will be inventoried based on sample plots installed as part of a forest inventory in 2015-2016. The inventory specifications are included as Attachment N. The cruise design consists of the installation of sample points randomly selected from a systematic grid 5 chains by 5 chains in size across the Project Area.

The sample design will include the installation of fixed area plots to measure both live and dead conifers and hardwoods. A 1/100th acre fixed area plot will be installed at each sample point to sample trees 1.0" DBH to 3.5" DBH; a 1/50th acre fixed area plot will be installed at each sample point to sample trees 3.6" DBH to 10.5" DBH, and a 1/10th acre fixed area plot will be installed at each sample point to sample trees 10.6" DBH and larger.

Attachment N describes the procedures for collecting field measurements, specific criteria pertaining to data collection, stratification rules, and documentation on quality assurance

and quality control. Documentation of analytic methods and biomass equations used to translate field measurements into volume or biomass carbon estimates are included in part B below.

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. This process has 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.

Inventory monitoring and update procedures are described in Attachment N.

IFM-3 Standing Dead:

As described above, and in Attachment N, standing dead trees will be sampled in conjunction with standing live trees.

IFM-6 Soil (if applicable):

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

IFM-7 Carbon in in-use forest products:

Carbon in in-use forest products has not been generated by the Project as no harvesting occurred in the Initial Reporting Period. Part B below includes documentation of analytic methods and biomass equations used to translate future harvest volumes delivered to the mill into appropriate carbon in in-use forest products values.

IFM-8 Forest product carbon in landfills (if applicable):

Carbon in landfills is a component of carbon related to forest products. No forest products have been generated by the Project in the Initial Reporting Period. Part B below includes documentation of analytic methods and biomass equations used to translate future harvest volumes delivered to the mill into appropriate forest products carbon in landfill values.

IFM-9 Biological emissions from site preparation:

As IFM-6 is an excluded carbon pool, IFM-9 is also an excluded pool.

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

Part B below includes documentation of analytic methods and biomass equations used to translate current and future harvest volumes delivered to the mill into appropriate values for the calculation of this carbon pool.

IFM-17 Biological emissions from decomposition of forest products:

This is quantified as a component of IFM-7 and IFM-8 per Appendix C of the Protocol.

VII.B.

IFM-1 Standing Live:

Above-ground standing live carbon in trees 1" DBH and larger were calculated using the appropriate biomass equation by species taken from the Compliance Offset Protocol U.S. Forest Offset Projects page on ARB's website. The current biomass equation documentation provided by ARB is included as Attachment O . 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:

Species	Bole Cubic Ft Volume	Bark Biomass	Live Branches Biomass
Coast Redwood	Equation 24	Equations 13 or 17	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
Gray Pine	Equation 5	Equation 9	Equation 7
Incense Cedar	Equation 19	Equation 12	Equation 10
California Nutmeg	Equation 8	Equation 13	Equation 10
Other Conifer	Equation 17	Equation 21	Equation 17
Tanoak	Equation 34	None	None
Pacific madrone	Equation 40	None	None
Interior Live oak	Equation 43	None	None
Canyon Live Oak	Equation 42	None	None
Coast Live Oak	Equation 43	None	None
Black oak	Equation 38	None	None
Oregon White oak	Equation 41	None	None
California laurel	Equation 33	None	None
Golden chinkapin	Equation 32	None	None
Bigleaf maple	Equation 37	None	None
Red Alder	Equation 26	Equation 20	Equation 20
California Buckeye	Equation 43	None	None
Other hardwood	Equation 41	None	None

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

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

Bole Biomass:

The Cubic foot volume of each tree is calculated as the volume of the total stem from ground to tip (includes the top and stump). FIA refers to this value as CVTS. Bole biomass

is calculated by multiplying the cubic volume by the wood density, and then dividing by 2.20462 to calculate weight in kilograms (kg). Above-ground biomass in kilograms (Kg) per acre is calculated by multiplying the FIA calculated kg per tree by each tree's per acre value.

Bark and Live Branches Biomass:

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

Missing volume of each tree is recorded as a percentage missing by 1/3rd segment of the tree (top, middle, bottom) as adapted from the Climate Action Reserve's "Quantification Guidance for Use with Forest Carbon Projects" dated November 15, 2012. The total heights of trees with broken tops were calculated from their measured top heights using FORSEE. If 1/3rd of the calculated tree height was less than the measured top height, then the break was assumed to be above the bottom 3rd of the tree. Likewise, if 2/3^{rds} of the calculated tree height was less than the measured tree height, the break was assumed to be in the top 3rd of the tree.

Missing volumes of damaged trees that were recorded in the field were then added to the estimated volume missing if there was a broken top. The total missing percentage of each tree is calculated based on 65% of the trees biomass being in the bottom 1/3rd , 25% in the middle 1/3rd, and 10% in the top 1/3rd. The total percentage of the tree that is missing is then calculated and multiplied by various biomass components of the tree as calculated above to calculate the net biomass of each component.

The net Kg per acre value of each tree on the plot is summed to derive above-ground live biomass Kg per acre for the plot. This value is used to calculate the respective below-ground live biomass component for the plot.

Below-ground live carbon is calculated at the plot level using the model provided by Cairns et. al. specified on page 88 of Appendix A of the Protocol. The formula has as its input, above-ground live biomass in Mg per hectare, and outputs below-ground biomass in Mg per hectare. Total net above-ground live carbon in Kg per acre for each plot is converted to Mg of biomass per hectare by multiplying by 2.471, and then dividing by 1000. After calculating the below ground component in Mg per hectare using the Cairns model, the results are converted to Kg per acre by multiplying by 1000 and dividing by 2.471.

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

IFM-3 Standing Dead:

Data on standing dead trees were collected as a part of the 2015-2016 Congaree River 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 includes trees 5” DBH and larger, with a minimum height of 15'.

Standing dead trees from the inventory data are classified into five decay classes based on descriptions contained in Research Paper NRS-15 (Harmon et al, 2011); however, collection of this data differed slightly by distinguishing between class 1 trees and recent mortality (class 0) with leaves still present. These decay classes are generally described as follows:

Class 1 All limbs and branches are present; the top of the crown is still present; all bark remains; sapwood is intact, with minimal decay; heartwood is sound and hard.

Class 2 There are few limbs and no fine branches; the top may be broken; a variable amount of bark remains; sapwood is sloughing with advanced decay; heartwood is sound at base but beginning to decay in the outer part of the upper bole.

Class 3 Only limb stubs exist; the top is broken; a variable amount of bark remains; sapwood is sloughing; heartwood has advanced decay in upper bole and is beginning at the base.

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

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

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

Missing volume of each tree is recorded as a percentage missing by 1/3rd segment of the tree (top, middle, bottom) as adapted from the Climate Action Reserve's "Quantification Guidance for Use with Forest Carbon Projects" dated November 15, 2012. The total heights of trees with broken tops are calculated from their measured top heights using FORSEE. If 1/3rd of the calculated tree height is less than the measured top height, then the break is assumed to be above the bottom 3rd of the tree. Likewise, if 2/3^{rds} of the calculated tree

height is less than the measured tree height, the break is assumed to be in the top 3rd of the tree.

Missing volumes of damaged trees that are recorded in the field are then added to the estimated volume missing if there was a broken top. The total missing percentage of each tree is calculated based on 65% of the trees biomass being in the bottom 1/3rd , 25% in the middle 1/3rd, and 10% in the top 1/3rd. The total percentage of the tree that is missing is then calculated and multiplied by various biomass components of the tree as calculated above to calculate the net biomass of each component.

Once the net biomass of each tree has been calculated, a relative density is applied by species and decay class. The relative density is in relation to the green density of sound wood, or the tree's wood density. The table below lists the relative densities applied by species and decay class taken from Differences Between Standing and Downed Dead Tree Wood Density Reduction Factors (Harmon et al, 2011).

Relative Density by Species and Decay Class:

	Decay Class (DC)				
Species	**DC1**	**DC2**	**DC3**	**DC4**	**DC5**
Redwood	0.994	0.951	0.902	0.605	0.605
Douglas-fir	0.892	0.831	0.591	0.433	0.433
Ponderosa pine	0.925	1.007	1.154	0.481	0.481
Sugar pine	1.040	0.906	0.735	0.517	0.517
California nutmeg	0.994	0.951	0.902	0.605	0.605
Grey pine	0.953	0.950	0.927	0.598	0.598
Incense cedar	1.040	0.972	1.011	0.596	0.596
California black oak	1.020	0.841	0.705	0.591	0.591
California laurel	0.982	0.793	0.618	0.525	0.525
Canyon live oak	1.020	0.841	0.705	0.591	0.591
California live oak	1.020	0.841	0.705	0.591	0.591
Interior live oak	1.020	0.841	0.705	0.591	0.591
California buckeye	1.020	0.841	0.705	0.591	0.591
Pacific madrone	0.982	0.793	0.618	0.525	0.525

	Decay Class (DC)				
Species	**DC1**	**DC2**	**DC3**	**DC4**	**DC5**
Oregon white oak	1.02	0.841	0.705	0.591	0.591
California laurel	0.982	0.793	0.618	0.525	0.525
Bigleaf maple	0.979	0.766	0.565	0.450	0.450
Golden chinkapin	0.982	0.793	0.618	0.525	0.525
Tanoak	0.982	0.793	0.618	0.525	0.525
Red alder	1.030	0.903	0.535	0.393	0.393
Other conifer	0.990	0.980	0.830	0.598	0.598
Other Coastal Hardwoods	1.020	0.700	0.858	0.591	0.591

Biomass components by Decay Class included in the calculation of standing dead carbon stocks are listed in the table below. Classes 3 through 5 are considered "Highly Decayed", and only bole volume is included.

Decay Class	Conifers	Hardwoods
1	All Aboveground tree portions	All Aboveground tree portions
2	Bole and Bark only	Bole and Bark only
3	Bole only	Bole only
4	Bole only	Bole only
5	Bole only	Bole only

Below-ground standing dead carbon is calculated at the plot level using the model provided by Cairns et. al. specified on page 88 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.

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

IFM-6 Soil (if applicable):

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

IFM-7 Carbon in in-use forest products:

Wood products delivered to the mill in any period is calculated beginning with the cubic volume of harvested conifer trees 10" DBH and larger. Conifers smaller than 10" DBH are not included as they are too small to be delivered to the mill. The dry weight of wood products in pounds is calculated by multiplying the wood density in lbs/cubic foot by the cubic volume for each softwood species harvested based on the CV6 (cubic foot volume above stump to a 6-inch top) values derived from the FIA equations listed above. Bark and branch biomass are not included in the volume harvested. The wood densities utilized are those for the Redwood Forest Type and are included in Table C.1 of Appendix C of the Protocol. The dry weight is multiplied by 0.5 to convert the weight to carbon weight only. The weight of carbon in lbs is divided by 2,204.6 to get the carbon weight in metric tonnes (Mg).

Mg of carbon is then multiplied by 0.675 to account for mill efficiencies, taken from the Compliance Offset Protocol U.S. Forest Offset Projects page on ARB's website.

The resulting Mg carbon value after accounting for milling efficiencies is then passed to the wood products worksheets for calculating long-term in-use wood products storage. The wood products carbon is separated into product classes and multiplied by the respective 100-year average storage factor. The tables below list the assignment of wood products by class per the most current Assessment Area Data File taken from the Compliance Offset Protocol U.S. Forest Offset Projects page on ARB's website, as well as the 100-year average

storage factors applied to each wood product class per table C.2 of Appendix C of the Protocol.

Wood Products by Class	
% Softwood Lumber	97.067%
% Hardwood lumber	0.002%
% Softwood Plywood	1.874%
% Oriented Strandboard	0.000%
% Non Structural Panels	0.244%
% Miscellaneous Products	0.095%
% Paper	0.717%

100-year Storage Rates Average Values from Appendix C, In-Use Table C.2

Softwood Lumber	0.463
Hardwood lumber	0.250
Softwood Plywood	0.484
Oriented Strandboard	0.582
Non Structural Panels	0.380
Miscellaneous Products	0.176
Paper	0.058

Average carbon stored in in-use wood products is calculated using equation C.1. Carbon is converted to CO_2-equivalent by multiplying by 3.664. This value is combined with IFM-8 using equation C.3 to represent $WP_{total, y}$ for the reporting period.

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

IFM-8 Forest product carbon in landfills (if applicable):

Wood products delivered to the mill in any period is calculated beginning with the cubic volume of harvested conifer trees 10” DBH and larger. Conifers smaller than 10" DBH are

not included as they are too small to be delivered to the mill. The dry weight of wood products in pounds is calculated by multiplying the wood density in lbs/cubic foot by the cubic volume for each softwood species harvested based on the CV6 (cubic foot volume above stump to a 6-inch top) values derived from the FIA equations listed above. Bark and branch biomass are not included in the volume harvested. The wood densities utilized are those for the Redwood Forest Type and are included in Table C.1 of Appendix C of the Protocol. The dry weight is multiplied by 0.5 to convert the weight to carbon weight only. The weight of carbon in lbs is divided by 2,204.6 to get the carbon weight in metric tonnes (Mg).

Mg of carbon is then multiplied by 0.664 to account for mill efficiencies, taken from the Compliance Offset Protocol U.S. Forest Offset Projects page on ARB's website.

The resulting Mg carbon value after accounting for milling efficiencies is then passed to the wood products worksheets for calculating long-term landfill wood products storage. The wood products carbon is separated into product classes and multiplied by the respective 100-year average storage factor. The table below lists the 100-year average storage factors applied to each wood product class per table C.3 of Appendix C of the Protocol.

100-year Storage Rates Average Values from Appendix C, In Landfill Table C.3

Softwood Lumber	0.298
Hardwood lumber	0.414
Softwood Plywood	0.287
Oriented Strandboard	0.233
Non Structural Panels	0.344
Miscellaneous Products	0.454
Paper	0.178

Average wood products carbon stored in landfills is calculated using equation C.2. Carbon is converted to CO_2-equivalent by multiplying by 3.664. This value is combined with IFM-7 using equation C.3 to represent $WP_{total, y}$ for the reporting period.

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

IFM-9 Biological emissions from site preparation:

As IFM-6 is an excluded carbon pool, IFM-9 is also an excluded pool.

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

The Protocol refers to this carbon pool as Secondary Effects which are calculated using equation 6.10 of the Protocol. Secondary Effects 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.

The PDM calculation each annual reporting period will be calculated based on a ratio between the average volume of wood delivered to the mill generated by the baseline analysis, and the average PDM value generated by the baseline analysis. Each reporting period, this ratio will be applied to the actual volume of wood delivered to a mill.

IFM-17 Biological emissions from decomposition of forest products:

This is quantified as a component of IFM-7 and IFM-8 as described above.

VII.C.

IFM-1 Standing Live: This carbon pool will be calculated each year as described in parts A and B above. The current standing live carbon pool is 1,287,438 $MgCO_2e$.

IFM-3 Standing Dead: This carbon pool will be calculated each year as described in parts A and B above. The current standing dead carbon pool is 17,380 $MgCO_2e$.

IFM-6 Soil (if applicable): N/A

IFM-7 Carbon in in-use forest products: This carbon pool will be calculated each year as described in parts A and B above. No harvesting has occured during the initial reporting period.

IFM-8 Forest product carbon in landfills (if applicable): This carbon pool will be calculated each year as described in parts A and B above. No harvesting has occured during the initial reporting period.

IFM-9 Biological emissions from site preparation: N/A

IFM-14 Biological emissions/removals from change in harvesting on forestland outside Project Area: This carbon pool will be calculated each year as described in parts A and B above. No harvesting has occurred during the initial reporting period, and as such this pool is calculated as -2,126 $MgCO_2e$ for the initial reporting period.

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

VII.D.

Stratified random sampling formulas taken from Shiver and Borders (1996) were used to calculate the sampling error for the Congaree River Project once mean standing live and standing dead pools have been determined for the 2015-2016 inventory. Estimates of the inventory confidence statistics, based on the confidence statistics as of 6/30/2016, are as follows:

Mean standing live and standing dead pools	65.46	Mg C per acre
SE of mean	1.50	Mg C per acre
SE of mean as %	2.29	1.50 ÷ 65.46
Sampling Error of 90% CI	3.77	(2.29%) * 1.645
Inventory Confidence Deduction	0%	3.8*% - 5.0%

*3.77 rounds to 3.8

VII.E.

The risk ratings shown on the next page assume that the Project will not employ a Qualified Conservation Easement.

Project Area Reversal Risk Rating:

Risk Category	Contribution to Reversal Risk Rating
Financial Failure	5.0%
Conversion	2.0%
Over-harvesting	2.0%
Social	2.0%
Wildfire	4.0%
Disease/Insect	3.0%
Other Catastrophic	3.0%
Total Buffer Pool Contribution	19.2%

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

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

The contribution to the Forest Buffer Account during the initial reporting period is 22,505 ROCs.

VIII.A.5.

Following the calculation methodologies described in section VII B above, the baseline modeling presented in the Modeling Plan (Attachment M) generates an average annual value for each of the above described wood products carbon pools. Actual wood products values for In-use, Landfill, and Prior to Delivery to the Mill ("PDM") are calculated based on a flow of wood products over the 100-year planning period. The table below presents an estimate of the average wood products stored long-term values that were generated by the baseline analysis.

Woods Products Class	Mg C/ acre	Total Mg CO2e
Average Annual Carbon 100-year In-Use	0.124	2,474
Average Annual Carbon 100-year Landfill	0.080	1,598
Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill	0.769	15,338

The initial reporting period for the Congaree River project is 0.693 years in length, and as such the annual wood products values generated by the baseline analysis presented above are multiplied by 0.693 and reported in the Annual OPDR for the initial reporting period baseline values. Subsequent one year long reporting periods will utilize the annual values reported above.

Baseline Wood Products for the Initial Reporting Period (RP1)

Woods Products Class	Annual Total Mg CO2e	RP1 Total Mg CO2e
Carbon 100-year In-Use	2,474	1,715
Carbon 100-year Landfill	1,598	1,108
Carbon in Harvested Trees Prior to Delivery to the Mill	15,338	10,632

VIII.B.7.

In modeling the baseline for standing live carbon stocks, the OPO must incorporate financial constraints that could affect baseline growth and harvesting scenarios. The Congaree River Project utilizes a financial analysis of the baseline harvesting regime that captures all relevant costs and returns, taking into account all legal, physical, and biological constraints. This financial analysis has been included as Attachment L of this OPDR. Cost and revenue variables included in the financial analysis are based on documented costs and returns for the Project Area, and on other properties in the Assessment Area. This financial analysis illustrates that the baseline harvest scenario is financially feasible.

X Attachments

The following attachments are included as a part of this OPDR:

Attachment A - Title Documents for the Congaree River.

Attachment E – Maps of the Project Area, including an ESRI Geodatabase that represents the Project Area.

Attachment F – Orthophoto Maps of the Project Area.

Attachment G – A Graph Portraying the Project's Baseline.

Attachment H – A Diagram of the Project's Baseline.

Attachment I – Baseline and Actual Harvest Volumes

Attachment K - Legal Constraints Affecting Forest Management Activities on the Project Area

Attachment L – Financial Analysis of the Baseline Scenario

Attachment M –Modeling Plan

Attachment N –Inventory Specification

Attachment O – Volume and Biomass Equations

ATTACHMENT A

The Grant Deed included here describes the lands included in the Congaree River carbon project with the following exceptions:

Lands in Tract One, Parcel One, in Sections 23, 24, and 25 all T14N R15W MDB&M, being APN#s 026-392-27, 026-392-32, 026-440-51, 026-440-53 and 026-440-54 are excluded.

Lands in Tract Two, Parcel I, in Section 27 T13N R16W being APN#s 133-190-03 and 133-190-04 are excluded.

Lands in Tract Two, Parcel I, in Section 34 T13N R16W being APN#s 133-200-23 and 133-200-24 are excluded.

2014-00381
Recorded at the request of:
REDWOOD EMPIRE TITLE
01/10/2014 03:02 PM
Fee: $37.00 Pgs: 1 of 9

OFFICIAL RECORDS
Susan M. Ranochak - Clerk-Recorder
Mendocino County, CA

Order No.
Escrow No.
Loan No.
WHEN RECORDED MAIL TO:

Congaree River LLC
53 West Jackson Blvd. Suite 530
Chicago, IL 60604

	$20.00 PAID
X	PCO FILED
	Exempt

SPACE ABOVE THIS LINE FOR RECORDER'S USE

MAIL TAX STATEMENTS TO:

SAME AS ABOVE

The undersigned grantor(s) declare(s):
CITY TRANSFER TAX $
DOCUMENTARY TRANSFER TAX $ None R&TC 11925 & 11930
SURVEY MONUMENT FEE $
( ) Computed on the consideration or value of property conveyed; OR
( ) Computed on the consideration or value less liens or encumbrances remaining at time of sale.

GRANT DEED

FOR A VALUABLE CONSIDERATION, receipt of which is hereby acknowledged,

Congaree River Limited Partnership, an Illinois limited partnership

hereby GRANT(S) to

Congaree River LLC, an Illinois limited liability company

the real property in the City of (unincorporated area)
County of Mendocino , State of California, described as

See Exhibit A attached hereto for legal description. It is the intent of the grantor to convey any and all of grantor's right, title and interest in and to any other real property or interest in real property of any kind or nature whatsoever situated in the County of Mendocino, State of California, whether specifically described herein or not, including also all rights of ingress and egress of any nature to property located in the County of Mendocino, State of California which grantor has the right to convey.

Congaree River Limited Partnership:

By: Francis Beidler III, general ptr.

By:

STATE OF ~~CALIFORNIA~~ ILLINOIS
COUNTY OF COOK

On January 8, 2014 before me, Connie Rosati, notary public, personally appeared Francis Beidler III who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s) or the entity upon behalf of which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature Connie Rosati

(This area above for official Notarial seal)

OFFICIAL SEAL
CONNIE ROSATI
NOTARY PUBLIC - STATE OF ILLINOIS
MY COMMISSION EXPIRES:04/09/16

Exhibit A

TRACT ONE:

Parcel One:

In Township 14 North, Range 15 West, Mount Diablo Base and Meridian

Section 23:

E 1/2 of SE 1/4

APN: 026-392-x27

Section 24:

Lots 9 and 10, and the S ½ of Lot 8, except that portion described in the quitclaim deed to George Gaines et al recorded July 18, 2011 as 2011-09778, Mendocino County Records.

Together with a portion of Lot 11 as described in the quitclaim deed to Congaree River Limited Partnership recorded July 18, 2011 as 2011-09779, Mendocino County Records.

APN: 026-392-x27, 026-392-32

Section 25:

Lots 1, 2, 3, 4, 5, and 12

APN: 026-440-51, 026-440-53, 026-440-54

Section 36:

All of Section 36, except Lot 13

APN: 026-440-32, 026-440-34, 026-440-38, 026-440-39, 026-440-41, 026-440-46, 026-440-52

In Township 13 North, Range 14 West, Mount Diablo Base and Meridian

Section 5:

Lots 1, 2, 3 and 4
S ½ of NE ¼
N ½ of SW ¼
S ½ of NW ¼
NW ¼ of SE ¼

APN: 029-650-27, 029-650-28, 029-650-x29, 029-650-30

Section 6:

Lots 1, 2, 3 and 4

S ½ of NE ¼
APN: 029-650-01, 029-650-02, 029-650-25, 029-650-26, 029-650-x29

Section 7:

Parcel One:
Lots 1, 2, 3 and 4
SE ¼ of NW ¼
E ½ of SW ¼
W ½ of SE ¼
SE ¼ of SE ¼
excepting from the said SE ¼ that certain parcel of land described in deed to Hanes Ranch, Inc., dated December 21, 1977, recorded December 28, 1977 in Book 1125 Official Records, Page 86, Mendocino County Records.

Also excepting any portion granted to James B. McVickar in the quitclaim deed recorded August 17, 2010 as 2010-11641, Mendocino County Records.

APN: 029-660-32, 029-660-34, 029-660-35

In Township 13 North, Range 15 West, Mount Diablo Base and Meridian

Section 1:

All of Section 1, except Lot 4

Also excepting any portion granted to James B. McVickar in the quitclaim deed recorded August 17, 2010 as 2010-11641, Mendocino County Records.

APN: 026-460-34, 026-460-46, 026-460-47, 026-460-51, 026-460-56, 026-460-67

Section 11:

E ½ of NE ¼
NW ¼ of NE ¼
E ½ of SE ¼

APN: 026-460-x58

Section 12:

All of Section 12, except any portion lying Northeasterly of the thread of Rancheria Creek.

APN: 026-460-x58, 026-460-x59, 026-460-60, 026-460-61, 026-460-62, 026-460-63

Section 13:

Those lands described in the deed to Congaree River Ltd. Partnership in the deed executed by The SMS I Group recorded September 25, 1992 in Book 2027, Page 307, Mendocino County Records.

Also:

N ½ of SW ¼
SW ¼ of SW ¼
NW ¼ of SE ¼

Also, beginning at the Northwest corner of Section 13, Township 13 North, Range 15 West, Mount Diablo Meridian, thence South 82° 00' 00" East, along the North line of said Section 13, 1050 feet more or less to the top of a ridge between Bear Trap Creek and Horse Creek; thence in a Southwesterly direction along the top of said ridge, 1180 feet more or less to the West line of said Section 13; thence North 06° 57' 00" East, along the said West line, 500 feet more or less to the point of beginning.

APN: 026-480-50, 026-480-51, 026-480-60, 026-480-62, 026-480-64

In Township 14 North, Range 14 West, Mount Diablo Base and Meridian

Section 29:

SW ¼ of SW ¼

APN: 046-110-61x

Section 30:

Lot 4, S ½ of the NE ¼ and SE ¼ of the NW ¼
SE ¼ of SW ¼
All of the SE ¼

Excepting therefrom that portion granted to Roland Wentzel et al as Trustee, in the deed recorded July 12, 2005 as 2005-14893, Mendocino County Records.

APN: 046-110-x59

Section 31:

All of Section 31

APN: 046-110-35, 046-110-x59, 046-110-60, 046-110-62, 046-110-x63, 046-110-64, 046-110-x65

Section 32:

All of the W ½
NW ¼ of the SE ¼
S ½ of the SE ¼

APN: 046-110-x61, 046-110-x63, 046-110-x65, 046-110-66, 046-110-67

Parcel Two:

The easements granted in Parcels II through VI of Tract Two of the deed to Congaree River Limited Partnership recorded November 29, 1983 in Book 1431, Page 504, Mendocino County Records.

EXCEPTING FROM ALL OF SAID TRACT ONE the oil, gas and other minerals which may be produced in connection with oil and gas including sulphur and any other gases or elements, carbon dioxide and geothermal energy resources, along with all equipment, machinery, buildings and improvements on the real property described herein presently used in connection with the production, storage, handling, treatment, transportation or marketing of said minerals, gases and resources, to the extent the same were reserved by Masonite Corporation on Page 38 and 39 of Exhibit A to the Corporation Quitclaim Deed (hereinafter referred to as the "Masonite Deed") from Masonite Corporation, a corporation organized under the laws of the State of Delaware, to Timber Realization Company, a Mississippi limited partnership, dated August 26, 1982 and recorded on August 27, 1982 in Book 1364 Official Records, Page 485, Mendocino County Records, and subject to the rights of the grantor under the Masonite Deed, to the extent specifically and expressly reserved in such Masonite Deed, to take water in connection with said grantor's mineral and resource rights reserved thereby and to inject water, brine and other fluids or gases into the subsurface.

TRACT TWO:

Parcel I:

In Township 13 North, Range 16 West, Mount Diablo Base and Meridian

Section 21:

All of Section 21, except the NW ¼ and the NW ¼ of the SW ¼

APN: 133-160-14, 133-160-15, 133-160-16, 133-160-17

Section 22:

S ½ of SW ¼
Excepting therefrom all that portion conveyed by deed executed by Leslie A. Hamilton, a single man to Ernest E. Titus et ux, dated April 3, 1953, recorded April 8, 1953 in Volume 341 of Official Records, Page 405, Mendocino County Records.

APN: 133-160-05

Section 27:

SE ¼ of SW ¼
E ½ of SW ¼ of SW ¼
NW ¼ of SW ¼
All of the NW ¼
All that portion of the SW ¼ of the SE ¼ lying South of the center line of the traveled County Road as the same existed on October 11, 1937.

Excepting therefrom all that portion conveyed by deed executed by Leslie A. Hamilton, a single man to Ernest E. Titus et ux, dated April 3, 1953, recorded April 8, 1953 in Volume 341 of Official Records, Page 405, Mendocino County Records.

Also excepting therefrom the following:

1st: Those lands described in deed dated August 17, 1962 from Frank Stanley and Viola

Stanley, his wife to Raymond Gary Ohleyer and Marie Ohleyer, his wife, recorded July 26, 1963 in Volume 633 of Official Records, Page 411, Mendocino County Records.

2nd: That portion conveyed in the deed executed by William E. Lawson et ux to County of Mendocino, dated May 13, 1968, recorded June 10, 1968 in Volume 766 of Official Records, Page 569, Mendocino County Records.

APN: 133-170-12, 133-170-x15, 133-190-03, 133-190-04

Section 28:

All of the N ½
NW ¼ of SW ¼
Excepting therefrom that portion thereof described in the deeds to Arthur C. Huntley, et ux recorded February 24, 1987 in Book 1608 of Official Records at Page 709 and recorded June 30, 1988 in Book 1694 of Official Records at Page 247, Mendocino County Records.

APN: 133-170-13, 133-170-14, 133-170-x15

Section 29:

NE ¼ of the NE ¼
excepting therefrom that portion thereof described in the deed to Wm. Hillis recorded October 13, 1891 in Book 55 of Deeds, Page 236, Mendocino County Records.

A strip of land 50 feet wide situated in the Southeast quarter of Section 29, Township 13 North, Range 16 West, Mount Diablo Base and Meridian, and lying 25 feet on either side of the following described centerline: BEGINNING at Station 115+00.46 on the center-line of the Mendocino County Road No. 510, called the Mountain View Road, said point of beginning bears North 05° 44' 21" East, 436.81 feet from the Southwest corner of the Southeast quarter of the Southeast quarter of said Section 29; running thence from the said point of beginning North 02° 00' 00" East, 67.68 feet; thence on a curve to the right with a radius of 200.00 feet, central angle 85° 30', for a distance of 298.45 feet; thence on a curve to the left with a radius of 200.00 feet, central angle 38° 45', for a distance of 135.26 feet; thence on a curve to the right with a radius of 200.00 feet. central angle 30° 30', for a distance of 106.47 feet; thence on a curve to the left with a radius of 100.00 feet, central angle 60° 20' 15" for a distance of 105.31 feet; thence North 18° 54' 45" East, 120.00 feet; thence on a curve to the right with a radius of 225.00 feet, central angle 31° 18' 25", for a distance of 122.94 feet; thence on a curve to the left with a radius of 550.00 feet, central angle 26° 14' 35", for a distance of 251.94 feet; thence North 13° 32' 15" East, 295.40 feet; thence on a curve to the right with a radius of 250.00 feet, central angle 72° 56' 30". for a distance of 318.28 feet; thence North 86° 28' 45" East, 124.30 feet; thence on a curve to the left with a radius of 1991.80 feet, central angle 05° 51' 50", for a distance of 203.86 feet to a point on the East boundary of Section 29, said point bears North 00° 56' 45" East, 502.83 feet from the Northeast corner of the Southeast quarter of the Southeast quarter of said Section 29.

APN: 133-130-04, 133-140-07

Section 34:

NW ¼ of the NE ¼
All of the NW ¼
excepting therefrom all that portion thereof conveyed by Quitclaim Deed executed by Eric

Roberts to the County of Mendocino recorded June 10, 1968 in Book 766 Official Records, Page 562, Mendocino County Records:

APN: 133-200-23, 133-200-24

Parcel II:

A right of way over a strip of land twenty-five feet wide, the centerline of which is described in the deed executed by Irma M. Zern to William E. Lawson et ux. recorded August 10, 1970 in Book 823 of Official Records. at Page 734, Mendocino County Records.
Said easement is appurtenant to and for the benefit of Parcel I above.

EXCEPTING FROM ALL OF TRACT TWO the oil, gas and other minerals which may be produced in connection with oil and gas including sulphur and any other gases or elements, carbon dioxide and geothermal energy resources, along with all equipment, machinery, buildings and improvements on the real property described herein presently used in connection with the production, storage, handling, treatment, transportation or marketing of said minerals, gases and resources, to the extent the same were reserved by Masonite Corporation on Page 38 and 39 of Exhibit A to the Corporation Quitclaim Deed (hereinafter referred to as the "Masonite Deed") from Masonite Corporation, a corporation organized under the laws of the State of Delaware, to Timber Realization Company, a Mississippi limited partnership, dated August 26, 1982 and recorded on August 27, 1982 in Book 1364 Official Records, Page 485, Mendocino County Records, and subject to the rights of the grantor under the Masonite Deed, to the extent specifically and expressly reserved in such Masonite Deed, to take water in connection with said grantor's mineral and resource rights reserved thereby and to inject water, brine and other fluids or gases into the subsurface.

TRACT THREE:

The easements in favor of Congaree River Limited Partnership in the following documents:

a) Easement Grant Deed executed by Sopher Wheeler Co. recorded July 23, 1984 in Book 1467, Page 299, Mendocino County Records.

b) Reciprocal Easement Agreement executed by Longview Fibre Company recorded November 20, 1984 in Book 1483, Page 129, Mendocino County Records.

c) Grant of Right of Way executed by Irma M. Zern recorded November 9, 1990 in Book 1870, Page 656, Mendocino County Records.

d) Awarded to Congaree River Limited Partnership in the Judgment recorded September 21, 1992 in Book 2026, Page 36, Mendocino County Records.

e) Easement Agreement executed by Mary Ellen Dearing recorded July 29, 1994 in Book 2192, Page 629, Mendocino County Records.

f) Agreement executed by Michael K. Holmberg et al recorded November 14, 2005 as 2005-24731, Mendocino County Records.

g) The easement reserved by Congaree in the deed recorded July 1, 2008 as 2008-09430, Mendocino County Records.

h) Awarded to Congaree River Limited Partnership in the Judgment recorded August 20, 2010 as 2010-11852, Mendocino County Records.

i) Easement Grant Deed executed by George C. Gaines and Mary Moore Gaines, trustees, recorded May 23, 2011 as 2011-07099, Mendocino County Records.

ATTACHMENT E

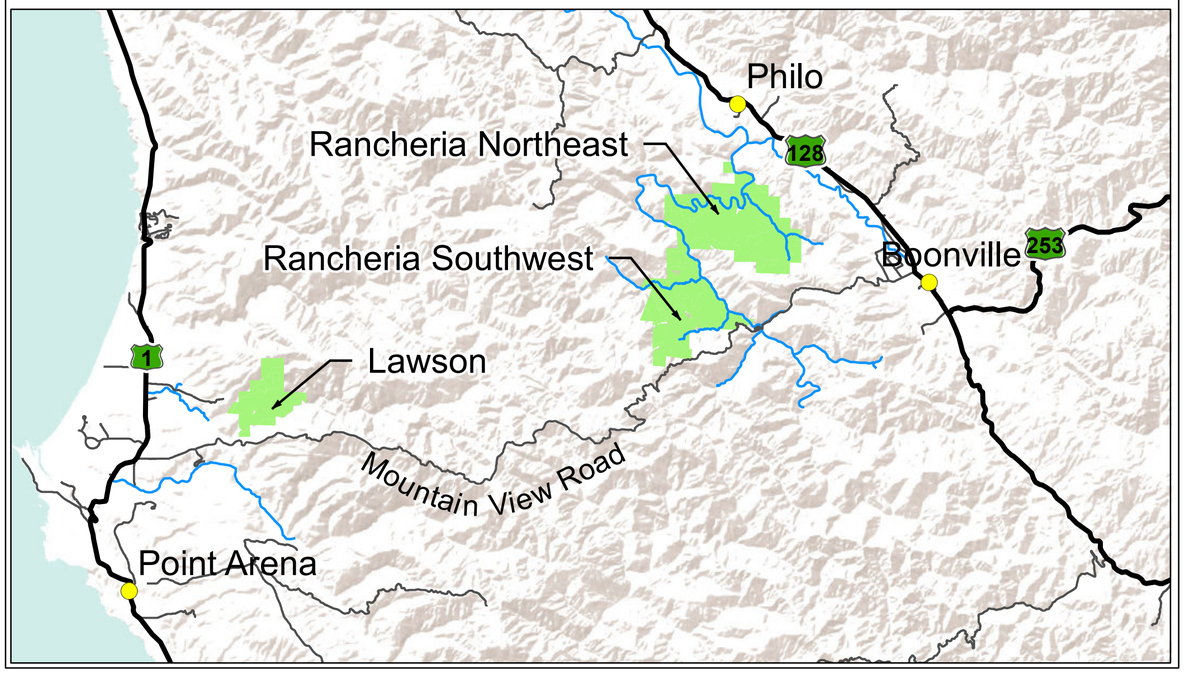
Congaree River Project

Portions of sections 29, 30, 31, and 32 T14N R14W, Sections 5, 6 and 7 T13N R14W,
Section 36 T14N R15W, Sections 1, 2, 11, 12, and 13 T13N R15W, and
Sections 21, 27, 28, and 29 T13N R16W all MDB&M

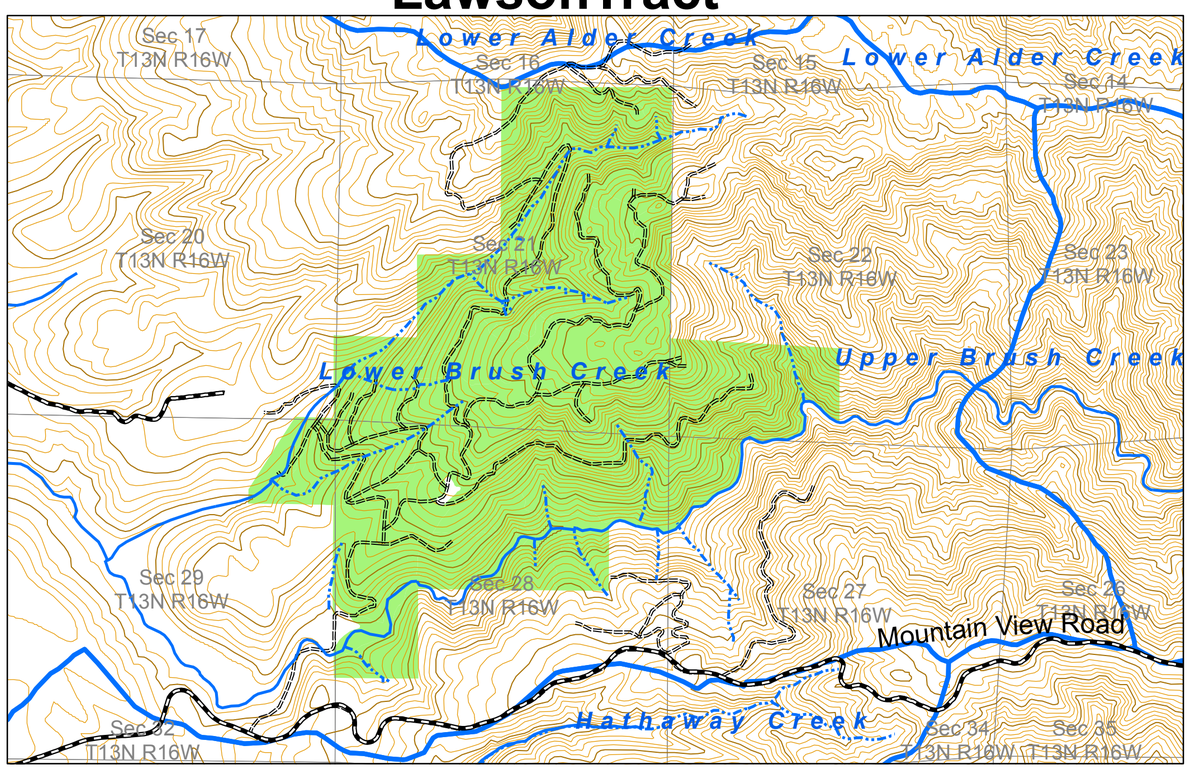
Legend

- Project_Area
- Watershed Boundary
- Public Road
- Watercourses
- Private Road
- Class 1
- Class 2

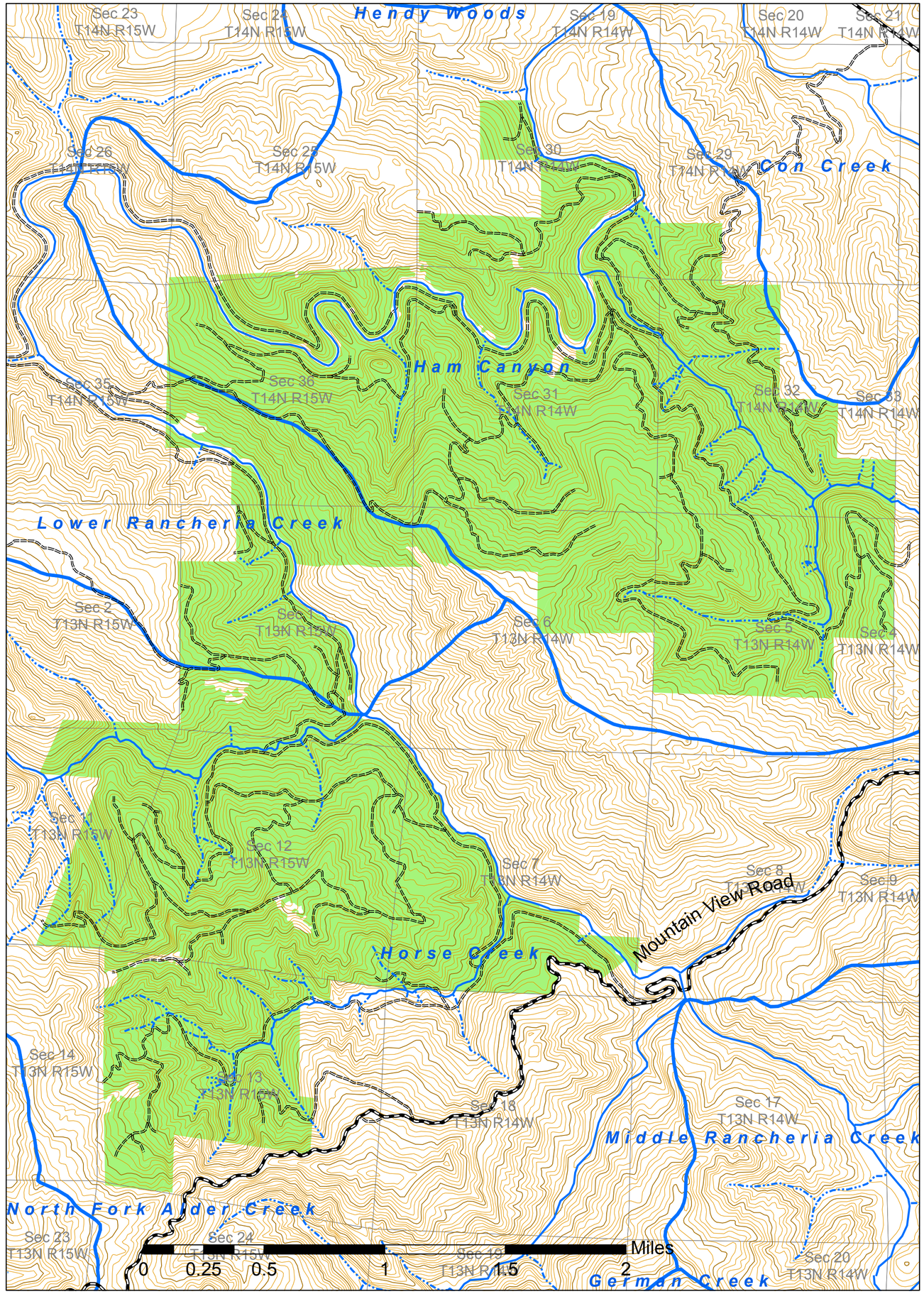
N W E S



LawsonTract



Rancheria Tracts



ATTACHMENT F

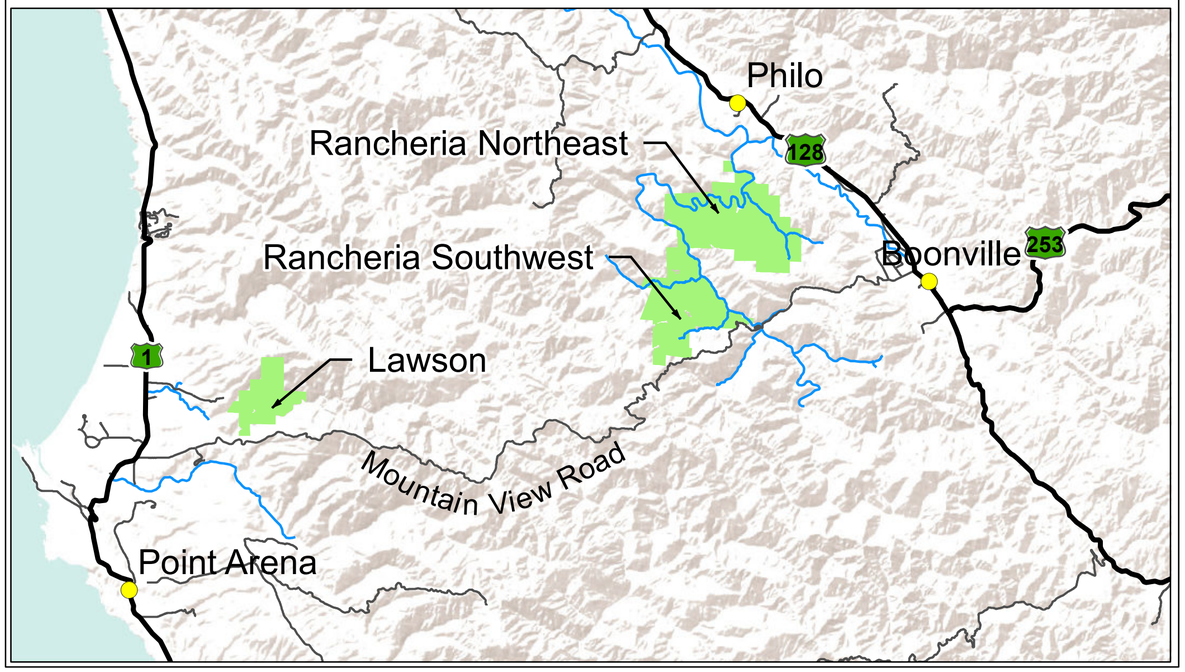
Congaree River Project

Portions of sections 29, 30, 31, and 32 T14N R14W, Sections 5, 6 and 7 T13N R14W,
Section 36 T14N R15W, Sections 1, 2, 11, 12, and 13 T13N R15W, and
Sections 21, 27, 28, and 29 T13N R16W all MDB&M

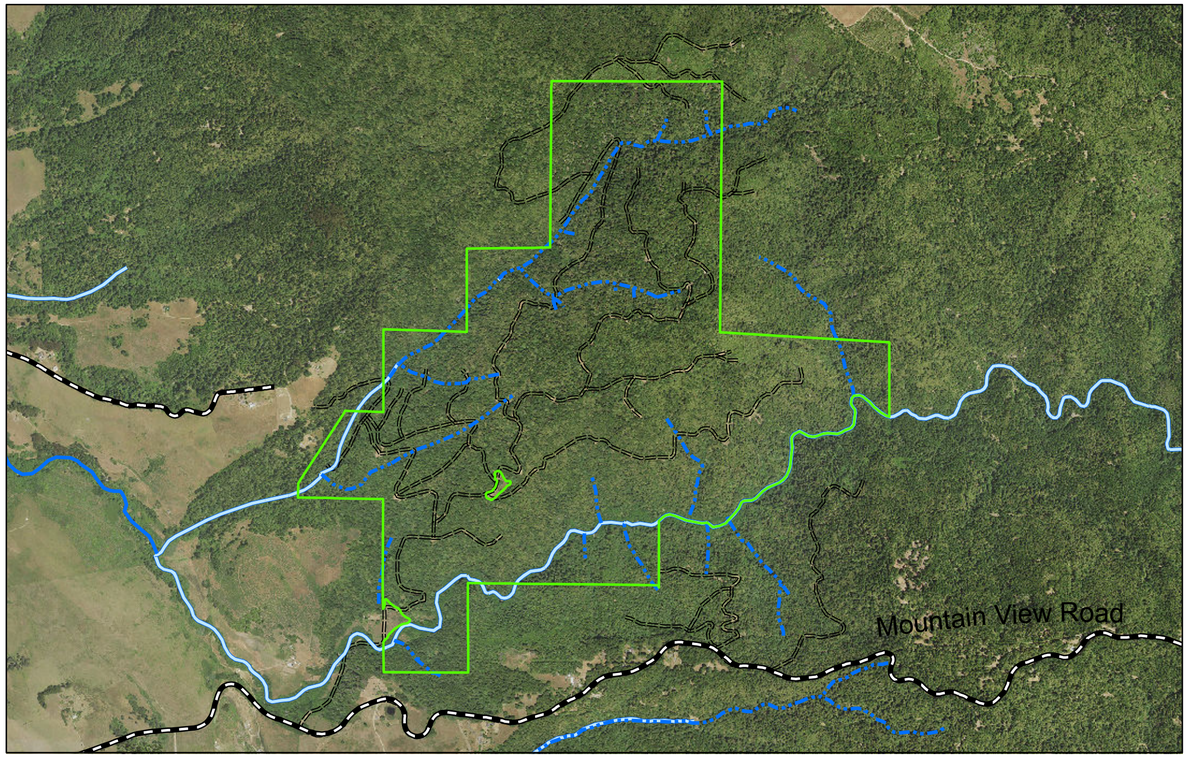
Legend

Project Area
Public Road
Private Road
Watercourses
Class 1
Class 2

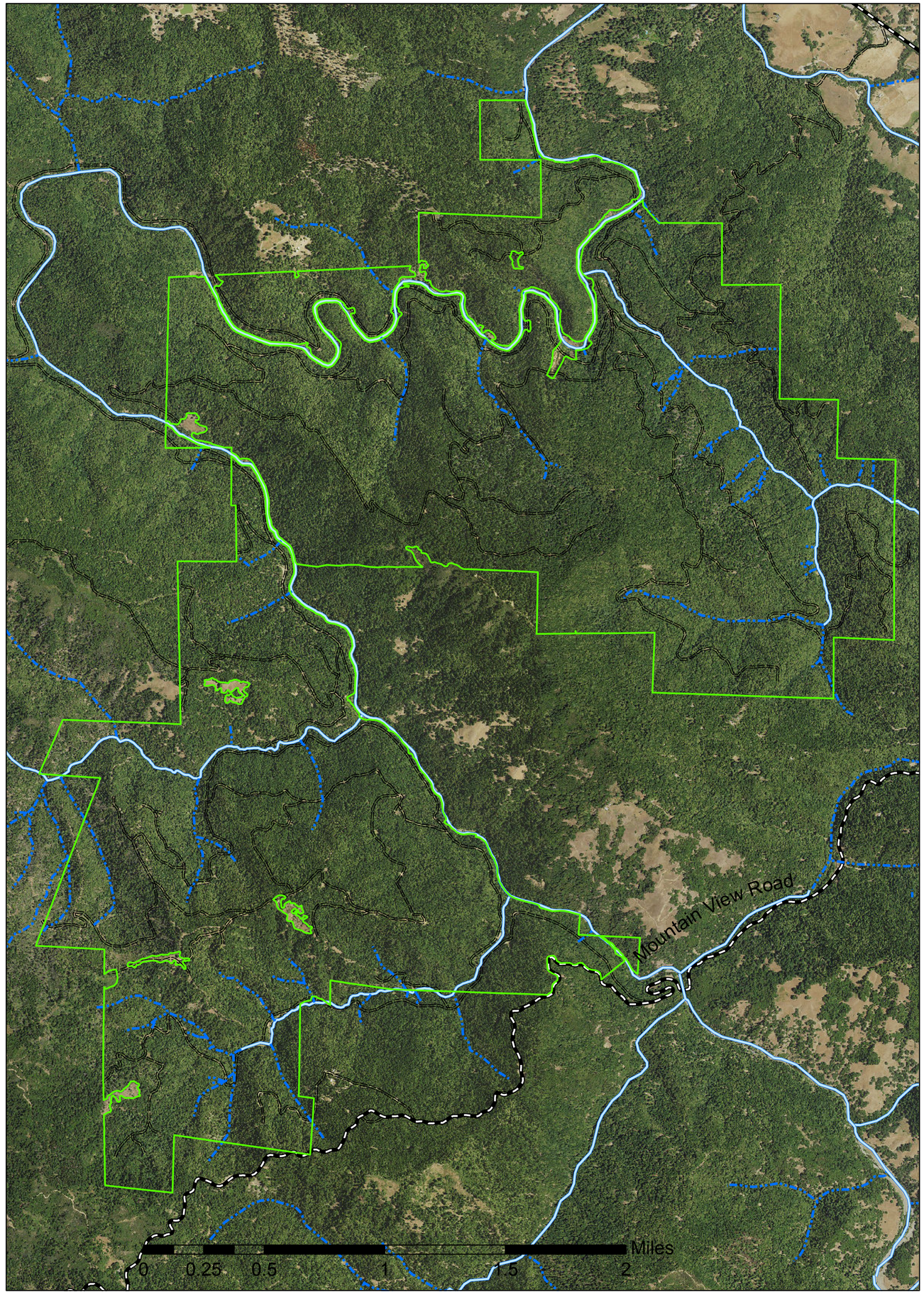
N
W E
S



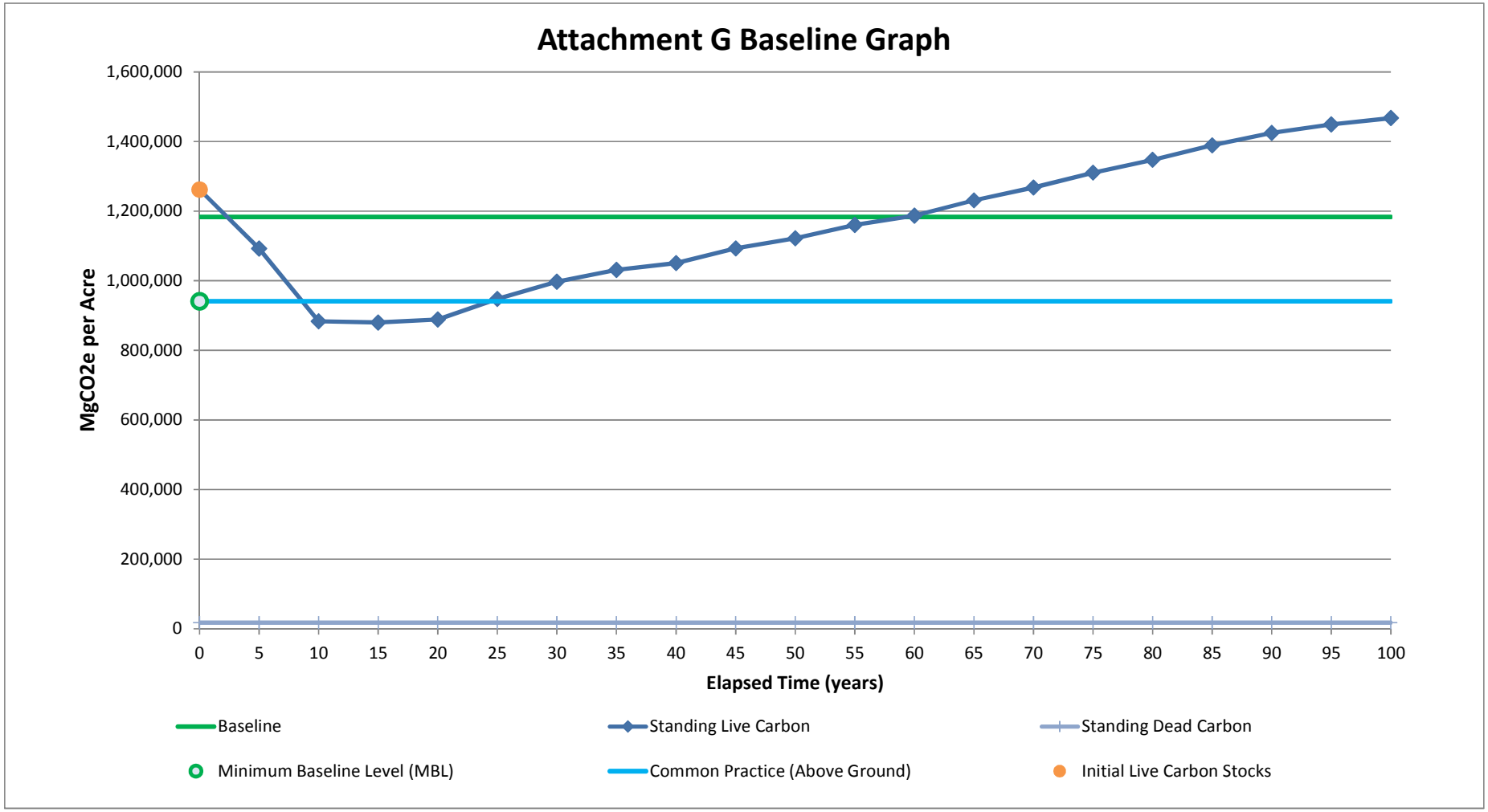
LawsonTract



Rancheria Tracts



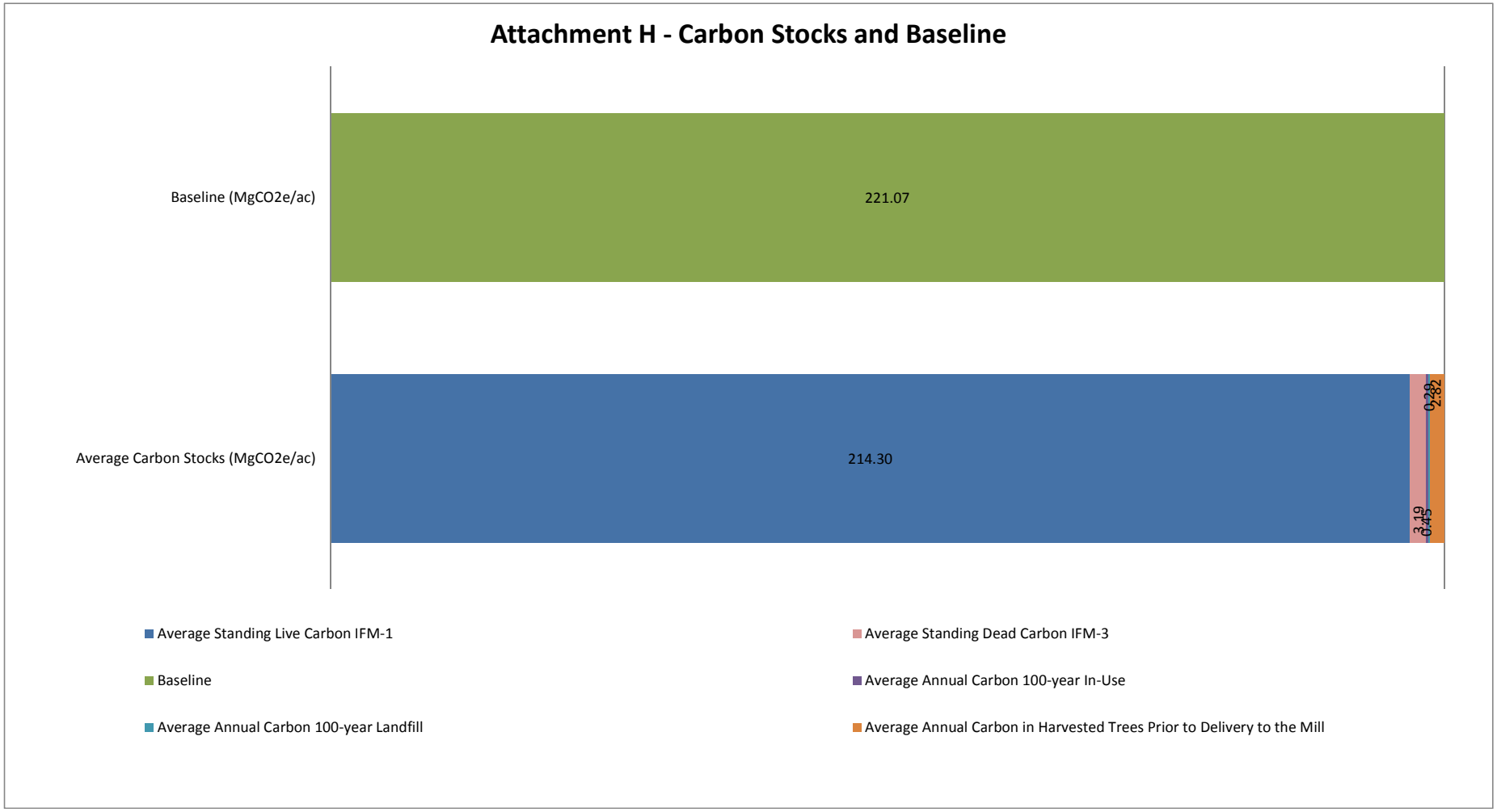
ATTACHMENT G


Attachment G Baseline Graph
MgCO2e per Acre
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Elapsed Time (years)
Baseline
Standing Live Carbon
Standing Dead Carbon
Minimum Baseline Level (MBL)
Common Practice (Above Ground)
Initial Live Carbon Stocks

Baseline Carbon Stocks ($MgCO_2e$ Total)

Elapsed Time	Standing Live Carbon	Standing Live Above Ground	Standing Live Below Ground	Standing Dead Carbon	Baseline	MBL	Above-Ground Common	Initial Live Carbon Stocks
0	1,262,054	1,018,407	243,647	17,380	1,183,218	941,309	941,309	1,262,054
5	1,092,262	879,652	212,615	17,380	1,183,218		941,309	
10	883,443	707,462	175,996	17,380	1,183,218		941,309	
15	880,091	705,422	174,681	17,380	1,183,218		941,309	
20	888,540	711,692	176,862	17,380	1,183,218		941,309	
25	947,753	760,450	187,315	17,380	1,183,218		941,309	
30	996,798	800,770	196,037	17,380	1,183,218		941,309	
35	1,031,362	829,601	201,768	17,380	1,183,218		941,309	
40	1,050,781	845,754	205,032	17,380	1,183,218		941,309	
45	1,092,670	880,532	212,142	17,380	1,183,218		941,309	
50	1,122,061	904,908	217,155	17,380	1,183,218		941,309	
55	1,160,055	936,543	223,511	17,380	1,183,218		941,309	
60	1,186,764	958,770	227,991	17,380	1,183,218		941,309	
65	1,231,137	995,589	235,542	17,380	1,183,218		941,309	
70	1,267,635	1,025,841	241,786	17,380	1,183,218		941,309	
75	1,310,765	1,061,654	249,100	17,380	1,183,218		941,309	
80	1,347,439	1,092,069	255,357	17,380	1,183,218		941,309	
85	1,389,048	1,126,645	262,388	17,380	1,183,218		941,309	
90	1,425,057	1,156,527	268,513	17,380	1,183,218		941,309	
95	1,449,429	1,177,025	272,384	17,380	1,183,218		941,309	
100	1,467,485	1,192,195	275,268	17,380	1,183,218		941,309	
Average	1,165,838	941,310	224,528	17,380	1,183,218		941,309	

ATTACHMENT H


Attachment H - Carbon Stocks and Baseline
Baseline (MgCO2e/ac)
Average Carbon Stocks (MgCO2e/ac)
221.07
214.30
3.19
0.45
0.28
2.82
Average Standing Live Carbon IFM-1
Average Standing Dead Carbon IFM-3
Baseline
Average Annual Carbon 100-year In-Use
Average Annual Carbon 100-year Landfill
Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill

Attachment H

Baseline Carbon Stocks ($MgCO_2e$ per Acre)

Elapsed Time	Standing Live Carbon Pool IFM-1	Standing Dead Carbon Pool IFM-3	Baseline
0	231.99	3.19	217.50
5	200.78	3.19	217.50
10	162.39	3.19	217.50
15	161.78	3.19	217.50
20	163.33	3.19	217.50
25	174.21	3.19	217.50
30	183.23	3.19	217.50
35	189.58	3.19	217.50
40	193.15	3.19	217.50
45	200.85	3.19	217.50
50	206.26	3.19	217.50
55	213.24	3.19	217.50
60	218.15	3.19	217.50
65	226.31	3.19	217.50
70	233.01	3.19	217.50
75	240.94	3.19	217.50
80	247.68	3.19	217.50
85	255.33	3.19	217.50
90	261.95	3.19	217.50
95	266.43	3.19	217.50
100	269.75	3.19	217.50
Average	214.30	3.19	217.50

Carbon Pool	Mg C/ acre	Total Mg CO2e
Average Standing Live and Standing Dead Pools	59.361	1,183,218
Average Annual Carbon 100-year In-Use	0.124	2,474
Average Annual Carbon 100-year Landfill	0.080	1,598
Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill	0.769	15,338

ATTACHMENT I

Attachment I

Per section 9.2.1 of the protocol, the following table represents the projected actual harvesting volumes from the Project Area over 100 years.

Elapsed Time (Years)	Average Decadal Harvest (Board feet per acre)
10	300
20	400
30	500
40	600
50	600
60	600
70	600
80	600
90	600
100	600

The baseline projection is provided in the Modeling plan included as Attachment M.

ATTACHMENT K

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 L

Congaree River Improved Forest Management Project
Financial Analysis of Baseline Scenario

This analysis is provided per section 6.2.1.3 (1) of Compliance Offset Protocol U.S. Forest Projects, November 14, 2014, 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	8.0%	
Inflation	0.0%	
Real price appreciation for delivered log values	0.0%	
Yield Tax	2.9%	MBF

Production Costs:

Item	**Cost per acre**	**Quantity**	**Total Cost**	**Cost per MBF**
THP Preparation	$150	5,440	$ 816,023	$15.21
Logging Supervision				$15.00
Property Management				$25.00
Logging and Hauling (Derived from BOE Stumpage Values)				$0.00
Total				**$55.21**

Herbicide Treatment of Hardwoods:

Period	**Cost per acre**	**% of Acres Treated**	**Total Cost**	**Cost per MBF**
1	$ 175.00	65%	$618,818	$11.54
2	$ 175.00	33%	$314,169	$17.57
3	$ 175.00	33%	$314,169	$17.46
4	$ 175.00	33%	$314,169	$15.24
5	$ 175.00	33%	$314,169	$14.93
6	$ 175.00	33%	$314,169	$14.97
7	$ 175.00	33%	$314,169	$17.95
8	$ 175.00	33%	$314,169	$18.19
9	$ 175.00	33%	$314,169	$18.01
10	$ 175.00	33%	$314,169	$13.53

Tree Planting: ($1 per tree cost)

Period	**Cost per acre**	**% of Acres Treated**	**Total Cost**	**Cost per MBF**
1	$ 125.00	35%	$238,007	$4.44
2	$ 125.00	25%	$170,005	$9.51
3	$ 125.00	20%	$136,004	$7.56
4	$ 125.00	20%	$136,004	$6.60
5	$ 125.00	20%	$136,004	$6.46
6	$ 125.00	20%	$136,004	$6.48
7	$ 125.00	20%	$136,004	$7.77
8	$ 125.00	20%	$136,004	$7.87
9	$ 125.00	20%	$136,004	$7.80
10	$ 125.00	20%	$136,004	$5.86

Congaree River Project

Financial Analysis of Baseline Scenario

Calculation of Net Present Value of Harvest Stream

Assumptions: Harvest levels are based on Baseline Harvest Scenario

Logging sytem mix estimated as 50% tractor, 50% cable.

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

0% Real price appreciation applied to delivered log values.

All calculations in constant dollars without inflation.

Discount Rate 8.0% Real.

	Annual Harvest Volume				Stumpage Values per MBF				Production	Herbicide	Tree	Yield	Net	Total	Present
	RW	DF	OC	Totals	RW	DF	OC	Camprun	Costs	Treatment	Planting	Taxes	Value	Net	Net
Year	MBF	MBF	MBF	MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	$ / MBF	Value	Value
2015	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	770,800
2016	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	713,704
2017	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	660,837
2018	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	611,886
2019	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	566,561
2020	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	524,594
2021	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	485,735
2022	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	449,755
2023	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	416,440
2024	2,807	2,543	14	5,364	400.00	50.00	50.00	233.16	55.21	11.54	4.44	6.76	155.21	832,464	385,592
2025	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	69,739
2026	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	64,573
2027	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	59,790
2028	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	55,361
2029	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	51,260
2030	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	47,463
2031	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	43,947
2032	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	40,692
2033	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	37,678
2034	656	1,133	-	1,789	400.00	50.00	50.00	178.37	55.21	17.57	9.51	5.17	90.92	162,605	34,887
2035	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	28,139
2036	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	26,055
2037	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	24,125
2038	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	22,338
2039	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	20,683
2040	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	19,151
2041	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	17,733
2042	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	16,419
2043	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	15,203
2044	585	1,215	-	1,800	400.00	50.00	50.00	163.67	55.21	17.46	7.56	4.75	78.70	141,648	14,077
2045	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	15,287
2046	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	14,154
2047	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	13,106
2048	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	12,135
2049	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	11,236
2050	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	10,404
2051	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	9,633
2052	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	8,920
2053	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	8,259
2054	662	1,400	-	2,061	400.00	50.00	50.00	162.36	55.21	15.24	6.60	4.71	80.60	166,132	7,647
2055	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	6,463
2056	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	5,985
2057	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	5,541
2058	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	5,131
2059	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	4,751
2060	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	4,399
2061	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	4,073
2062	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	3,771
2063	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	3,492
2064	620	1,485	-	2,105	400.00	50.00	50.00	153.10	55.21	14.93	6.46	4.44	72.05	151,647	3,233
2065-2114															33,134
														Total	6,485,970

ATTACHMENT M

Congaree River
Modeling Plan

By James D. Clark, RPF #2528

May 2, 2017

Growth and Yield Modeling:

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

Plot Data:

The modeling presented in this document is based 357 inventory plots installed in 2015 and 2016 across the Congaree River Project Area. This inventory design is described in the Inventory Specifications included as Attachment N to the OPDR.

Updating the Inventory:

The inventory methodology included as Attachment N to the OPDR provides a detailed description of the methods that will be used to maintain and update the Congaree River inventory. FORSEE will be used to project inventory data either forward or backward as needed so that inventory plot data can be adjusted to the appropriate date for reporting of carbon stocks in future OPDRs. The following procedures will apply to inventory updates using average diameter and height increment data derived from 5-year FORSEE projections:

1. Inventory data gathered less than 3 months from the end of the reporting period will not be adjusted to the reporting period date.
2. Inventory data gathered between 3 months and 6 months from the end of the reporting period will be adjusted for one-half year's growth to represent the reporting period date.
3. Inventory data gathered between 6 months and 12 months from the end of the reporting period will be adjusted for one year's growth to represent the reporting period date.

Alternatively, if the inventory data needs to be adjusted in whole year increments, the inventory update feature of FORSEE may be utilized.

Volume Calculations:

Conifer board foot volume calculations presented in Table 5a below utilize the standard FORSEE volume equations. Reported volumes are in board feet Scribner Scale for all conifers 8.5 inches DBH and larger. The FIA volume

and biomass equations described in the OPDR are used for the calculation of all carbon stock values presented below.

Biomass Calculations:

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

Adjusting the 2015-2016 Inventory Data to 10/21/2015:

As the plots were measured between October 2015 and March of 2016, the cruise data was adjusted backward to the Offset Project Commencement date of 10/21/2015 by adjusting the height and diameter of each tree in the inventory database based on the number of days from 10/21/2015 to the date the plot on which the tree is located was cruised and applying a calculated height and diameter increment developed from data produced by growing the plot data five years forward in FORSEE.

Projecting the 2015-2016 Inventory Data to 6/30/2016:

The inventory data used to estimate carbon stocking as of 6/30/2016 or the end of the first reporting period was constructed in a manner similar to the adjustment to the start date described above; however, the height and diameter of each tree was increased or decreased based on the number of days since the plot was cruised and the end of the reporting period.

Calibration:

The FORSEE model allows the assignment of 'calibration' factors to each species for height, DBH, and crown growth and mortality. The harvest regimes described in Table 3b below do not use calibration.

Missing Volume:

The inventory data upon which the baseline growth and yield analysis is based gathered data on missing volume from trees with broken tops, or from trees that included defects that reduced the tree's net carbon value. FORSEE outputs all growth and yield results in terms of gross volume or biomass. The carbon stock values presented in the OPDR as of the project commencement

date, and the end of the initial reporting period are net of the missing volume recorded in the inventory data. In order to represent this missing volume in the baseline analysis, the average percentage of missing standing live carbon stocks as of the Project start date are used to reduce the baseline growth and yield output from FORSEE.

Ingrowth:

Ingrowth in FORSEE is handled through the sprouting of species such as tanoak, madrone, black oak and white oak, and the addition of regeneration to bring the stand up to a minimum Forest Practice point count. The sprouting function in FORSEE (FSE.fsprout) was set to sprout 20% of sprouting species, as well as bringing the point count up to the minimum point count defined by the Forest Practice Rules (150 points per acre for sites IV and V and 300 points per acre for site III). This is done by calculating the minimum TPA needed to reach the minimum point count and applying the FORSEE TPA regeneration function (FSE.fRegen_PtCount). Redwood was not included in sprouting species because the FORSEE point count regeneration function was used to moderate ingrowth.

Tables 1 and 2 below represent the regeneration tree list, and sprout tree list used by FORSEE as a part of the regeneration functions.

Table 1: Regeneration Tree List

SpeciesID	SpNum	DBH	TotalHT	CRatio	RegenYears	Relative Weight
DF	3	1	7	80	5	49
RW	22	1	5	77	5	50
GF	6	1	5	65	5	1

Table 2: Sprout Tree List

SpeciesID	SpNum	DBH	TotalHT	CRatio	RegenYears	Relative Weight
hILO	62	1	7	80	5	9
hMD	64	1	7	80	5	13
hOCH	65	1	7	80	5	3
hTO	69	1	7	80	5	75

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 the

Project Area. FORSEE calculates 50-year base age site index for all species on the project area based on estimated 50-year site index for Douglas-fir.

Average site index values by soil type were used to calculate an average site index for each stand type found on the Congaree River Project by calculating the weighted average site index based on the acres of each soil type in a given stand type. Average site index by soil type was used as a method of capturing the variability of site potential across each stand type. Douglas-fir 50-year site index for the project area is calculated from site index data provided by the Soil Survey of Mendocino County Western Part (United States Department of Agriculture, Soil Conservation Service, 2002) for Douglas-fir as described below:

Site index was estimated at the stand level using soil survey data and site index data for associated soil components. Soils were categorized by map unit symbol. For those with Douglas-fir site index data (DFSI) for major components, average DFSI was calculated by weighting major component site index data by their relative percentages within the map unit symbol. For soil map unit symbols with only DFSI data for minor components, relative percentages for weighting were not used. The average DFSI of each minor component within the map unit symbol was calculated. This minor component DFSI data was then averaged again to estimate average DFSI for each soil map unit symbol without major component DFSI data. Some soil map unit symbols on the property lacked both major component and minor component DFSI data. These soil map unit symbols were reassigned to others that had DFSI data based on similarities assessed using orthographic photos. Site indices for each map unit symbol in a stand were weighted by the relative acreage of that symbol's area within the stand to calculate average stand site index.

Individual site class assignments by plot were calculated using a method similar to the one described above. Plots were assigned a soil map unit symbol and its associated site class if they were within its bounds. These site class assignments were used in assigning silvicultural prescriptions only. Site indices used to grow plots forward or to apply regimes were consistent with the site indices at the stand level.

Site index estimates from soil data are reported as 100-year base age from McArdle and Meyer, Bulletin 201. These site indices were converted to the King 50-year base age values using table 1 from Research Note No 10 (Krumland and Wensel, 1979). The proportional difference between a stand's 100-year site index and the upper and lower bounds of its class according to Bulletin 201 was applied to the site index ranges of that class according to King to yield an estimate of each plot's 50-year base site index. The average

Douglas-fir 50-year base age site index for each stand type are shown in Table 3a below.

Table 3a: Average Douglas-fir 50-year base age Site Index by Stand

Stand Type	Site Index
C1	101.7
C2	99.7
C3	118.0
C4	143.3
H1	99.7
H2	113.1

Project Acreage:

The Congaree River Project is comprised of approximately 5,440 acres of timberland. The topographic map included in Attachment E of the Project Application shows the Project Area boundary. Attachment E also includes GIS data in the form of a geodatabase that includes the Project Area boundary.

Baseline Modeling:

The baseline modeling utilizes the above-described 10/21/2015 plot dataset, and an unevenaged management harvesting strategy employing selection, transition and rehabilitation of understocked stands. Portions of Congaree River timber stands are dominated by hardwoods species, or are in an understocked condition. The baseline modeling assumes an aggressive treatment of hardwood species in order to release existing conifer regeneration, and convert areas dominated by hardwoods to conifer occupation. This reduction is accomplished through rehabilitation and hardwood release treatments.

At the Project's initiation on 10/21/2015 there were no approved Timber Harvest Plans (THPs) on the Project Area.

Baseline Harvest Strategy:

The baseline harvest strategy relies on the application of a series of harvest regimes across the Project Area timber stands. The regimes are modeled at the plot level and the growth and yield data is converted to stand level data.

This group-selection harvest strategy results in the eventual harvest in small groups of those areas of the property located outside of Water and Lake Protection Zones (WLPZ) and no-harvest reserve areas within an 80-year period. Table 3b below describes the harvest regimes applied across the Congaree River timber stands. The final baseline growth and yield analysis is determined by applying a percentage of each regime to each timber stand type.

The silvicultural prescriptions incorporated into the regimes are designed to best accommodate local timber stand conditions, while complying with the Forest Practice Rules as well as all other legal requirements. To accomplish this, a harvest strategy has been developed that evaluates each plot's stocking status in square feet of basal area per acre and point count stocking. Tables 4a-4c below illustrate the silviculture decision matrix upon which the growth and yield modeling is based. Harvesting under selection-transition, utilizes a BDq harvest strategy.

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

Table 3b: Harvest Regime Descriptions

Regime	Harvest Scenario Description
R1	This regime applies the silvicultural parameters outlined in tables 4a through 4c below. Simulates group selection by assigning plots to be group-selected in a given decade.
R9	No-harvest prescription applied to within 1,000 feet of each NSO activity centers and to WLPZ core zones.
R3	WLPZ harvest prescription. Performs selection harvest every decade while retaining a minimum of 150 square feet of conifer and hardwood basal area per acre.
R2	NSO Foraging Habitat prescription. Performs selection harvest every decade while retaining a minimum of 82 square feet of conifer and hardwood basal area per acre and 40%-100% canopy.
R10	NSO Nesting/Roosting prescription. Performs selection harvest every decade while retaining a minimum of 150 square feet of conifer and hardwood basal area per acre, and 60% canopy.

General Harvest Constraints:

Harvest on the Congaree River Project is constrained by several factors. Firstly, the California Forest Practice Rules (FPR) create a minimum set of silvicultural standards below in 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. Congaree River is subject to the Z'berg- Nejedly Forest Practice Act of 1973 (FPA) and the corresponding Forest Practice Rules (FPR).

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

The pertinent rules include the following:

- 14 CCR 913.11(c): Maximum Sustained Production of High Quality Timber Products;
- 14 CCR 913.2: Minimum basal area retention standards for Unevenaged Regeneration Methods;
- 14 CCR 913.2 (a)(2)(B): Group selection harvest limitations;
- 14 CCR 913.2 (b)(6): Minimum post-harvest residual basal area retention standards for the Transition method;
- 14 CCR 913.4 (b): Standards for rehabilitation of Understocked Areas;
- 14 CCR 913.1 (c): Standards for Seed Tree Seed Step;
- 14 CCR 916.5: Procedure for Determining Watercourse and Lake Protection Zone (WLPZ) Widths and Protective Measures;
- 14 CCR 916.9: Details harvest limitations for Watercourse and Lake Protection Zones around Class 1, 2 and 3 streams;
- 14 CCR 919.9: Northern Spotted Owl
- 14 CCR 912.7(b): Resource Conservation Standards for Minimum Stocking

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

Constraints Analysis:

Characterization:

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

Baseline Legal Constraints:

Constraints that affect land-use specific to forest management activities have been incorporated into the carbon modeling. For this project, legal constraints

have the greatest effect on timber harvesting levels, as opposed to what is financially feasible or physically possible. These legal constraints dictate what types of silvicultural activities (treatment types) are allowed, and where (spatial) and when (temporal) they are allowed, that is, there are different legal constraints for different locations of the project area.). There are four general constraint types that determine what treatments are operable for any given area: 1) Timber Site; 2) NSO designated habitat; and 3) Water and Lake Protection Zones; and 4) Watercourse core zones. Each constraint, and how it is applied in the modeling, is described below by constraint class.

Northern Spotted Owl:

For NSO activity centers associated with the Congaree River Forest Project Area, harvest activity is restricted using the following parameters taken from guidance from the US Fish and Wildlife Service "Northern Spotted Owl Take Avoidance Analysis and Guidance For California Coast Forest District" ("Attachment A"), March 15, 2011.

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

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

1) Retain habitat to maximize attributes desirable for NSO.

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

    a) Retain 200 acres of Nesting/Roosting habitat within a 0.7 mile radius of the Activity Center consisting of:
        i) 100 acres of the 200 acres of Nesting /Roosting habitat retained should be contiguous, or contiguous as possible with the Activity Center.
        ii) An Additional 100 acres of Nesting/Roosting habitat within the 0.7 mile radius:
            1) If the second 100 acres of Nesting/Roosting habitat is also contiguous with the Activity Center, or within the same drainage, operations should retain a minimum of 66% of the pre-harvest basal area per acre of trees at least 11" DBH.
            2) If the remaining 100 acres of Nesting/Roosting habitat is not contiguous with the Activity Center, retain at least Nesting/Roosting habitat.

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

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

NSO Habitat Definitions:

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

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

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

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

Regimes R2, R9, and R10 have been designed to retain the required basal area and tree sizes as described in tables 4a-4c below for each respective NSO habitat type description. A buffer analysis around the NSO activity centers was conducted to ensure that the required acreage of each type of NSO habitat was retained in the required quantity.

In general, areas designated as WLPZ were adjacent to stands selected as R2 or R10. Within 1000 feet of each AC, no harvest was modeled and stratum acreage within this 1000' buffer distance are assigned to the R9 regime. Within a 0.7 mile radius of the AC, acreage was assigned to either the R2 or R10 regime while considering proximity to the NSO activity center. Areas classified as the R10 regime were selected from stands in proximity to the 1000' AC buffer in order to create a contiguous core zone for each NSO. Areas

classified as the R2c regime were selected from the remaining acreages of strata with the best available habitat, based on BA/acre, within the 0.7 mile AC buffer. Stands classified as WLPZ buffer within the 0.7 mile buffer were not included in the assignment of R2/R10 regimes, but were spatially considered in the selection of stands to be retained as either R2 or R10.

As a means of performing a conservative analysis of NSO habitat retention, 88% of stand acres assigned to the R10 regime within the 0.7 mile AC buffer are modeled as no harvest as a part of the final NSO harvest constraint analysis. This is felt to be conservative given the fact that some level of harvest is allowed within stands designated as NSO Nest/Roost habitat as long as sufficient acreage is retained.

These constraints are modeled by calculating the constrained acreage by timber stand, and the plot data is run with a 100-year no-harvest regime (Regime R9 in Table 3b above). The yield stream from this no-harvest regime 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 and II no Harvest Zone:

Utilizing the Congaree River GIS, areas located within Class I or II core zones, where harvesting is restricted, will be identified pursuant to 14 CCR916.9 as indicated in tables 3d through 3g from the Forest Practice Rules, shown below. Class II-L watercourse segments were identified as those Class II watercourse segments within 1000 feet of a Class I watercourse. All other Class II watercourse segments were identified as Class II-S. Class I and Class II-L segments were given a 30-foot core zone on either side of the watercourse, and Class II-S watercourse segments were given a 15-foot core zone on either side of the watercourse This analysis identified 138.13 acres within the core zone of Class I or Class II watercourses where harvesting is restricted outside of areas restricted for NSO harvest. In some instances, NSO no-harvest areas are coincident with watercourse core-zones (6.77 acres).

These constraints are modeled by calculating the acreage by timber stand, and applying a 100-year no-harvest regime (Regime R9 in Table 3b above). 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.

Harvesting WLPZ Areas:

Utilizing the Congaree River GIS the acreage associated with Class I and II WLPZs was determined. These WLPZ acres are harvested using selection silvicultural prescription R3. Harvest levels within the WLPZ are designed to meet FPR standards for shade canopy retention. FPR requirements for the retention of the largest trees, and restrictions on harvests within the channel zone are addressed by adhering to harvest methods allowed by zone and slope pursuant to 14 CCR 916.9 as indicated in tables 3d through 3g from the Forest Practice Rules, shown below.

An analysis of the potential distribution of WLPZ areas by slope class was performed. Based on this analysis, it was determined that the greatest horizontal distance for a Class II-S WLPZ would be approximately 85 feet, approximately 100 feet for a Class II-L WLPZ, and approximately 100 feet for a Class I WLPZ. Given a reasonable distribution of slope classes within any one of the watercourse class designations, the average WLPZ buffer distance would be less than the calculated maximum. The baseline modeling has been revised to include an 85 foot WLPZ buffer on Class II-S watercourses, and a 100-foot buffer on Class II-L and Class I watercourses. These buffer distances are felt to meet the definition of "Conservative" per Section 95802 of the Regulation in that these modeled buffer distances meet the largest potential buffer that would need to be applied per the Forest Practice Rules. Across the Congaree River Project Area, this buffer analysis resulted in 617.67 acres located within Class I or IIWLPZs. WLPZ areas represent 11.4% of the total timbered acreage

As with Class I and II core zones, in some instances, NSO no-harvest areas are coincident with WLPZ zones.

Table 3c: Acres by Regime following NSO, Core Zone. WLPZ Buffer Analysis, and MBL Adjustment

Stand	Acres	R10	R9	R3	R2	Constrained Acres
C1	738.84	0.00	170.98	24.98	229.37	425.33
C2	3,154.29	0.00	314.33	156.02	246.52	716.88
C3	374.18	0.00	42.08	4.53	38.82	85.42
C4	20.03	0.00	0.00	0.00	0.00	0.00
H1	1,110.71	0.00	102.63	94.47	16.88	213.98
H2	42.09	0.00	18.80	0.00	0.00	18.80
Total	**5,440.15**	**0.00**	**648.83**	**280.00**	**531.59**	**1,460.42**

Table 3d: Procedure for Determining WLPZ Widths and Protective Measures Class I WLPZs - Confined Channels - Coastal Anadromy Zone						
Pursuant to 14 CCR 916.9 (f)(2)						
Zone Designation	**Zone width (ft.)**	**Overstory Canopy Cover**		**Large Tree Retention**	**Silviculture Requirements**	**Operational Requirements**
Channel Zone	Variable	Retain all trees except per 916.9 [936.9, 956.9](e)(1) A-F or 916.9 [936.9 956.9] (v)		Retain all trees except per 916.9 [936.9, 956.9](e) (1) A-F or 916.9 [936.9 956.9] (v)	Retain all trees except per 916.9 [936.9, 956.9] (e) (1) A-F or 916.9 [936.9, 956.9](v)	No timber operations except per 916.9 [936.9, 956.9] (e) (1)A-F or 916.9 [936.9, 956.9](v);
Core Zone per 916.9 [936.9 956.9] (f)(2)(A)	30 ft.	Retain all trees except per 916.9 [936.9, 956.9](e) (1)A-F or 916.9 [936.9 956.9] (v)		Retain all trees except per 916.9 [936.9, 956.9](e)(1) A-F or 916.9 [936.9 956.9] (v)	Retain all trees except per 916.9 [936.9, 956.9] (e) (1) A-F or 916.9 [936.9, 956.9](v); no sanitation salvage except 916.9 (s)(t)and (u).	No timber operations except per 916.9 [936.9, 956.9] (e) (1) A-For 916.9 [936.9, 956.9](v);
Inner Zone per 916.9 [936.9 956.9] (f)(2)(B)	70 ft.	80% Coast and Southern Forest District of Coastal Anadromy Zone per 916.9 [936.9 956.9] (f)(2)(B)3.	70% in Northern Forest District of Coastal Anadromy Zone per 916.9 [936.9 956.9] (f)(2)(B)3.	13 largest trees /ac. per 916.9 [936.9 956.9] (f)(2)(B)4.	Increase QMD; No sanitation salvage except 916.9 (s)(t)and (u); commercial thinning or single tree selection only.	Preferred Management Practices in 916.9[936.9, 956.9] (f)(2)(D)
Outer Zone per 916.9 [936.9 956.9] (f)(2)(C) Outer Zone applicable only where even-aged regeneration used adjacent to the WLPZ	50 ft.	50% per 916.9 [936.9 956.9] (f)(2)(C).1.		NA	Commercial thinning or single tree selection only; Retain wind firm trees.	Preferred Management Practices in 916.9[936.9, 956.9] (f)(2)(D)
Special Operating Zone per 916.9 [936.9 956.9] (f)(2)(E)	50 ft.	NA		NA	SOZ applicable only where even-aged regeneration used adjacent to the WLPZ **.** Retain understory and midstory trees per 916.9 [936.9, 956.9] (f)(2)(E)	All other Forest Practice Rules

Table 3e: Procedure for Determining WLPZ Widths and Protective Measures Class I WLPZs – with flood prone areas or channel migration zones						
Pursuant to 14 CCR 916.9 (f)(3)						
Zone Designation	**Zone width (ft.)**	**Overstory Canopy Cover**		**Large Tree Retention**	**Silviculture Requirements**	**Operational Requirements**
Channel Zone or Channel Migration Zone per 916.9 [936.9 956.9] (f)(3)(A)	Variable	Retain all trees except per 916.9 [936.9, 956.9](e) (1)A-F or 916.9 [936.9 956.9] (v)		Retain all trees except per 916.9 [936.9, 956.9](e) (1)A-F or 916.9 [936.9 956.9] (v)	Retain all trees except per 916.9 [936.9, 956.9] (e) (1) A-F or 916.9 [936.9, 956.9](v)	No timber operations except per 916.9 [936.9, 956.9] (e)(1) A-For 916.9 [936.9, 956.9](v);
Core Zone per 916.9 [936.9 956.9] (f)(3)(B)	30 ft.	Retain all trees except per 916.9 [936.9, 956.9](e) (1)A-F or 916.9 [936.9 956.9] (v)		Retain all trees except per 916.9 [936.9, 956.9](e) (1)A-F or 916.9 [936.9 956.9] (v)	Retain all trees except per 916.9 [936.9, 956.9] (e) (1) A-F or 916.9 [936.9, 956.9](v); no sanitation salvage except 916.9 (s)(t)and (u).	No timber operations except per 916.9 [936.9, 956.9] (e) (1)A-For 916.9 [936.9, 956.9](v);
Inner Zone A per 916.9 [936.9 956.9] (f)(3)(C)	Minimum 70 ft. Maximum 120 ft.	80% Coast and Southern Forest District of Coastal Anadromy Zone per 916.9 [936.9 956.9] (f)(3)(C)3.	70% in all other watersheds per 916.9 [936.9 956.9] (f)(3)(C)3.	13 largest trees /ac. per 916.9 [936.9 956.9] (f)(3)(C)4.	Increase QMD; No sanitation salvage except 916.9 (s)(t)and (u); commercial thinning or single tree selection only.	Preferred Management Practices in 916.9 [936.9, 956.9] (f)(3)(E)
Inner Zone B per 916.9 [936.9 956.9] (f)(3)(D)	Variable: distance from Inner Zone A to end of FPA.	50%		13 largest trees /ac. per 916.9 [936.9 956.9] (f)(3)(D)1.	Increase QMD; No sanitation salvage except 916.9 (s)(t)and (u); commercial thinning or single tree selection only.	Preferred Management Practices in 916.9[936.9, 956.9] (f)(3)(E)
Outer Zone per 916.9 [936.9 956.9] (f)(3)(F) Applicable only where even-aged regeneration used adjacent to the WLPZ	50 ft.	50%		NA	Commercial thinning or single tree selection only; Retain wind firm trees.	Preferred Management Practices in 916.9[936.9, 956.9] (f)(3)(E)

Table 3f. Core and Inner Zone widths.				
Water Class	**Class II-S (feet)**		**Class II-L (feet)**	
Geographic location	**Watersheds in the coastal anadromy zone**		**Watersheds in the coastal anadromy zone**	
Slope class	Core Zone (feet)	Inner Zone (feet)	Core Zone (feet)	Inner Zone (feet)
≤30%	15	35	30	70
30-50%	15	60	30	70
>50%	15	85	30	70

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

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

Unevenaged Silviculture:

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

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

Selection:

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

Unevenaged management is utilized to establish and maintain an unevenaged stand structure. Unevenaged management attributes include the establishment and/or maintenance of a multi-aged, balanced stand structure, promotion of growth on leave trees throughout a broad range of diameter classes, and encouragement of natural reproduction.

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

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

2) Post harvest stand stocking levels shall be stated in the THP. The level of residual stocking shall be consistent with maximum sustained production of high

quality timber products. In no case shall stocking be reduced below the following standards:

A. Selection System.

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

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

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

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

B. Group Selection.

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

2. Not more than 20% of the stocked plots may meet stocking standards utilizing the 300 point count standard with trees that are at least 10 (ten) years old.

3. An RPF or supervised designee may offset up to 8 plots per 40 plots where those plot centers are initially placed within small group clearings created during the current harvest. Unless substantially damaged by fire, the RPF or supervised designee shall not exclude small group clearings created by previous timber harvesting from the stocking survey.

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

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

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

Transition:

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

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

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

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

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

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

5) Immediately following the completion of timber operations, the minimum basal area standards in 14 CCR 912.7(b)(2) shall be met.

6) The post harvested residual stand shall contain at least 15 square feet of basal area per acre of seed

trees at least 12 inches dbh or greater for timber sites I, II or III; or 12 square feet of basal area per acre of seed trees 12 inches dbh or greater for timber sites IV or V. Unless obviously stocked, these basal area requirements will be determined from sampling averaged across each harvested area required in 14 CCR § 913.2(b)(1). Unless the plan submitter demonstrates how the proposed harvest will achieve MSP pursuant to 14 CCR § 913.11(a) or (b) [953.11(a) or (b)], where present in the preharvest stand, disease free, undamaged seed trees 18 inches dbh or greater shall be retained post harvest until the stand exceeds the minimum seed tree requirements of 14 CCR § 913.1(c)(1)(A). The seed trees shall be full crown, capable of seed production and representative of the best phenotypes available in the present stand.

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

14 CCR 912.7: Resource Conservation Standards for Minimum Stocking:

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

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

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

Commercial Thinning:

14 CCR 913.3: Intermediate Treatments:

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

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

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

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

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

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

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

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

Rehabilitation of Understocked Areas:

14 CCR 913.3: Special Prescriptions:

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

b) **Rehabilitation of Understocked Area Prescription**. For the purposes of restoring and enhancing the productivity of commercial timberlands which do not meet the stocking standards defined in 14 CCR 912.7 prior to any timber operations on such lands, an area may be harvested provided it

is restocked in accordance with Subsections (l) or (2). To facilitate restocking, a regeneration plan must be included in the THP. The regeneration plan shall include site preparation, method of regeneration, and other information appropriate to evaluate the plan.

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

2) On understocked timberlands where no countable conifer trees are to be harvested and the broadleaf species are not designated for management, the area shall be planted to equal or exceed the stocking standards of 14 CCR 912.7(b)(1) [932.7(b)(1), 952.7(b)(1)] and shall be considered acceptably stocked if within five years of completion of timber operations it contains at least an average point count of 150 of Group A species on all site classifications.

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

MSP:

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

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

other public trust resources through the application of these rules.

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

This overall constraint is emulated in the baseline by requiring that selection and transition harvest retain at least 15 square feet of conifer basal area in trees 18" DBH or larger for site class III areas, and 12 square feet of conifer basal area in trees 18" DBH or larger and that rehabilitation and commercial thinning harvests meet the minimum stocking standards of the Forest Practice Rules.

Hardwood Harvest:

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

Baseline Harvest Summary:

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

Non-Commercial Treatments:

Portions of the Congaree River'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. For 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, Congaree River

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.

The arrangement of these treatments over time and space create timber product value in both yields and appreciation and provide NSO habitat that is in line with the baseline scenario characterization and legal constraints. By the end of the baseline model, 292.67 acres remain un-treated as a result of being protected NSO habitat or restricted WLPZ areas. The application of the silvicultural regimes described below at the landscape level, yield an acceptable return on investment for the forest owner while maintaining compliance with the California Forest Practice Rules and NSO Take Avoidance protection measures. Overall, the baseline regime reflects maximum sustained productivity and a harvest and growth pattern that indefinitely serves multiple management objectives.

Standing Dead

The standing dead carbon pool represents approximately 1.6% of the total carbon found on the Project Area; however, standing dead levels are below the one metric ton test in the structural elements evaluation criteria under section 3.8.2 (Table 3.2) of the protocol. The standing dead carbon pool is treated as a static pool as a part of the baseline analysis. The level of the standing dead carbon pool on the Congaree River meets the minimum standards for Standing Dead per the Natural Forest Management requirements of the protocol; furthermore, as the baseline analysis involves ongoing forest management and maintenance of young and vigorous stands, standing dead levels are expected to be maintained at the current levels. It could be argued that the baseline harvesting scenario would remove poorly formed and suppressed trees, thus capturing mortality that would have otherwise occurred under a harvest scenario that removed fewer trees and less volume over time.

Silvicultural Prescriptions

The following tables show the silvicultural constraints designed to demonstrate conformance with the requirements of the Forest Practice Rules. Table 4b contains the parameters used to assign first period (decade) silviculture. Harvests in following decades is guided by the minimum retention values shown in table 4c.

Table 4a: Silvicultural Prescriptions used by the Congaree River Project

Regime	Prescription	Description
R1	Selection	The goal of this prescription is to create and maintain, multistoried, uneven-aged stands with varied diameter classes. Trees are harvested individually, or in small groups up to 2.5 acres in size.
	Transition	The goal of this prescription is to develop uneven-aged stands from stands that have an even-aged or irregular stand structure. Trees are harvested individually, or in small groups up to 2.5 acres in size.
	Rehabilitation	The goal of this prescription is to regenerate stands that are primarily experiencing excessive hardwood competition, and that also do not meet minimum stocking standards. Successive harvests will utilize uneven-aged silviculture.
	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.
	Commercial Thinning	To promote timber growth and improve forest health through the harvest of trees in a manner that results in a stand capable of being managed using single tree or group selection.
R9	No Harvest	This prescription is used to account for those portions of the Project Area where harvesting is prohibited.
R3	Single Tree Selection (WLPZ)	The goal of this prescription is to create and maintain dense, multistoried, uneven-aged stands with varied diameter classes.
R10	Single Tree Selection (NSO Nest Roost Habitat)	The goal of this prescription is to create and maintain dense, multistoried, uneven-aged stands with varied diameter classes while meeting the retention standards for NSO Nesting/Roosting Habitat.
R2	Single Tree Selection (NSO Foraging Habitat)	The goal of this prescription is to create and maintain dense, multistoried, uneven-aged stands with varied diameter classes while meeting the retention standards for NSO Foraging Habitat.

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

Regime	Prescription	Pre-Harvest Conifer Basal Area (Square Feet per Acre)		Other Pre-Harvest Considerations
		Lower Limit	Upper Limit	
R1	Selection Site Class II and III	125	None	Retain at least 15 square feet of basal area in trees 18" or larger.
	Selection Site Class IV	70	None	Retain at least 12 square feet of basal area in trees 18" or larger.
	Transition Site Class II and III	70	125	Retain at least 15 square feet of basal area in trees 18" or larger.
	Rehabilitation Site Class II and III	0	50	Less than 300 point count, at least 35 square feet of hardwood basal area.
	Rehabilitation Site Class IV	0	50	Less than 150 point count, at least 35 square feet of hardwood basal area.
	Hardwood Release Site Class II and III	0	70	Stocked per FPR, and at least 35 square feet of hardwood basal area.
	Hardwood Release Site Class IV	0	70	Stocked per FPR, and at least 35 square feet of hardwood basal area.
	Commercial Thinning Site Class II and III	100	None	At least 300 point count.
R9	No Harvest	None	None	
R3	Single Tree Selection (WLPZ)	None	None	Retain at least 12 or 15 square feet of basal area in conifer trees 18" or larger.
R10	Single Tree Selection (NSO Nest Roost Habitat)	None	None	At least 130 square feet of basal area in trees 11" or larger. Retain at least 12 or 15 square feet of basal area in conifer trees 18" or larger.
R2	Single Tree Selection (NSO Foraging Habitat)	None	None	At least 75 square feet of basal area in trees 11" or larger. Retain at least 12 or 15 square feet of basal area in conifer trees 18" or larger.

Table 4c: Post-harvest Stocking by Silvicultural Prescription

Regime	Prescription	Stocking Considerations	Conifer Basal Area Retention (sq. ft. per acre)	Hardwood Basal Area Retention (sq. ft. per acre)	Regeneration Assumptions	Time to Next Treatment
R1	Selection Site Class II and III	Less than 20% of stand in group openings, at least 15 sq. ft. >18" DBH	≥75	32	300 Point Count, Sprout 20%	At Least 10 Years
	Selection Site Class IV	Less than 20% of stand in group openings, at least 12 sq. ft. >18" DBH	≥50	32	150 Point Count, Sprout 20%	At Least 10 Years
	Transition Site Class II and III	Less than 20% of stand in group openings, at least 15 sq. ft. >18" DBH	≥50	32	300 Point Count, Sprout 20%	Selection within 10-20 Years
	Rehabilitation Site Class II and III		≥10 where conifer≥10 pre-harvest	32	300 Point Count, Sprout 20%	Selection within 30-40 Years
	Rehabilitation Site Class IV		≥10 where conifer≥10 pre-harvest	32	150 Point Count, Sprout 20%	Selection within 30-40 Years
	Hardwood Release Site Class II and III	No Commercial Conifer Harvest	No Commercial Conifer Harvest	32	None	Selection within 20-40 Years
	Hardwood Release Site Class IV	No Commercial Conifer Harvest	No Commercial Conifer Harvest	32	None	Selection within 10-20 Years
	Commercial Thinning Site Class II and III	≥ average stand diameter than pre-harvest stand	>100 if QMD >14" and 100 4"+ trees if QMD <14"	32	300 Point Count, Sprout 20%	Selection within 10-20 Years
R9	No Harvest	None	None		None	
R3	Single Tree Selection (WLPZ)	Retain at least 130 square feet of basal area in trees 11" or larger.	130	32	150 – 300 Point Count, Sprout 20% Hardwoods	At Least 10 Years
R10	Single Tree Selection (WLPZ/NSO Nest Roost Habitat)	Retain at least 130 square feet of basal area in trees 11" or larger.	130	32	150 – 300 Point Count, Sprout 20% Hardwoods	At Least 10 Years
R2	Single Tree Selection (NSO Foraging Habitat)	Retain at least 75 square feet of basal area in trees 11" or larger.	75	32	150 – 300 Point Count, Sprout 20% Hardwoods	At Least 10 Years

Growth and Yield Analysis:

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

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

Elapsed Time (years)	Beginning Inventory (board feet)	Average Decadal Growth (board feet)	Average Decadal Harvest (board feet)	Ending Inventory (board feet)
10	15,671	567	986	11,484
20	11,484	570	329	13,895
30	13,895	630	331	16,889
40	16,889	660	379	19,703
50	19,703	656	387	22,390
60	22,390	640	386	24,933
70	24,933	628	322	28,000
80	28,000	628	318	31,103
90	31,103	628	321	34,179
100	34,179	622	427	36,135

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

Elapsed Time (year)	Beginning Inventory (Mg	Average Decadal Growth (Mg	Average Decadal Harvest (Mg Carbon)	Ending Inventory (Mg Carbon)
10	63.32	1.81	3.61	45.32
20	53.32	1.66	1.63	53.58
30	53.29	1.49	0.94	58.85
40	58.64	1.42	1.15	61.41
50	60.88	1.33	0.96	64.53
60	64.07	1.25	0.91	67.39
70	66.99	1.18	0.77	71.14
80	70.89	1.14	0.73	74.99
90	74.81	1.11	0.71	78.79
100	78.65	1.08	0.86	80.83

Table 5c: Average Annual per Acre Total Live Carbon Growth and Yield through the Planning Horizon (Total MgC)

Elapsed Time (year)	Beginning Inventory (Mg	Average Decadal Growth (Mg	Average Decadal Harvest (Mg Carbon)	Ending Inventory (Mg Carbon)
10	344,447	9,840	19,631	246,540
20	290,074	9,036	8,894	291,496
30	289,930	8,110	5,089	320,142
40	319,005	7,744	6,237	334,070
50	331,173	7,238	5,249	351,065
60	348,575	6,774	4,968	366,631
70	364,427	6,428	4,172	386,996
80	385,665	6,202	3,975	407,935
90	406,959	6,030	3,864	428,619
100	427,884	5,863	4,679	439,724

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	134	95	100	108	111	114	117	123	130	137	140
Hardwood	81	53	43	46	42	43	43	43	43	43	42
Total	215	148	143	154	154	157	160	166	172	179	182

Table 7 presents the percentage of each silvicultural regime applied to the various timber stratum for the entire baseline modeling analysis. No plots were treated as group selection.

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

	Regime					
Stand	R1	R2	R3	R9	R10	Total
C1	42.4%	31.0%	3.4%	23.1%	0.0%	100.0%
C2	77.3%	7.8%	4.9%	10.0%	0.0%	100.0%
C3	77.2%	10.4%	1.2%	11.2%	0.0%	100.0%
C4	100.0%	0.0%	0.0%	0.0%	0.0%	100.0%
H1	80.7%	1.5%	8.5%	9.2%	0.0%	100.0%
H2	55.3%	0.0%	0.0%	44.7%	0.0%	100.0%

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 Compliance Offset Protocol U.S. Forest Projects, November 14, 2014.

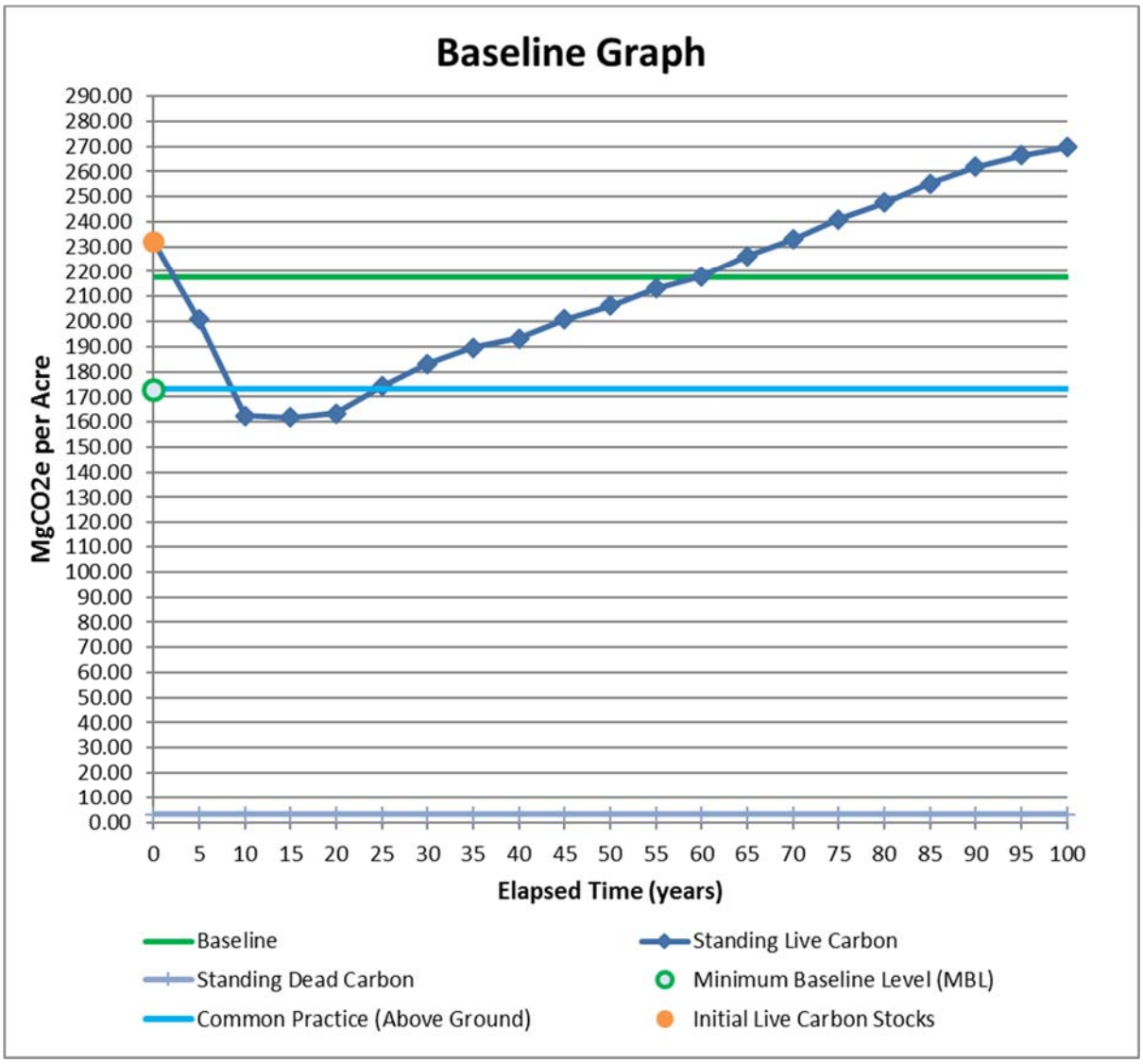
Key components of the calculated baseline are as follows:

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

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

Elapsed Time	Standing Live Carbon Pool IFM-1	Standing Live Above Ground	Standing Live Below Ground	Standing Dead Carbon Pool IFM-3	Baseline
0	231.99	187.20	44.79	3.19	217.50
5	200.78	161.70	39.08	3.19	217.50
10	162.39	130.04	32.35	3.19	217.50
15	161.78	129.67	32.11	3.19	217.50
20	163.33	130.82	32.51	3.19	217.50
25	174.21	139.78	34.43	3.19	217.50
30	183.23	147.20	36.04	3.19	217.50
35	189.58	152.50	37.09	3.19	217.50
40	193.15	155.47	37.69	3.19	217.50
45	200.85	161.86	39.00	3.19	217.50
50	206.26	166.34	39.92	3.19	217.50
55	213.24	172.15	41.09	3.19	217.50
60	218.15	176.24	41.91	3.19	217.50
65	226.31	183.01	43.30	3.19	217.50
70	233.01	188.57	44.44	3.19	217.50
75	240.94	195.15	45.79	3.19	217.50
80	247.68	200.74	46.94	3.19	217.50
85	255.33	207.10	48.23	3.19	217.50
90	261.95	212.59	49.36	3.19	217.50
95	266.43	216.36	50.07	3.19	217.50
100	269.75	219.15	50.60	3.19	217.50
Average	214.30	173.03	41.27	3.19	217.50

Figure 1: Baseline Carbon Stocks



Wood Products

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

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

Woods Products	Mg C/ acre	Total Mg CO2e
Average Annual Carbon 100-year In-Use	0.124	2,473.96
Average Annual Carbon 100-year Landfill	0.080	1,598.34
Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill	0.769	15,337.98

ATTACHMENT N

CONGAREE RIVER CARBON PROJECT INVENTORY METHODOLGY

This document contains specifications for the collection of data in the field for the Congaree River Inventory, as well as the data to be collected and the standards for data collection and processing. The Congaree River Project includes approximately 5,440 acres of timberland characterized by Coastal Redwood, Douglas-fir, Tanoak, Pacific Madrone, true oak, and associated conifer and hardwood species. The Project Boundary includes the following GHG emission sources, GHG sinks, and GHG reservoirs (SSRs or Carbon Pools) as defined in table 5.1 of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014:

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

This Forest Carbon Inventory at its core consists of a systematic sampling of the timber stands found on the Congaree River Project. Sampling will be conducted utilizing a random selection of plots located across timber stratum. Plot locations will be determined from a random selection of plots from a 5 chain by 5 chain grid that uniformly covers the entire Project Area. The final inventory design is expected to result in the installation of 357 plots across the Project Area.

The standard procedures for collecting field measurements are detailed below and are generally aimed at the collection of tree data pertaining to the quantification of the IFM-1 and IFM-3 carbon pools. Carbon in carbon pools IFM7, IFM-8, IFM-14, and IFM-17 are calculated as described in the calculation methodologies section below.

Inventory Methodologies

A description of the inventory methodology for each of the carbon pools listed above is included in the Initial OPDR under section VII (A) and is included herein by reference. The data collection procedures for IFM-1 and IFM-3 SSRs are described in detail in the attached Congaree River Carbon Project Inventory Specification included as Appendix B.

Calculation Methodologies

A description of the calculation methodologies used to determine metric tons per acre of each of the carbon pools listed above is included in the Initial OPDR under section VII (B) and is included herein by reference. Included are the analytic methods and biomass equation references used to translate field measurements into volume and biomass carbon estimates.

Data Management Systems and Data Processing

The inventory data gathered by this inventory methodology is entered into an Access database as described in the attached Congaree River Inventory Plot Data Entry Procedures (Appendix C). Plot data within the database was extensively sorted and queried to look for data entry errors. This process result in a final data set for cruise processing. The Access database serves as the repository for inventory data and is accessed by the growth and yield model during growth and yield simulations.

The inventory database is utilized to process the inventory data through the growth and yield model FORSEE. The calculation of volume, biomass and the ultimate conversion to carbon utilizes the inventory data and growth and yield output data and applies the volume formulas and biomass conversion factors described in section VII (B) of the Initial OPDR as referenced above.

Management of inventory data over the life of the Project will include archiving of retired inventory data as the data exceeds the maximum plot life requirements prescribed by the Protocol. Archived inventory data will also include a copy of each inventory database used to develop those carbon stock estimates reported in each OPDR submitted for the Project. This series of archived inventory database files will serve as the repository of inventory data as it existed for each reporting period.

Stratification Methodology

The Congaree River Project Area was stratified based on species composition and relative stocking. The Project Area is dominated by Coastal redwood and Douglas-fir with varying levels of hardwood species, and other conifer species. Stratification was performed pre-sampling utilizing aerial photos with GIS system polygon overlays. Vegetation strata were verified utilizing historic and current field verification. Boundaries were established utilizing GIS overlays with sample stratification based on plot location within identified vegetation strata polygons. The strata boundaries were digitized into the Congaree River Geographical Information System utilizing orthophoto imagery as a guide. A map of the timber stand boundaries and inventory plot locations is included as Appendix D.

The stratification resulted in the following project acreages:

Table 1: Strata and Plot Summary

Stratum	Plots	Acres
C1	49	738.84
C2	201	3154.29
C3	25	374.18
C4	5	20.03
H1	72	1110.71
H2	5	42.09
Total	**357**	**5440.15**

Quality Assurance/Quality Control (QA/QC)

Procedures for ensuring quality control are explained in the attached Congaree River Carbon Project Inventory Specifications document under the "Check Cruising" heading. Procedures in verifying the integrity of inventory data are described above.

Inventory Monitoring

Updating the Inventory

As timber management activities take place on the Congaree River Project Area or disturbance such as fire or mortality resulting from pathogens or other factors occurs, cruise plots installed in 2015 will be relocated and remeasured within areas that have been harvested, treated for hardwood reduction, or subject to disturbance. By 2027, all of the plots installed in 2015 will have been remeasured regardless of whether or not the plot had been harvested, treated for hardwood reduction, or subject to disturbance. On this basis, Congaree River will maintain a forest inventory system that will meet the inventory specifications and requirements contained in Appendix A of the Compliance Offset Protocol U.S. Forest Projects, with plots which are no more than 12 years old.

Updating the Project's carbon stocks from the end of the last reporting period to the end of the current reporting period will involve the following steps:

1. Any newly installed inventory plots will be incorporated into the inventory estimate. Newly installed plots will be grown forward to the end of the reporting period utilizing FORSEE as described in the modeling plan.
2. Existing inventory plots that are less than 12 years old will be updated using FORSEE as described in the modeling plan. This update process will involve adjusting the plot data one year forward either by using FORSEE's "Inventory Update" tool, or through the application of average annual increment based on diameter and height increment predicted by FORSEE over the next-five year period.
3. Plots older than 12-years will be replaced in the database by new plot data collected at the same plot location. Retired plot data will be archived as described in the Data Management Systems section above.
4. Updating the forest inventory for harvests or disturbances will involve either the installation of new plots, or adjustments to previous plot data.
    a. If new inventory plots are installed, they will be installed at randomly selected plot locations taken from the 5x5 chain grid within the harvested or disturbed portion of the Project Area. The number of randomly selected plots will be determined based on the size of the area harvested or disturbed, and estimated carbon stock variability within the harvested or disturbed area.
        i. Existing inventory plot data within the harvested or disturbed area will be removed from the inventory database.
        ii. Harvested or disturbed areas will be stratified based on the current inventory stratification, or may be placed into a new stratum representing the harvested or disturbed area.

b. At the discretion of the OPO, inventory updates may involve adjustments to existing plot data (depletions) that will involve the following steps:
    i. The carbon in harvested wood products delivered to the mill will be calculated using the "Harvested Wood Products Worksheet" provided by CAR, and included as Appendix E herein.
    ii. Using the ratio of harvested wood carbon to harvested tree carbon calculated in Table 8 of the CAR worksheet. The carbon in harvested wood products will be multiplied by this ratio to determine the total amount of carbon subject to harvest. This carbon will be subtracted from the carbon stock estimate derived through the inventory stock estimate generated by updating the existing inventory data as described above.

5. Disturbances related to fire, insect or disease, and unauthorized harvest will be monitored through annual inspections of the Project Area by the OPO. Portions of the Project Area affected by fire, insect or disease, or unauthorized harvest will be mapped and reported in the OPDR. If the mapped disturbed portion of the Project Area is less than 5 acres in cumulative size, no adjustment to the carbon stock inventory will be performed. For mapped disturbances between 5 and 40 acres of cumulative size, a depletion of the inventory based on the average stocking and acreage of each stratum disturbed will be calculated, or at the discretion of the OPO, new inventory plots may be installed following the procedures described in step 4(a) above. For mapped disturbances larger than 40 acres in cumulative size, new inventory plots will be installed following the procedures described in step 4(a) above.
6. The field collection of updated inventory data following harvest, hardwood reduction or disturbance will be conducted prior to the next field verification, and at a minimum within 36 months of the harvest or disturbance.
7. A revised inventory confidence deduction will be calculated each year following the update process.

Identification of Known or Potential Diseases:

Known or potential diseases that may affect the health of the project's inventory, specifically above-ground standing live and dead trees are listed below:

In Douglas-fir the most prevalent disease is Phellinus pini, known as white pocket rot, white speck or red ring rot. This is the most damaging wood rot in the western states. The presence of fruiting bodies or "conks" is the best indicator of infection. The size and frequency of the conks present may provide an indication of the amount of decay, but caution must be exercised until local conditions can be assessed. Infections associated with white speck become established through living and dead branches or branch stubs. The best way to reduce risk of white speck infection is to avoid damaging trees within the stand. This disease does not usually result in the imminent death of the infected tree.

Fomes annosus root rot can attack Douglas-fir present on the project. The sapwood and inner bark of small to medium sized roots and the heartwood of larger roots is infested when the fungus attacks. Frequently, the infection spreads through the roots and into the lower trunk of the host, causing butt rot of the heartwood. Heartwood and root rots often predispose fir trees to

wind throw and/or fatal insect attack. Within 2 to 6 years, the disease moves to the tree's root crown and girdles it, thereby killing the tree. The Fomes fungus subsequently acts as a wood decay organism and may remain viable in surrounding soil for as long as fifty years. The disease is spread by spores that colonize freshly cut stumps, growing into the root system and spreading to surrounding areas via root contacts with adjacent trees. Fomes annosus has not been observed during fieldwork on the property. Group killing of trees, with the oldest deaths at the center and more recently dead trees on the periphery, is a common symptom of infection within pine stands. The presence of fruiting bodies on infected trees is the best evidence of disease. These vary in size, but are usually found around the base of the tree just below the duff, or within the hollow of infected stumps. Examination of roots or root crowns can also indicate the presence of the disease.

Another disease present in the Douglas fir is Leptographium wageneri var. pseudotsugae, black stain root disease. Black stain is recognizable by weakening symptoms in the trees such as declining vigor, reduced needle retention, and dull gray/green foliage discoloration. Black stain will occur in the sapwood of the roots, root crown and lower bole. The stain in cross section follows the annual rings in circular pattern and not radially as typical of other stains. Since black stain spreads by root graft (as well as by spores), the disease can be partially controlled by removing all the infected trees from the area of infection as well as adjacent trees not yet displaying symptoms.

Sudden Oak Dealth (SOD) is a plant disease caused by the pathogen Phytophthora ramorum. This disease may be transported to new areas when infected plants, infested soil, or contaminated water are moved. Although not detected on the property to date, the Project Area is within the SOD zone of infestation. Tanoak would be the primary species affected by this pathogen but a variety of other species, both hardwood and conifer, can be infected. Information about ongoing research and up to date regulations are available at www.suddenoakdeath.org, a site operated by the California Oak Mortality Taskforce.

Appendices:

A. Inventory Change Log
B. Congaree River Carbon Project Inventory Specification
C. Congaree River Inventory Plot Data Entry Procedures
D. Plot and Strata Map
E. CAR Harvested Wood Products Worksheet

Appendix A

Inventory Change Log

Date of Change	Note (changes made)

Appendix B

Congaree River Carbon Project

Inventory Specification

Congaree River Carbon Project
Inventory Specification

October 15 2015

The cruise shall include the Congaree River property for a total of approximately 5,600 acres. The emphasis of the cruise is to develop timber stand and stock tables at the ownership level, calculate live carbon and standing dead carbon pools, and allow for growth and yield projections to be performed.

The cruise is based on a systematic sample of the ownership, and will include pre-cruising stratification. The cruise design will install approximately 350 plots that were randomly selected from a systematic 5 chain by 5 chain grid that covers the entire project area.

Plot Documentation and Location: Cruisers will be supplied with maps that show the locations of the plots and plot numbers, air photo maps, and an electronic 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 systematic list of GPS coordinates as supplied by NCRM and if necessary, due to lack of adequate GPS satellite reception, take-off points established by NCRM, and field measurement (hip chain, or electronic device). Handheld GPS equipment will be used to establish plot centers. As needed, 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 closest and easiest access point to the plot in question using the handheld GPS units. As needed and 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 to a given plot with the handheld GPS unit, the cruiser will set a "proximity" alarm on the GPS unit. The first time that the GPS unit triggers the proximity alarm, the cruiser shall stop and note the best achievable distance and direction to the plot as indicated by the GPS unit. The cruiser shall then measure the distance to the plot center using a hand compass and steel tape, hip chain or electronic device.

Plots shall be measured where they fall regardless of roads, watercourses, or unmapped non-timbered areas. The cruise will be based on all acres within the timbered strata including roads and small non-timbered areas. Where plots are located adjacent to mapped non-timber areas or on boundaries between different timber types, cruise plot locations should be relocated in half-chain increments such that the plot is entirely within the timbered type. The plot center shall be moved in the cardinal direction most close to perpendicular to the type boundary. For such plots, a GPS coordinate of the actual plot center shall be recorded.

Plot centers will be documented with a rebar stake (provided by NCRM) and flagging (tied to the stake) with the plot number written in rain proof ink. Rebar must be driven down deep enough to leave 2-3 inches above ground. If the plot center falls on an access road, the rebar must be driven completely in so the tip is just below the road surface and a hole must be dug just around it for access. A second 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. Certain "aesthetic plots" will not be painted; trees on such plots will be identified with tree tags nailed at breast height (BH). Flagging to establish plot center shall be glow lime green and provided by NCRM.

At each plot center, two plot reference trees at least 3.5" in diameter will be established near the cardinal directions for the purpose of relocating the plot center. Theses reference trees shall be established after performing all other measurements on the plot; a reference tree tag shall be placed on each reference tree within 1' of the ground line on the face of the tree which is facing plot center. The plot number shall be scribed on each reference tree tag. Species, azimuth and slope distance (rounded down to nearest $1/10^{th}$ inch) from the nail hole on the reference tree to the plot center shall be recorded with the plot data. A ring shall be painted around the circumference of the reference tree at DBH to identify these trees and the plot in the future (excluding aesthetic plots). Paint color shall be glo-orange. Prior to leaving each plot, trees should be tallied and correlated to each tree recorded as a check.

Plot Card Format: Paper field data forms will follow the format of the attached sample cruise card. Cruiser shall fill out all appropriate information on cruise cards while in the field; including plot number, date, cruiser initials. All cruise cards produced within any day shall be completed and "proofed" by the cruiser the same day.

Sampling Method: All plots will be circular fixed plots; plot radius distances will be horizontal distances.

The cruise will consist of three nested circular plots:

1. $1/10^{th}$ acre (37.24' limiting distance)– Conifers and hardwoods 10.6" and larger.
2. $1/50^{th}$ acre (16.66' limiting distance)– Conifers and hardwoods 3.6" to 10.5" DBH.
3. $1/100^{th}$ acre (11.77' limiting distance)– Conifers and hardwoods 1.0" to 3.5" DBH.

Data to be collected:

1. Tree number shall be recorded clockwise from north and painted on the tree above DBH with orange paint (only paint tree numbers on trees in two largest plots as trees smaller than 3.6" DBH are difficult to paint). Record all the trees in the largest plot first then the middle plot and finally the smallest plot.
2. Species Code
3. DBH to the nearest $1/10^{th}$ inch (paint a horizontal line at DBH location on the uphill side of the tree).

4. Live crown ratio (LCR) to the nearest 10%
5. Total height to the nearest foot (and the lean in degrees if lean>15° from a vertical line above the base of the stem)
6. Status Code
7. Conifer and hardwood snag trees if they are at least 5" DBH and 15.0' in height prior to rounding. Above 15' height will be recorded to the nearest foot (height to the break, if snag is broken), including decay class.
8. Missing volume by 1/3rd segment of the tree as described below.

Blank Plots

If there are no trees located on any of nested plots, the plot is considered a Blank Plot. Blank Plots are noted on the plot card by including "XX" in the Species column.

Species Codes:

DF	Douglas-fir	TO	Tanoak
SP	Sugar pine	PM	Madrone
PP	Ponderosa pine	BO	Black oak
WF	White fir	WO	Oregon white oak
IC	Incense cedar	LO	Interior live oak
WH	Western hemlock	CLO	Coast live oak
CX	Other conifer	CNO	Canyon live oak
NM	California nutmeg	BM	Bigleaf maple
GP	Gray pine	CL	California laurel
RW	Coast Redwood	RA	Red alder
XX	Blank Plot	CB	California buckeye
		GC	Golden chinkapin
		HX	Other hardwood*

*Include the species of each "Other hardwood" in the note field.

Diameter at Breast Height:

Measure DBH at 4.5 feet above ground on the uphill side of tree perpendicular to angle of the tree. On leaning or pistol butt trees, measure 4.5 feet along the stem, not vertical distance. Ground level (duff layer or mineral soil) is beneath any branches or forest litter that may be accumulated on the uphill side. For 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 is recorded to the nearest 0.1". If the diameter reading is not exactly on a tenth, record the DBH to the next lower one-tenth inch. Paint a horizontal line at the DBH location on the uphill side of the tree. Do not remove moss from trees prior to measuring DBH. Where trees have moss at DBH, pull the Spencer's tape sufficiently tight to be pressed against the bole, but not so tight as to compress the bark. Please see Appendix A for special instructions regarding DBH measurements. If, for any reason, DBH is estimated, make note on the plot card.

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.

Missing Volume:

Record missing gross volume for each 1/3rd portion of the tree, bottom, middle, and top. If a tree has a broken top, record missing volume by thirds of the height to the break. DO NOT record missing volume for the portion of the tree missing above the break. For example, if the broken top is the only missing portion of the tree, record nothing for missing volume for this missing portion of the tree as the cruise compiler will estimate the missing portions based on a regressed total tree height. Record missing volume to the nearest 10 percent by segment for any tree with missing volume. If any portion of the tree is missing, record the missing volume for each 1/3rd segment of the tree. For example if 20% of the bottom 1/3rd, and 60% of the middle 1/3rd is missing, record 20-60-0 for the tree.

Total Height:

Total height to the nearest foot will be measured for all trees on each plot (Measure total height from the ground (uphill side of the tree) to the highest point on top of the tree (highest branch) unless it is broken then measure to the top of the break in the stem. Trees with previously broken tops are considered recovered when a new leader (dead or alive) is 1/3 the diameter of the broken top at the point where the top was broken (not where the new leader originates from the trunk). If a tree has recovered from a broken top, then measure to the height of the new leader. Trees with broken tops will have the condition of the top noted in the Status Code column (broken [BT], broken and recovered [RL], dead [DT]). DO NOT record BT for a tree having a broken top if it has recovered as defined above.

Status Codes:

BT	Broken top
FT	Forked top (significantly forked conifers only)
RL	Recovered leader
DT	Dead top
SN	Snag

Snag Decay Class:

Each snag recorded on a given plot shall have its decay class recorded. These decay classes are generally described as follows:

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.

Check Cruising: A minimum of five 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 NCRM for check cruising within 3 days of cruising. NCRM will randomly select plots to be checked as plot data is received from cruiser. All check cruise reports should be provided to cruiser in a timely manner and no later 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 1/10th , and 1/50th acre plot only including snags	None.
Species	None.
Total height	±10% or 10' whichever is less, on each tree.
DBH 1/10th acre plot	±0.3" for trees less than 24" DBH ±0.5" for conifer trees and ±1" for hardwood trees 24" DBH or greater
DBH 1/50th and 1/100th acre plots	±0.3" for all trees
Live crown ratio	20%.
Plot location	Within one chain of mapped location
Tree count on 1/100th – acre plot	±20% 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 86% 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 by the same cruiser 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 by the same cruiser will have to be re-measured in their entirety.

Remarks:

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

Special Circumstances:

DBH: See Appendix A.

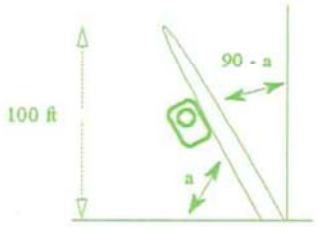
As the plots are fixed area plots, trees are considered on the plot if the center of the tree at ground level is within the fixed plot radius. If it is not possible to get a DBH it can be estimated by the cruiser and noted in the remarks section that the tree (use the tree "line number on the cruise card," to identify the tree) was estimated. If possible, a half diameter measurement can be taken and doubled to estimate DBH with nails marking the zero and estimated half diameter points. If necessary, a nail can be placed at breast height on one side of the tree and a compass reading taken from several steps back where the nail is in line with the center of the tree. Then a second nail can be placed on the opposite tree face in line with the center of the tree using the reversed compass reading.

The reference for determining if a tree is off or on the plot is the point where the tree meets the ground. On slopes, ground level is along the general slope around the stem; thus, the point along the general sloped-ground level at which the center of the tree intersects is the point of measurement for borderline limiting distance calls. Trees leaning away from plot center are on the plot in question if the center of the base of the tree, not the tree's DBH, is within the plot radius.

Leaning Trees: Total height on slightly leaning trees (<16°) shall be measured perpendicular to the lean of the tree. Height of significantly leaning trees (16°-75°) shall be taken from a point as perpendicular to the lean as possible and measured along the vertical distance from the ground to the highest main stem of the tree; from the same ground, the angle of the tree lean (along a straight line between base and top height measurement) shall be measured to the nearest 5°. The cruiser may additionally estimate the trees height using the heights of similar diameter trees that are standing upright. Severely leaning trees (80°+) must be measured horizontally with steel tape and noted as such in the notes column; such heights are not subject to penalties by check cruisers.

A) **Slope Correction Factor Method**:

1. Measure vertical height to tree tip from a point perpendicular to tree lean.
2. Measure angle of tree lean, reading from the side of clinometer (in Degrees).
3. Subtract the degree reading from 90 °
4. Find slope correction factor for step 3 angle.
5. Multiply vertical height by slope correction factor.



EXAMPLE:

Vertical height = 100 ft. Clinometer reading = 61° (a = 61)
90° - 61° = 29° Slope Correction Factor for 29°= 1.14
Corrected height = 100 * 1.14 = **114 ft**

Measurement Tools:
Tree heights shall be measured using laser hypsometers, DBH shall be measured with steel diameter tapes, plot diameters shall be determined utilizing steel tapes while correcting for slope. Slope shall be determined with a Relaskop or clinometer.

Borderline Calls:

DBH: Extra care should be taken when measuring DBH on trees near the cutoff between the 10th and 50th acre plots. Trees with DBHs between 10.4" and 10.8" must be remeasured at the breast height mark confirmed at 4.5' (or BH). Make notes regarding any decisions pertaining to the measurements that may be controversial, such as irregularities at BH, diameter height, and/or alternative diameter measurements. If a tree's DBH is within five hundredths below 10.6, record it as a 10.6.

Plot Boundary: Any tree on the 10th acre or 50th acre plot within 3 feet of the plot boundary should have its slope distance from plot center to the center of the tree remeasured with the steel tape and its horizontal distance calculated on the notes section of the plot card to verify if it's within the limiting distance.

Review of Plot card Prior to Leaving the Plot:

Prior to leaving the plot, a review of trees recorded on the plot card shall be performed. The cruiser should be looking for data entry errors such as a DBH recorded less than 10.6" for a tree on the 1/10th acre plot, a missing tree or visual errors such as under recorded or over recorded diameters or heights.

APPENDIX A – SPECIAL INSTRUCTIONS FOR DBH MEASUREMENTS

The attached special instructions for DBH measurement are taken from the FIA National Core Field Guide, Version 6.1 dated October, 2014 section 5.9.2. Not all instructions apply to Congaree River Carbon Project Inventory. For example, where the special instructions refer to multi-stemmed woodland species, no such species as defined in Appendix 3 of the Core Field Guide are found on the Congaree River Project Area, and as such, references to multi-stemmed woodland species can be ignored. Also, forked trees may be considered branches. For this cruise, when a tree fork, below DBH and above one-foot from the ground, has an angle greater than 45° from the main stem, that fork shall be treated as a branch and not an individual tree.

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

Special DBH situations:

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

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

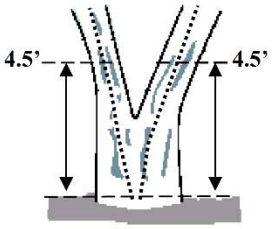


Figure 23. Forked below 1.0 ft.

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

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

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

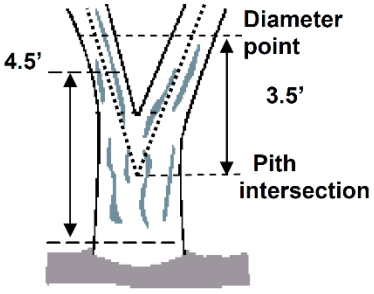


Figure 24. Forked between 1.0-4.5 ft.

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

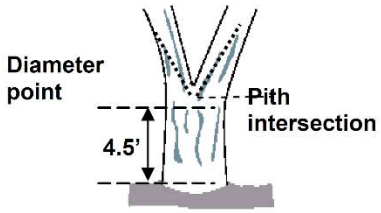


Figure 25. One tree.

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

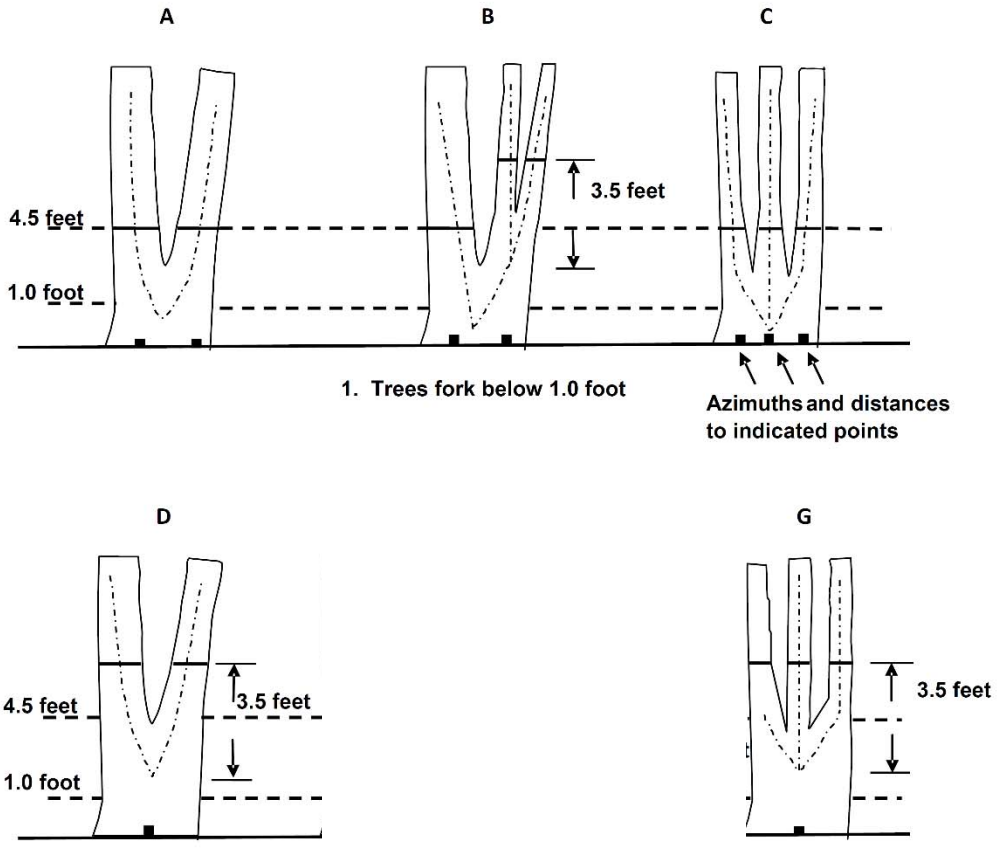


Figure 26. Summary of where to measure DBH, distance, and azimuth on forked trees.

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

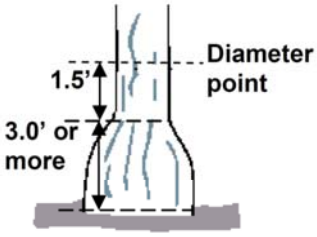


Figure 27. Bottleneck tree.

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

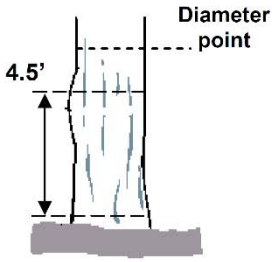


Figure 28. Tree with swelling.

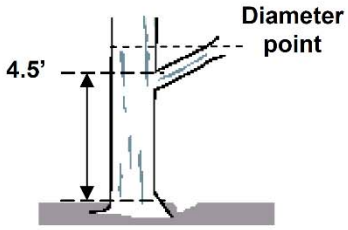


Figure 29. Tree with branch.

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

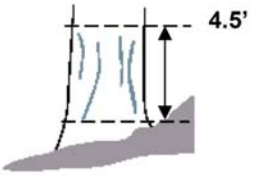


Figure 30. Tree on a slope.

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

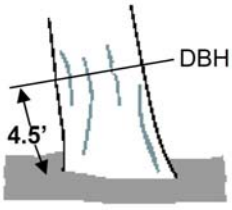


Figure 31. Leaning tree.

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

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

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

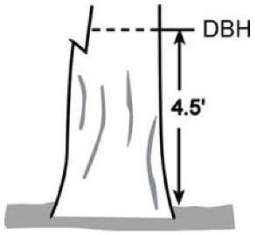


Figure 32. Tree with part of stem missing.

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

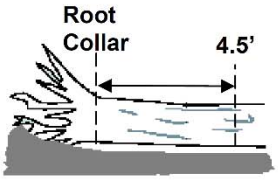


Figure 33. Tree on the ground.

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

    - If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (fig. 34).
    - If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 feet from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 feet above the pith intersection for both the main bole and the tree-like branch.

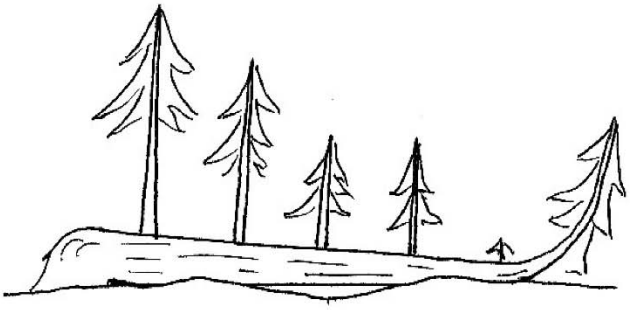


Figure 34. Down tree above duff.

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

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

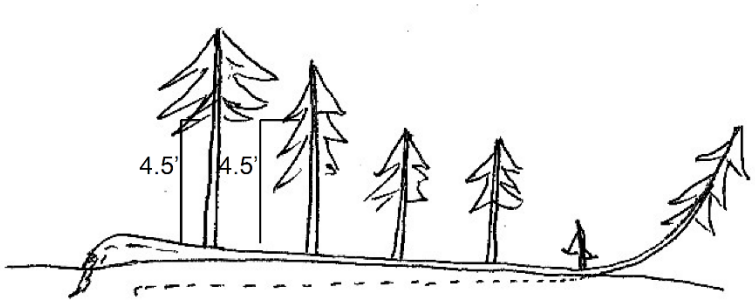


Figure 35. Down tree below duff.

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

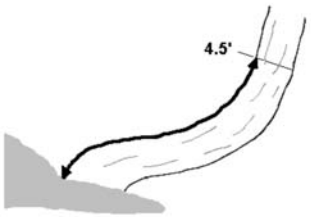


Figure 36. Tree with curved bole (pistol butt tree).

REFERENCES

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

Appendix C

Congaree River Inventory
Plot Data Entry Procedures

Congaree River Inventory
Plot Data Entry Procedures

The following data entry procedures indicate the steps taken for the current Project inventory, as well as the steps that will be taken as additional inventory data is collected across the Project Area.

1. Cruise cards are ordered as they are received from the cruisers. A page number is added to the lower left corner of each card. A copy of the cards with this page number is made and used for the basis of data entry. Data entry cards are stored in a binder with a copy of the completed data entry form.
2. Open the "Select Plot to View" form in the "Congaree_Carbon_Project_2015.mdb" Access database found at L:\Projects\Congaree River LLC\Carbon_Project\Inventory.
3. Type the plot number ("Plot" on the field card) in the StandId field and hit the enter key to move through the other data in the plot header.
4. Irregularities in the header data should be noted in the Data Entry Note field.
5. To begin entering the tree data, click in the upper left most cell in the TREE DATA portion of the form and type the Tree No.s from 1 to the total number of trees on the plot in the Tree# column. Then enter the remaining data by column from left to right. It is more efficient to enter data by moving up and down the columns, rather than across columns for each tree.
6. Snags are recorded with "SN" in the status column followed by the decay class. SN1 is a snag with decay class 1. Record SN in the Status column, and 1 in the DC (Decay Class) column. Record zero for LCR for all snags.
7. Enter Log Ht and defect by log position data as recorded on the field card. This data is not used for the carbon inventory, but must be entered properly. WTS cruisers include a line through log position columns if the data is the same as the cell to the left of the line. Record the value in the cell to the left of the line for all columns through which the line passes up to the recorded log Ht.
8. Leaning trees have the lean in degrees recorded in the Remarks column. Enter the lean from the Remarks column to the nearest 5 degrees in the Lean column.
9. Missing volume is recorded in the Remarks column on the field card, and in the B1/3, M1/3, and T1/3 columns in the database. Missing volume is recorded to the nearest 10 percent by segment for any tree with missing volume. If any portion of the tree is missing, the missing volume for each 1/3rd segment of the tree is recorded. For example if 20% of the bottom 1/3rd, and 100% of the middle 1/3rd is missing, 20-100-0

is recorded for the tree. The B1/3, M1/3, and T1/3 columns default to zero, separate the recorded data into the respective columns.

10. Record all of the data in the Remarks column of the card into the Note column in the form, even if the data is recorded elsewhere on the form with the exception of 0-0-0 data included for trees without missing volume.
11. If there is a problem reading the data for a tree, or if the data entered differs from the data on the cruise card, describe the issue in the Entry Note column for the tree in question.
12. When data entry is complete, the person entering the card shall write the word "Entered", the date entered, and their initials in the upper right corner of the card in the box where the word "Remarks" is found.

Data Review

1. Data review begins with a visual review of the plot card and the data entered. Check that data is entered in the appropriate column, and in the appropriate order.
2. Save a PDF of the completed plot card with the StandId as the file name into the following directory on the server:
   L:\Projects\Congaree River LLC\Carbon_Project\Inventory\Plotcards\Final_Plot_Cards
3. Print a hard copy of the PDF and place it in the Data Entry binder opposite the field card.
4. Review the printed card against the field card. Make any corrections, then reprint the completed card.
5. Scan a copy of the field card with the StandId and "_field" as the file name and save it as a PDF into the following directory on the server:
   L:\Projects\Congaree River LLC\Carbon_Project\Inventory\Plotcards\Field_Cards

Appendix D

Plot Map

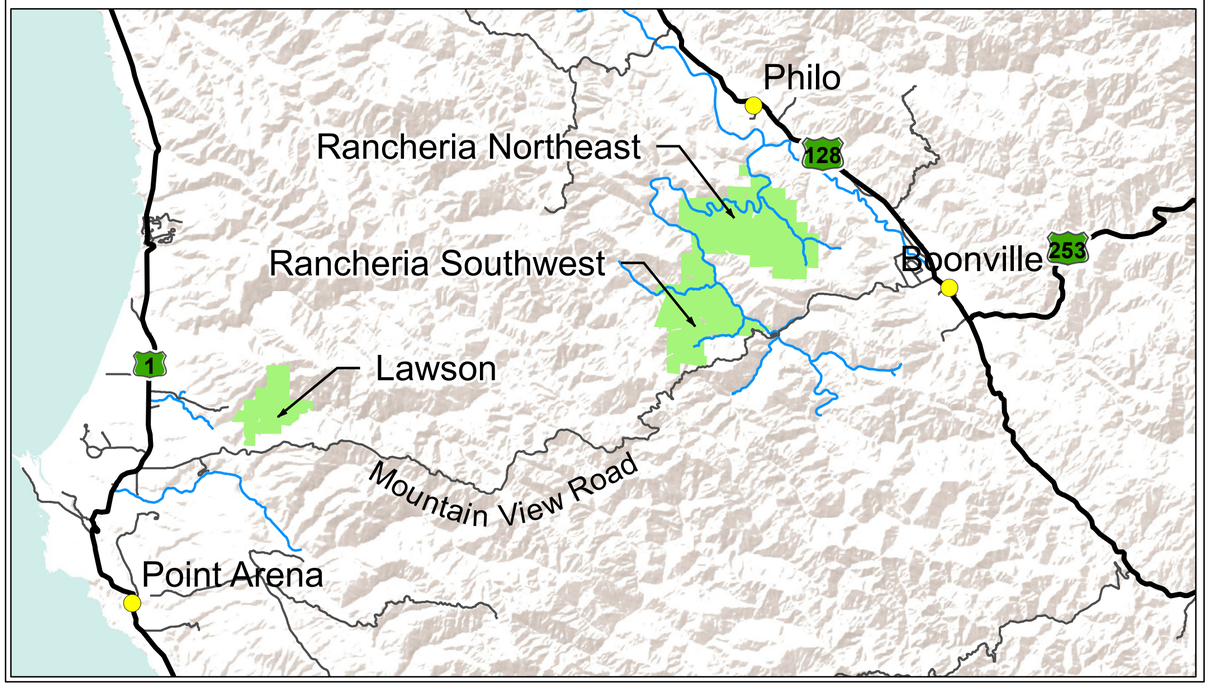
Congaree River Project

Portions of sections 29, 30, 31, and 32 T14N R14W, Sections 5, 6 and 7 T13N R14W,
Section 36 T14N R15W, Sections 1, 2, 11, 12, and 13 T13N R15W, and
Sections 21, 27, 28, and 29 T13N R16W all MDB&M

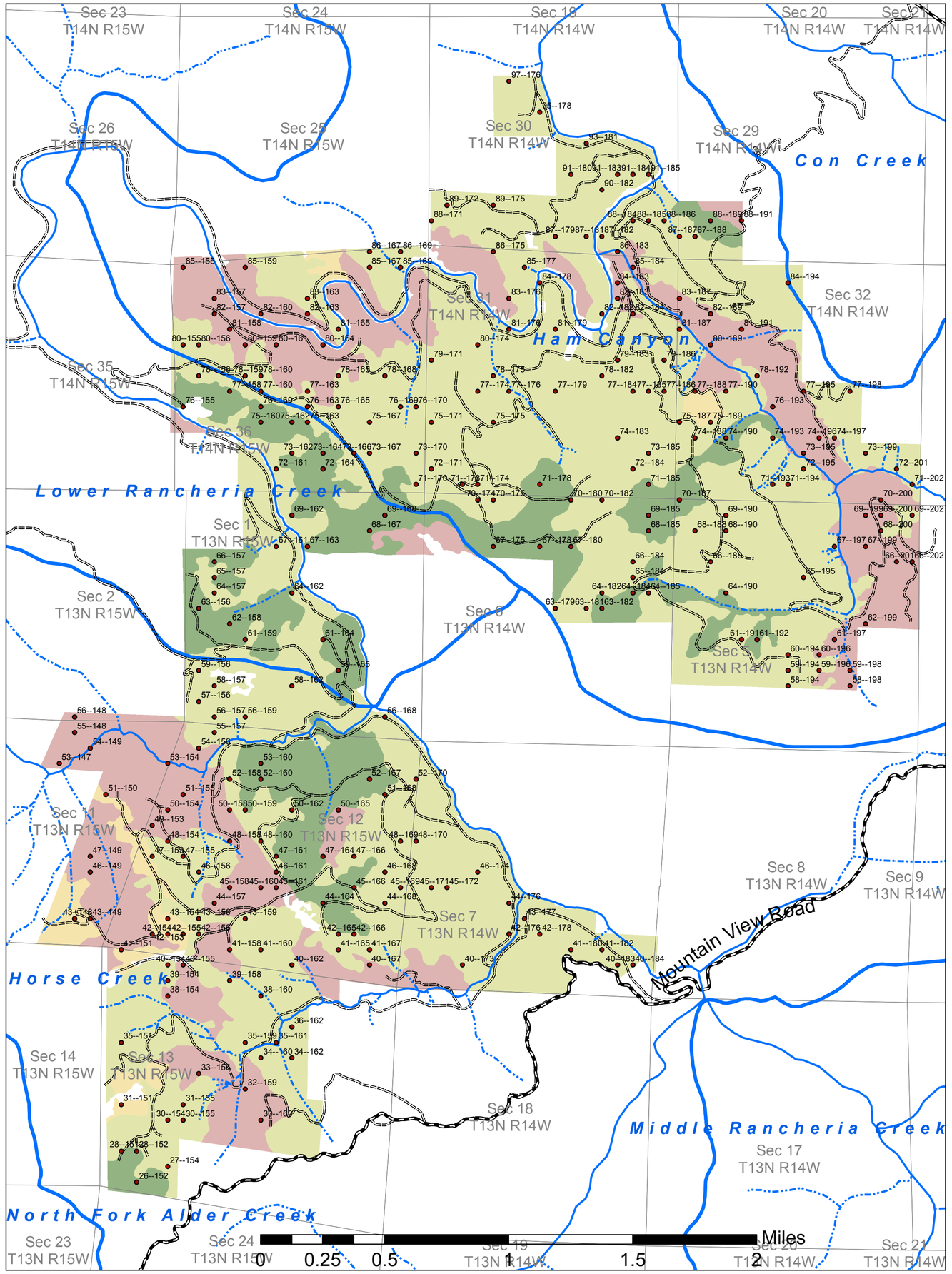
Legend

- Inventory Plot
- Public Road
- Private Road
- Watershed Boundary
- Watercourses
  - Class 1
  - Class 2
- Strata
  - C1
  - C2
  - C3
  - C4
  - H1
  - H2

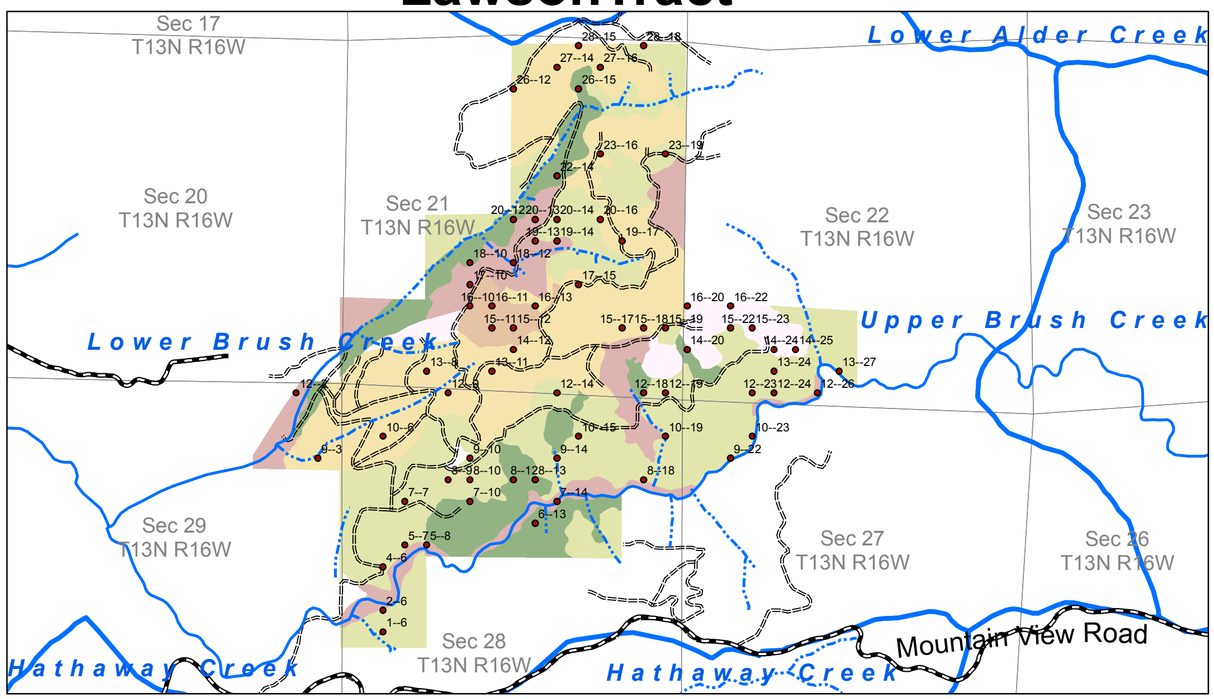
N W E S



Rancheria Tracts



LawsonTract



Appendix E

CAR Harvested Wood Products Worksheet

Harvested Wood Products Worksheet

The Harvested Wood Products (HWP) Worksheet is designed to standardize and facilitate the reporting of harvested wood products for each Reporting Period in the Calculation Worksheet. The HWP worksheet produces standardized outputs that Project Developers must insert into the Calculation Worksheet for the following areas:

1) Actual Project Carbon in Harvested Wood Delivered to Mill (tCO2e)
2) Actual Project Carbon in Trees Harvested for Wood Products (tCO2e)
3) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
4) Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill
5) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill
6) Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill

The default values (conversions, mill efficiencies, etc) must be used unless the Project Developer can provide verifiable alternatives. The HWP worksheet is divided into 3 sections (Data Inputs, Estimates of Carbon Storage in Wood Products and Emissions associated with Harvested Trees, and Conversion Assumptions). Project Developers must make a separate copy of the HWP worksheet for each Reporting Period and submit it as part of the Annual Monitoring Report.

Section 1. Data Inputs

Table 1. Key to worksheet inputs

The key below provides a color-coded reference to cells in this worksheet. User action is required wherever a 'Step' is mentioned.

Step Guidance	
Project data entered by Project Developer	
Assumptions and/or data populated automatically	
Default Values	
Data calculated automatically for input into the Calculation Worksheet	

Table 2. Project Characteristics

Step 1. Using the pull-down menus where provided, enter the current reporting period project data into Table 2. If multiple hardwood and/or softwood harvest units were recorded, consolidate into one hardwood and one softwood harvest unit using the values in Table 9.

Region*:	Pacific Southwest (PSW)
Reporting Period:	
Hardwood Harvest Units:	Cubic Feet
Softwood Harvest Units:	MBF-Scribner ("Large" or "Long")

*From the Reserve's Assessment Area Data File.

Table 3. Default Wood Products Classes; Volume Totals

Step 2. If the default wood products classes are being used, enter the appropriate values from the Assessment Area data file and proceed to **Step 3** if harvesting occurred or **Step 5** if there was no harvest. If the actual distribution of wood products generated from the reporting period harvest is known, skip this step and proceed to **Step 4**.

Softwood Lumber	Hardwood Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Miscellaenous	Paper
0%	0%	0%	0%	0%	0%	0%

Step 3. If the default wood products classes are being used, enter the total amount of wood delivered to the mill(s) and proceed to **Step 5**.

Hardwood		Softwood	
Total	0	Total	
%	#DIV/0!	%	#DIV/0!

Table 4. Volume in Logs Delivered to Mill

Step 4. Enter the name of the mill(s) and the volume of harvested wood sent to the mill(s) during the current reporting period in Table 4. Both the hardwood and softwood volumes must be categorized based on the wood product classes shown below. If wood products class data is only partially available, categorize the unknown wood products as "miscellaneous". If wood products class data is unavailable **or no wood products were harvested in the current reporting period**, refer to **Steps 2 and 3**. Default mill efficiencies are listed in Table 12. These default values may be overwritten if mill-specific data is available and verifiable.

	Hardwood							Softwood							
	Wood Product Classes							Wood Product Classes							
Mill	*Mill Efficiency*	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper	*Mill Efficiency*	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	*Mill Efficiency*	Paper
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
	56.8%	N/A	N/A	N/A	N/A	56.8%	N/A	67.5%	N/A	N/A	N/A	N/A	N/A	67.5%	N/A
Gross Total:		-	-	-	-		-		-	-	-	-	-		-
Net Total:		-	-	-	-		-		-	-	-	-	-		-

Section 2. Estimates of Carbon Storage in Wood Products and Emissions Associated with Harvested Trees

Table 5. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Project Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
Project carbon in harvested wood delivered to mills (Cubic Feet)	-	-	-	-	-	-	-	-	-	-	-	-
Project carbon in harvested wood delivered to mills (tCO_2e)	-	-	-	-	-	-	-	-	-	-	-	-
Project carbon transferred to wood products (Cubic Feet)	-	-	-	-	-	-	-	-	-	-	-	-
Project carbon transferred to wood products (tCO_2e)	-	-	-	-	-	-	-	-	-	-	-	-
% Product												0%
Long-term storage in in-use wood products (tCO_2e)	-	-	-	-	-	-	-	-	-	-	-	-
Long-term storage in wood products in landfills (tCO_2e)	-	-	-	-	-	-	-	-	-	-	-	-

Table 6. Estimates of CO_2-equivalent (CO_2-e) in Harvested Wood Products associated with Baseline Activities

	Hardwood					Softwood						
Units	Lumber	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Lumber	Plywood	Oriented Strandboard	Non Structural Panels	Misc Products	Paper	Sum
tCO2e	-	-	-	-	-	-	-	-	-	-	-	-
% Product	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Long-term storage in in-use wood products (tCO2e)	-	-	-	-	-	-	-	-	-	-	-	-
Long-term storage in wood products in landfills (tCO2e)	-	-	-	-	-	-	-	-	-	-	-	-

Table 7. Calculation Worksheet Information

Calculation Sheet Inputs (for Current Reporting Period)		Row Location in Calculation Worksheet
Actual Project Carbon in Harvested Wood Delivered to Mill (tCO2e)	-	11 (Excel 22)
Actual Project Carbon in Trees Harvested for Wood Products (tCO2e)	-	9 (Excel 20)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	-	13 (Excel 24)
Actual Project Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	-	14 (Excel 25)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Excl Landfill	-	15 (Excel 26)
Baseline Carbon Stored Long-term in Wood Products (tCO2e) - Incl Landfill	-	16 (Excel 27)

Table 8. Ratio of Harvested Wood Carbon to Harvested Tree Carbon

Step 5. Enter the 100-year baseline data to calculate a ratio of carbon in trees harvested for wood products to carbon in harvested wood delivered to the mill.

Baseline Carbon in Trees Harvested for Wood Products (tCO_2e) (from Excel Row 21 of the Monitoring Calculation Worksheet)	
Baseline Carbon in Harvested Wood Delivered to Mill (tCO_2e) (from Row 23 of the Monitoring Calculation Worksheet)	
Multiplier of Carbon in Wood Delivered to Mill to Carbon in Trees Harvested for Wood Products	**0.00**

Section 3. Conversion Assumptions

Table 9. Volume multipliers for converting timber and chip units to Cubic Feet

Unit	Factor
Bone Dry Tons	71.3
Bone Dry Units	82.5
Cords	75
Cubic Feet	1
Cubic Meters	35.3
Cunits-Chips (CCF)	100
Cunits-Roundwood	100
Cunits-Whole tree chip	126
Green tons	31.5
MBF-Doyle	222
MBF-International 1/4"	146
MBF-Scribner ("C" or "Small")	165
MBF-Scribner ("Large" or "Long")	145
MCF-Thousand Cubic Feet	1000
Oven Dried Tonnes	75.8

Source: American Forest & Paper Association, Sustainable Forestry Initiative Program Annual Progress Reporting Form

Table 10. Conversion Factors: to convert volume estimates to CO2-e

		Source
Cubic Feet / Hardwood Harvest Unit	1	Table 9.
Cubic Feet / Softwood Harvest Unit	145	Table 9.
SG of Softwoods by Region	0.399	Table 12.
SG of Hardwoods by Region	0.51	Table 12.
Tree Carbon:Wood Carbon	0.00	Table 8.
Pounds to Metric Tons	0.0004535970	-
Portion of Carbon in Biomass	0.5	-
Carbon to CO2-e	3.67	Reserve FPP
Density of water (lbs/cf)	62.43	-

Table 11. 100-year average storage factors

Wood Product Class	In-Use	Landfills
Softwood Lumber	0.463	0.298
Hardwood Lumber	0.250	0.414
Softwood Plywood	0.484	0.287
Oriented Strandboard	0.582	0.233
Non Structural Panels	0.380	0.344
Miscellaneous Products	0.176	0.454
Paper	0.058	0.178

Source: Reserve Forest Project Protocol, Appendix C.3 & C.4

Table 12. Average regional factors: specific gravity (SG) and mill efficiencies (ME)

	Hardwoods			Softwoods		
Region	**SG**	**Saw Log ME**	**Pulp ME**	**SG**	**Saw Log ME**	**Pulp ME**
Northeast (NE)	0.518	0.614	0.650	0.371	0.569	0.513
Northern Lake States (NLS)	0.473	0.585	0.685	0.360	0.630	0.514
Northern Prairie States (NPS)	0.537	0.585	0.685	0.434	0.630	0.514
Pacific Northwest, East (PWE)	0.424	0.568	0.568	0.396	0.637	0.637
Pacific Northwest, West (PWW)	0.415	0.531	0.531	0.426	0.740	0.500
Pacific Southwest (PSW)	0.510	0.568	0.568	0.399	0.675	0.675
Rocky Mountain, North (RMN)	0.389	0.568	0.568	0.394	0.704	0.704
Rocky Mountain, South (RMS)	0.353	0.568	0.568	0.369	0.704	0.704
Southeast (SE)	0.508	0.609	0.591	0.462	0.636	0.553
South Central (SC)	0.529	0.587	0.581	0.463	0.629	0.570

Sources: USDA Forest Service, Forest Inventory and Analysis Program database of forest surveys (SG) and *Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program* (ME). Average wood specific gravity is the density of wood divided by the density of water based on wood dry mass associated with green tree volume.

ATTACHMENT O

FIA Volume Equation documentation updated on 9-19-2014

Contacts: Karen Waddell, Kurt Campbell, Olaf Kuegler, Glenn Christensen

Volume estimation for PNW- Databases -- NIMS and FIADB

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.

All total stem volumes are calculated on all live trees in the inventory that are >= 1” DIA, and on dead trees that are >= 5” DIA.

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 from these equations 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.

Growing stock volume is the volume of a tree, from a 1-foot stump to a 4" top, calculated on all trees >= 5” DIA. Board foot volume (sawtimber volume); for softwoods it is the volume of a tree from a 1-foot stump to a 6" top, calculated for softwood species >= 9” DIA; and for hardwoods, it is the volume of a tree from a 1-foot stump to an 8" top, calculated for hardwood species >= 11” DIA.

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

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

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

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

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

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

CUBIC VOLUME (in cubic feet)

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

BOARD FOOT VOLUME (square feet)

Type of Volume	Calculated on trees with a DIA of:	Volume name in equations
Softwoods:		
Scribner volume, 16-foot log rule, 1-foot stump to a 6-inch top (Eastern OR; Eastern WA; CA)	>= 9”	SV616
Scribner volume, 32-foot log rule, 1-foot stump to a 6-inch top (Western OR; Western WA)	>= 9”	SV632
International 1/4" volume, 16-foot log rule, 1-foot stump to a 6-inch top (all states)	>= 9”	XINT6
Hardwoods:		
Scribner volume, 16-foot log rule 1-foot stump to an 8-inch top (all states)	>=11”	SV816
International 1/4" volume, 8-foot log rule, 1-foot stump to an 8-inch top (all states)	>= 11”	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 25-31

1. Calculate CVTS from published or documented volume equations for the species.
2. Calculate the TARIF number from CVTS, using the equation in DNR report #24.
3. Calculate CV4 from the TARIF number and tree basal area.
4. Calculate CVT from the TARIF number and DIA.

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, DIA and height.
6. Calculate the TARIF number from CV4 and tree basal area.
7. If the tree >= 6" DIA then Calculate CVTS from CV4.
8. If the tree < 6" DIA then adjust the TARIF before calculating CVTS.
9. Calculate CVT from the TARIF number and DIA.

CUBIC VOLUME Method 3: The TARIF number is based on CV8.
Hardwood equations 32 to 44

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

---

13. CALCULATE CONVERSION RATIOS:

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

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

SOFTWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
11	Pacific silver fir	11	11	10	10	11
14	Bristlecone fir	--	--	--	--	18
15	White fir	23	11	10	10	23
17	Grand fir	11	11	10	10	23
19	Subalpine fir	11	11	10	10	18
20	California red fir	18	--	10	--	18
21	Shasta red fir	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
52	Baker cypress	--	--	--	--	19
54	Monterey cypress	--	--	--	--	19
55	Sargent's cypress	--	--	--	--	19
56	McNabb cypress	--	--	--	--	19
62	California juniper	--	--	--	--	14
64	Western juniper	21	21	21	21	21
65	Utah juniper	--	--	--	--	14
66	Rocky mountain juniper	--	--	14.2	--	14.2
72	Subalpine larch	--	22	22	22	--
73	Western larch	22	22	22	22	22
81	Incense cedar	19	19	19	19	19
92	Brewer spruce	13	--	13	13	12
93	Engelmann spruce	13	13	12	12	12
98	Sitka spruce	13	13	13	13	12
101	Whitebark pine	15	15	15	15	20
102	Bristlecone pine	--	--	--	--	16
103	Knobcone pine	15	15	15	--	16
104	Foxtail pine	--	--	--	--	16
108	Lodgepole pine	15	15	15	15	16
109	Coulter pine	--	--	--	--	5
113	Limber pine	--	--	16	--	16
116	Jeffrey pine	5	--	4	--	5
117	Sugar pine	20	--	20	--	20
119	Western white pine	15	15	15	15	20
120	Bishop pine	16	--	16	--	16
122	Ponderosa pine	5	4	4	4	5
124	Monterey pine	--	--	--	--	16
127	Gray pine	--	--	--	--	5
130	Scotch pine	15	--	--	--	--
133	Singleleaf pinyon pine	--	--	--	--	14.1

SOFTWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers
(continued)

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
137	Washoe pine	--	--	--	--	5
142	Great Basin bristlecone pine	--	--	--	--	16
201	Bigcone Douglas-fir	--	--	--	--	3
202	Douglas-fir	1	1	2	2	3
211	Redwood	24	24	24	--	24
212	Giant Sequoia	24	--	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
298/299	Unknown Conifer	17	17	17	17	17

There are many equations used to estimate softwood cubic-foot volume. Each equation below has been cross-walked to a particular tree species in the table above.
Click on an equation number to view the actual equation and procedure used to estimate volume.

SOFTWOOD VOLUME EQUATION SOURCES

EQUATION 1	DOUGLAS-FIR	(Brackett, 1973; DNR RPT # 24,1977)
EQUATION 2	DOUGLAS-FIR	(DNR MEMO--SUMMERFIELD,11/7/80)
EQUATION 3	DOUGLAS-FIR	(USDA-FS RES NOTE PNW-266)
EQUATION 4	PONDEROSA PINE	(DNR MEMO--SUMMERFIELD,11/7/80)
EQUATION 5	PONDEROSA PINE	(USDA-FS RES NOTE PNW-266)
EQUATION 6	W.HEMLOCK	(DNR NOTE 27,4/79)
EQUATION 7	W.HEMLOCK	(BROWNE (1962) BC FOREST SERV,P33)
EQUATION 8	REDCEDAR	(REDCEDAR INTERIOR--DNR RPT # 24,1977)
EQUATION 9	REDCEDAR	(REDCEDAR COAST--DNR RPT # 24,1977)
EQUATION 10	TRUE FIRS	(INTERIOR BALSAM--DNR RPT # 24,1977)
EQUATION 11	TRUE FIRS	(COAST BALSAM--DNR RPT # 24,1977)
EQUATION 12	SPRUCE	(SITKA SPRUCE INTERIOR--DNR RPT # 24,1977)
EQUATION 13	SPRUCE	(SITKA SPRUCE MATURE--DNR RPT # 24,1977)
EQUATION 14	Other junipers	(Chojnacky, 1985)
EQUATION 14.1	Singleleaf pinyon	(Chojnacky, 1985)
EQUATION 14.2	Rocky mountain juniper	(Chojnacky, 1985)
EQUATION 15	LODGEPOLE PINE	(LODGEPOLE PINE--DNR RPT # 24,1977)
EQUATION 16	LODGEPOLE PINE	(USDA-FS RES NOTE PNW-266)
EQUATION 17	MTN.HEMLOCK	(BELL, OSU RES.BULL 35)
EQUATION 18	SHASTA RED FIR	(USDA-FS RES NOTE PNW-266)
EQUATION 19	INCENSE CEDAR	(USDA-FS RES NOTE PNW-266)
EQUATION 20	SUGAR PINE	(USDA-FS RES NOTE PNW-266)
EQUATION 21	W.JUNIPER	(CHITTESTER,1984)
EQUATION 22	W.LARCH	(LARCH--DNR RPT # 24,1977)
EQUATION 23	WHITE FIR	(USDA-FS RES NOTE PNW-266)
EQUATION 24	REDWOOD	(Krumland and Wensel 1975; DNR RPT # 24,1977)

Equation 7
Browne, J.E. 1962. Standard cubic-foot volume tables for the commercial tree species of British Columbia. B.C. Forest Service, Victoria. 107 p.

Equations 1, 8, 9, 10, 11, 12, 13, 15
Brackett, M. 1973. Notes on TARIF tree volume computation. Res. Management Report 24. WA Dept. of Nat. Resources. Olympia. 26p.

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)

Equations 2, 4
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.

Equations 3, 5,16,18,19,20,23
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)

Equation 6
Chambers, C.J. and Foltz, B. 1979. The TARIF system -- revisions and additions., Resource Management Report # 27. WA Dept. of Nat. Resources. Olympia. (see page 2)

Equations 14, 14.1, 14.2
Chojnacky D.C., 1985. Pinyon-Juniper Volume Equations for the Central Rocky Mountain States.Res. Note INT-339, USDA, Forest Service, Intermountain Res. Station, Ogden, UT 84401.

Equation 17
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. OSU Forest Research Lab, School of Forestry, Oregon State University, Corvallis, OR. (see page 6)

Equation 21
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)

Equation 24
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)

Softwood cubic volume equations

Equation 1

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

CVTS=10**CVTSL (2)

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 2

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

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

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = Natural Log, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 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)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 4

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

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

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = Natural Log (ln), CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 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)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 6

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

CVTS=10**CVTSL

(2)

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 7

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

CVTS=10**CVTSL

(2)

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 8

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

CVTS=10**CVTSL

(2)

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 9

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

(2)

CVTS=10**CVTSL

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 10

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

CVTS=10**CVTSL

(2)

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 11

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

CVTS=10**CVTSL

(2)

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 12

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

CVTS=10**CVTSL

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 13

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

CVTS=10**CVTSL

(2)

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 14

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

IF STEMS=1 THEN S = 1
IF STEMS>1 THEN S = 0

VOLUME = (-.13386 + (.133726 *x* (Factor $^{1/3}$)) + (.036329 *x* S)) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter
(includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree

DRC (inches) = Diameter at the root collar

HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 14.1

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

IF STEMS = 1 THEN S = 1
IF STEMS > 1 THEN S = 0

VOLUME = (-0.14240 + (. 148190 x (Factor $^{1/3}$)) - (.016712 x S)) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter
(includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree

DRC (inches) = Diameter at the root collar

HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 14.2

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

VOLUME = (0.02434 + (0.119106 x (Factor $^{1/3}$))) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter (includes live wood, dead wood, and bark)

DRC (inches) = Diameter at the root collar

HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 15

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

CVTS=10**CVTSL

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 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)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 17

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

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 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)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

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

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

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

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

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

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

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

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

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

ELSEIF

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

END IF

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)
HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # .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)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # .27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 21

$$\mathbf{CVTS} = 0.005454154 \times \left[0.30708901 + 0.0008615762\ 2 \times HT\text{-}0.0037255243 \times DBH \times \frac{HT}{HT - 4.5} \right] \times DBH^2 \times HT \times \left(\frac{HT}{HT - 4.5} \right)^2 \quad (1)$$

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

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

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

If CVTS < 0 then CVTS = 2
If CV4 < 0 then CV4 = 1

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 22

Use for dbh>2

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

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

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

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

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

WHERE:

DBH (inches) = DBH (CM) CONVERTED TO INCHES (DBH/2.54)

HT (feet) = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 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)
CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP
TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)
CVT = CUBIC FOOT VOLUME ABOVE STUMP
CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

Equation 24

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

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

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

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

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 DBH^2

CVTS = CUBIC FOOT VOLUME, INCLUDING TOP AND STUMP

TARIF = TARIF NUMBER EQUATION (REF. DNR NOTE # 27, P.2)

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME ABOVE STUMP, 4-INCH TOP

SOFTWOOD BOARDFOOT VOLUME EQUATIONS

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

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

IF CV6 > CV4 THEN CV6 =CV4

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

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

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

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

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

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

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

$$\textbf{SCRIB} = SV632$$

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

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

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

Where:

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

HARDWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
312	Bigleaf maple	37	25	37	25	37
313	Boxelder	37	25	37	25	38
320	Norway maple	37	--	--	--	--
321	Rocky Mountain maple	45	45	45	45	45
322	Bigtooth maple	45	45	45	45	45
333	California buckeye	--	--	--	--	43
341	Tree of heaven	26	--	26	--	--
351	Red alder	25	26	26	26	26
352	White alder	26	26	26	26	26
361	Pacific madrone	40	25	--	--	40
374	Water birch	25	25	25	25	25
375	Paper birch	25	25	25	25	25
431	Golden chinkapin	32	25	32	--	32
475	Curlleaf mountain-mahogany	45	45	45	45	45
492	Pacific dogwood	25	25	25	25	37
500	Hawthorn	25	25	25	25	42
510/511	Eucalyptus	--	--	--	--	31
542	Oregon ash	38	25	38	25	38
547	Velvet ash	--	--	--	--	38
590/591	Holly	25	25	25	25	25
600	Walnut	--	--	--	--	38
603	Northern California black walnut	38	--	--	38	38
604	Southern California black walnut	--	--	--	--	38
611	Sweet gum	--	--	--	--	26
631	Tanoak	34	--	--	--	34
660	Apples	25	25	25	25	42
661	Oregon crabapple	25	25	25	25	42
730	California sycamore	--	--	--	--	42
731	American sycamore	--	--	--	--	42
746	Quaking aspen	25	25	25	25	28
747	Black cottonwood	25	25	25	25	27
748	Fremont poplar	--	--	--	--	27
756	honey mesquite	--	--	--	--	46
758	screwbean mesquite	--	--	--	--	46
760	Cherry	25	25	25	25	26
763	Common chokecherry	25	25	25	25	41
768	Bitter cherry	25	25	25	25	26
771	Sweet cherry	25	--	--	--	--

HARDWOOD CUBIC VOLUME EQUATIONS

Volume equation numbers
(Continued)

		Halfstate				
Species Code	**Species**	**WOR**	**WWA**	**EOR**	**EWA**	**CA**
801	California live oak	--	--	--	--	43
805	Canyon live oak	42	--	--	--	42
807	Blue oak	--	--	--	--	39
811	Englemann oak	--	--	--	--	36
815	Oregon white oak	41	25	41	25	41
818	California black oak	38	--	38	--	38
821	California white oak	35	--	--	--	35
826	Chinkapin oak	--	--	--	--	38
839	Interior live oak	--	--	--	--	44
901	Black locust	37	--	37	25	38
920	Willows	25	25	25	25	40
922	Black willow	40	--	--	--	40
926	Balsam willow	25	--	--	--	--
927	White willow	25	25	--	--	--
929	Weeping willow	--	--	25	--	--
981	California-laurel	33	--	--	--	33
990	Desert ironwood	--	--	46	46	46
997	Russian-olive	37	25	37	25	38
998	Unknown hardwood	25	25	25	25	41
999	Unknown Tree	25	25	25	25	41

HARDWOOD VOLUME EQUATION SOURCES

EQUATION 25	ALDER	(CURTIS/BRUCE, PNW-56 and DNR 24)
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)
EQUATION 34	TANOAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 35	CALIF WHITE OAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 36	ENGELMANN OAK	(PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)
EQUATION 37	BIGLEAF MAPLE	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 38	CALIF BLACK OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 39	BLUE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 40	PACIFIC MADRONE	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 41	ORE WHITE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 42	CANYON LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 43	COAST LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 44	INT LIVE OAK	(PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)
EQUATION 45	MTN. MAHOGANY	(Chojnacky, 1985)
EQUATION 46	MESQUITE	(Chojnacky, 1985)

Equation 25
Curtis, Robert O., Bruce, David, and Caryanne VanCoevering. 1968. Volume and taper tables for red alder. US Forest Serv. Res. Pap. PNW-56. PNW Forest & Range Exp. Sta., Portland, Oregon. 35p.

Equations 26,27,28,29,30
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)

Equation 31
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

Equations 32 - 44
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.

Equations 45, 46
Chojnacky D.C., 1985. Pinyon-Juniper Volume Equations for the Central Rocky Mountain States. Res. Note INT-339, USDA, Forest Service, Intermountain Res. Station, Ogden, UT 84401.

HARDWOOD CUBIC VOLUME EQUATIONS

EQUATION 25

If HT < 18 then set HT = 18

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

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

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

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

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

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

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

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

$$\mathbf{CV4X} = CV4$$

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

EQUATION 26

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

CVTS=10**CVTSL

(2)

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

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

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

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

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

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 27

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

CVTS=10**CVTSL (2)

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

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

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

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

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

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 28

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

CVTS=10**CVTSL (2)

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

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

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

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

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

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 29

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

CVTS=10**CVTSL (2)

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

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

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

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

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

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 30

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

CVTS=10**CVTSL (2)

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

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

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

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

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

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTSL = LOG BASE 10, CUBIC FOOT VOLUME, TOP AND STUMP

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 31

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

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

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

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

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

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

$$\mathbf{CV4X} = CV4$$

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 32

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

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

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

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

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

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

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 33

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

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

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

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

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

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

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 34

If HT > 120 feet then set HT = 120 feet

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

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

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

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

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

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

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 35

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

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

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

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

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

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

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

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 36

$$\mathbf{CVTS} = 0.01914531910 \times DBH^{2.40248} \times HT^{0.28060} \quad (1)$$

$$\mathbf{CV4} = 0.00538663530 \times DBH^{2.61268} \times HT^{0.31103} \quad (2)$$

CV8 =CV4 (3)

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

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

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

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

WHERE:

DBH = DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 37

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC= HARDWOOD FORM CLASS

CVTS= CUBIC FOOT VOLUME, TOP AND STUMP

TARIF= TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 38

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 39

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 40

If HT > 120 feet then set HT = 120 feet

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA= BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 41

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 42

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 43

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 44

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

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

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

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

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

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

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

WHERE:

DBH= DBH(CM) CONVERTED TO INCHES (DBH/2.54)

HT = HT (M) CONVERTED TO FEET (HT/0.3048)

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH^2

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

EQUATION 45

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

IF STEMS =1 then

VOLUME = (-0.13363 + (0.128222 *x* (Factor $^{1/3}$)) + 0 .080208) ^{3}

ELSE IF STEMS > 1 THEN

VOLUME = (-0.13363 + (0.128222 *x* (Factor $^{1/3}$))) ^{3}

IF VOLUME <=0 then VOLUME = 0.1

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter (includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree

DRC (inches) = Diameter at the root collar
HT (feet) = Total height of the tree

No boardfoot equation is available

Equation 46

IF (DRC >= 3 AND HT > 0) then Factor = DRC *x* DRC *x* HT;

```
IF STEMS > 1 then
      if DRC**2 * HT/1000 <=2 then
         VOLUME = 0.020 + 1.8972 * DRC**2*HT/1000 + 0.5756 * (DRC**2*HT/1000)**2
       Else
         VOLUME = 6.927 + 1.8972 * DRC**2*HT/1000 - 9.210 / (DRC**2*HT/1000)

IF STEMS =1 then
      if DRC**2 * HT/1000 <=2 then
         VOLUME = -0.043 + 2.3378 * DRC**2*HT/1000 + 0.8024 * (DRC**2*HT/1000)**2
       Else
         VOLUME =  9.586 + 2.3378 * DRC**2*HT/1000 - 12.839 / (DRC**2*HT/1000)

IF VOLUME <=0  then VOLUME = 0.1
```

WHERE:

VOLUME = cubic foot volume from ground level to a 1.5-inch minimum branch diameter (includes live wood, dead wood, and bark)

STEMS = number of stems 3 inches and larger within the first foot above DRC. When STEMS=1 it is a single stemmed tree.

DRC (inches) = Diameter at the root collar
HT (feet) = Total height of the tree

HARDWOOD BOARDFOOT VOLUME RATIOS and EQUATIONS

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

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

IF Hardwood Equation Number is 25 to 31 THEN set
CV4X = CVT
TARIFX = TARIF (note that TARIF was calculated in the cubic volume equation)

Otherwise, for all other hardwood equation numbers, calculate CV4X and TARIFX as follows:

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

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

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

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

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

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

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

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

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

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

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

$$SV816 = RS816 \times SV616 \quad (9)$$

Calculated on hardwood species only:

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

$$XINT8 = XINT6 \times RI8 \quad (11)$$

WHERE:
B4 = BINGO FACTOR
CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION
RC6 = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP
CV6 = CUBIC FOOT VOLUME, 6-INCH TOP (SAWLOG)
RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS
SV616 = SCRIBNER VOLUME--6-INCH TOP (IN 16-FT LOGS)
RS816 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 8-INCH TOP IN 16-FT LOGS
SV816 = SCRIBNER VOLUME--8-INCH TOP (IN 16-FT LOGS)
XINT6 = INTERNATIONAL ¼ INCH VOLUME--6-INCH TOP (IN 16-FT LOGS)
RI8 =RATIO TO CONVERT INTERNATIONAL ¼ INCH 6-INCH TOP TO INTERNATIONAL ¼ INCH 8-INCH TOP
XINT8 = INTERNATIONAL ¼ INCH VOLUME--8-INCH TOP (IN 8-FT LOGS)

REGIONAL BIOMASS EQUATIONS USED BY FIA TO ESTIMATE BOLE, BARK, AND BRANCHES

Updated 09-19-2014

(text in red has been updated since the last version of this document)

BIOMASS OF THE TREE STEM

Tree stem biomass, regardless of whether it is merchantable bole or total stem, is calculated from cubic volume estimates and the wood density factor (in tables below) as follows:

Cubic volume = green cubic volume in cubic feet (ft3)
Wood density = (Specific gravity of a tree species) * (62.4 lbs/ft3)

Weight of water = 62.4 pounds/cubic foot

Biomass of the tree stem (in tons**) =** (cubic foot volume * wood density) / 2000

The tables below contain specific gravity and wood density values for many species.

Softwoods – specific gravity

Code	Species	Specific gravity	Wood density
10	fir spp.	0.36	22.46
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 yellow-cedar	0.42	26.21
50	Cypress spp	0.41	25.58
52	Modoc cypress	0.41	25.58
54	Monterey cypress	0.41	25.58
55	Sargent's cypress	0.41	25.58
62	California juniper	0.45	28.08
64	western juniper	0.45	28.08
65	Utah juniper	0.68	42.43
66	Rocky Mountain juniper	0.45	28.08
72	subalpine larch	0.49	30.58
73	western larch	0.48	29.95
81	incense-cedar	0.35	21.84
90	spruce spp.	0.36	22.46
92	Brewer spruce	0.36	22.46
93	Engelmann spruce	0.33	20.59
98	Sitka spruce	0.33	20.59
100	pine spp.	0.43	26.83
101	whitebark pine	0.43	26.83
102	Bristlecone pine	0.43	26.83
103	knobcone pine	0.39	24.34
104	foxtail pine	0.43	26.83
108	lodgepole pine	0.38	23.71
109	Coulter pine	0.43	26.83
113	limber pine	0.37	23.09
116	Jeffrey pine	0.37	23.09
117	sugar pine	0.34	21.22
119	western white pine	0.36	22.46

Softwoods – specific gravity
(continued)

Code	Species	Specific gravity	Wood density
120	bishop pine	0.45	28.08
122	ponderosa pine	0.38	23.71
124	Monterey pine	0.4	24.96
127	gray pine	0.4	24.96
130	Scotch pine	0.43	26.83
133	singleleaf pinyon	0.43	26.83
137	Washoe pine	0.43	26.83
142	Great Basin bristlecone pine	0.43	26.83
201	bigcone Douglas-fir	0.45	28.08
202	Douglas-fir	0.45	28.08
211	redwood	0.36	22.46
212	giant sequoia	0.34	21.22
231	Pacific yew	0.6	37.44
242	western redcedar	0.31	19.34
251	California torreya	0.41	25.58
263	western hemlock	0.42	26.21
264	mountain hemlock	0.42	26.21
299	Unknown dead conifer	0.41	25.58

Hardwoods – specific gravity

Code	Species	Specific gravity	Wood density
312	bigleaf maple	0.44	27.46
313	boxelder	0.42	26.21
320	Norway maple	0.47	29.33
321	Rocky Mountain maple	0.47	29.33
333	California buckeye	0.33	20.59
341	ailanthus	0.46	28.70
351	red alder	0.37	23.09
352	white alder	0.37	23.09
361	Pacific madrone	0.58	36.19
374	water birch	0.51	31.82
375	paper birch	0.48	29.95
431	golden chinkapin	0.42	26.21
475	curl-leaf mountain-mahogany	0.52	32.45
492	Pacific dogwood	0.58	36.19
500	Hawthorn	0.52	32.45
510	eucalyptus spp.	0.52	32.45
511	Tasmanian bluegum	0.52	32.45
540	ash spp.	0.51	31.82
542	Oregon ash	0.5	31.20
591	American holly	0.5	31.20
600	walnut spp.	0.44	27.46
603	northern California black walnut	0.44	27.46
604	southern California black walnut	0.44	27.46
611	sweetgum	0.46	28.70
631	tanoak	0.58	36.19
661	Oregon crab apple	0.61	38.06
730, 731	California sycamore	0.46	28.70
746	quaking aspen	0.35	21.84
747	black cottonwood	0.31	19.34
748	Fremont cottonwood	0.41	25.58
756,758	mesquite	0.78	48.67
760	cherry and plum spp.	0.47	29.33
763	chokecherry	0.47	29.33
768	bitter cherry	0.47	29.33
771	sweet cherry, domesticated	0.47	29.33
801	California live oak	0.59	36.82
805	canyon live oak	0.7	43.68
807	blue oak	0.59	36.82
811	Engelmann oak	0.59	36.82
815	Oregon white oak	0.64	39.94
818	California black oak	0.51	31.82

Hardwoods – specific gravity
(continued)

Code	Species	Specific gravity	Wood density
821	California white oak	0.55	34.32
826	chinkapin oak	0.59	36.82
839	interior live oak	0.59	36.82
901	black locust	0.66	41.18
920	willow spp.	0.36	22.46
922	black willow	0.36	22.46
926	balsam willow	0.36	22.46
927	white willow	0.36	22.46
981	California-laurel	0.51	31.82
990	desert ironwood	0.52	32.45
997	Russian-olive	0.52	32.45
998	Unknown dead hardwood	0.52	32.45
999	Other or unknown live tree	0.52	32.45

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF BARK

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
11	Pacific silver fir	22	22	22	22	22
14	Bristlecone fir	--	--	--	--	2
15	White fir	1	2	1	2	1
17	Grand fir	2	2	2	2	2
19	Subalpine fir	3	3	3	3	3
20	California red fir	4	--	3	--	4
21	Shasta red fir	4	--	4	--	4
22	Noble fir	5	5	5	5	5
41	Port-Orford-cedar	38	13	13	13	13
42	Alaska-cedar	23	23	23	23	13
50	Cypress	--	--	--	--	13
52	Baker cypress	--	--	--	--	13
54	Monterey cypress	--	--	--	--	13
55	Sargent's cypress	--	--	--	--	13
56	Mcnabb cypress	--	--	--	--	13
62	California juniper	--	--	--	--	16
64	Western juniper	16	16	16	16	16
65	Utah juniper	--	--	--	--	16
66	Rocky mountain juniper	--	--	16	--	16
72	Subablpine larch	--	24	24	24	--
73	Western larch	24	24	24	24	24
81	Incense cedar	12	12	12	12	12
92	Brewer spruce	7	--	7	7	7
93	Engelmann spruce	7	7	7	7	7
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
104	Foxtail pine	--	--	--	--	14
108	Lodgepole pine	14	14	14	14	14
109	Coulter pine	--	--	--	--	9
113	Limber pine	--	--	14	--	14
116	Jeffrey pine	9	--	9	--	9
117	Sugar pine	10	--	10	--	10
119	Western white pine	11	11	11	11	11
120	Bishop pine	14	--	14	--	14
122	Ponderosa pine	9	9	9	9	9
124	Monterey pine	--	--	--	--	14
127	Gray pine	--	--	--	--	9
133	Singleleaf pinyon	--	--	--	--	14
137	Washoe pine	--	--	--	--	14

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS
--continued—

BIOMASS OF BARK

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
142	Great Basin bristlecone pine	--	--	--	--	14
201	Bigcone Douglas-fir	--	--	--	--	8
202	Douglas-fir	8	8	25	25	8
211	Redwood (when DBH > 39.37 inches)	17	17	17	17	17
211	Redwood (when DBH <= 39.37 inches)	13	13	13	13	13
212	Giant Sequoia (when DBH > 39.37 inches)	17	--	17	--	17
212	Giant Sequoia (when DBH <= 39.37 inches)	13	--	13	--	13
231	Pacific yew	38	13	13	38	13
242	Western redcedar	38	13	13	13	13
251	California nutmeg	--	--	--	--	13
263	Western hemlock	26	26	26	26	15
264	Mountain hemlock	21	21	21	21	21
298	Unknown Conifer	21	21	21	21	21

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF LIVE BRANCHES

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
11	Pacific silver fir	18	18	18	18	18
14	Bristlecone fir	--	--	--	--	1
15	White fir	1	1	1	1	1
17	Grand fir	1	1	1	1	1
19	Subalpine fir	2	2	2	2	2
20	California red fir	3	--	2	--	3
21	Shasta red fir	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
52	Baker cypress	--	--	--	--	10
54	Monterey cypress	--	--	--	--	10
55	Sargent's cypress	--	--	--	--	10
56	Mcnabb cypress	--	--	--	--	10
62	California juniper	--	--	--	--	13
64	Western juniper	13	13	13	13	13
65	Utah juniper	--	--	--	--	13
66	Rocky mountain juniper	--	--	13	--	13
72	Subablpine larch	--	20	20	20	--
73	Western larch	20	20	20	20	20
81	Incense cedar	10	10	10	10	10
92	Brewer spruce	4	--	4	4	4
93	Engelmann spruce	4	4	4	4	4
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
104	Foxtail pine	--	--	--	--	11
108	Lodgepole pine	11	11	11	11	11
109	Coulter pine	--	--	--	--	7
113	Limber pine	--	--	11	--	11
116	Jeffrey pine	7	--	7	--	7
117	Sugar pine	8	--	8	--	8
119	Western white pine	9	9	9	9	9
120	Bishop pine	11	--	11	--	11
122	Ponderosa pine	7	7	7	7	7
124	Monterey pine	--	--	--	--	11
127	Gray pine	--	--	--	--	7
130	Scotch pine	11	--	--	--	--
133	Singleleaf pinyon	--	--	--	--	11
137	Washoe pine	--	--	--	--	7
142	Great Basin bristlecone pine	--	--	--	--	11

BIOMASS OF LIVE BRANCHES

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
201	Bigcone Douglas-fir	--	--	--	--	6
202	Douglas-fir	6	6	22	22	6
211	Redwood	10	10	10	--	10
212	Giant Sequoia	10	--	10	--	10
231	Pacific yew	10	10	10	10	10
242	Western redcedar	10	10	10	10	10
251	California nutmeg	--	--	--	--	10
263	Western hemlock	23	23	23	23	12
264	Mountain hemlock	24	24	24	24	17
298	Unknown Conifer	24	24	24	24	17

HARDWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF BARK

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
312	Bigleaf maple	--	29	--	29	--
313	Boxelder	--	29	--	29	--
320	Norway maple	--	--	--	--	--
321	Rocky Mountain maple	--	--	--	--	--
333	California buckeye	--	--	--	--	--
341	Tree of heaven	20	--	20	--	--
351	Red alder	20	20	20	20	20
352	White alder	20	20	20	20	20
361	Pacific madrone	--	34	--	34	--
374	Water birch	27	27	27	27	27
375	Paper birch	27	27	27	27	27
431	Golden chinkapin	--	32	--	--	--
475	Curlleaf mountain-mahogany	--	--	--	--	--
492	Pacific dogwood	29	29	29	29	--
500	Hawthorn	37	37	37	37	--
510/511	Eucalyptus	--	--	--	--	--
542	Oregon ash	--	39	--	39	--
547	Velvet ash	--	--	--	--	--
590	Holly	27	27	27	27	27
600	Walnut	--	--	--	--	--
603	N. California black walnut	--	--	--	--	--
604	S. California black walnut	--	--	--	--	--
611	Sweetgum	--	--	--	--	20
631	Tanoak	--	--	--	--	--
660	Apple	37	37	37	37	--
661	Crab apple	37	37	37	37	--
730/731	California sycamore	37	37	37	37	--
746	Quaking aspen	18	18	18	18	18
747	Black cottonwood	28	28	28	28	28
748	Fremont poplar	--	--	--	--	18
756	Honey mesquite	--	--	--	--	--
758	Screwbean mesquite	--	--	--	--	--
760	Cherrys	27	27	27	27	27
763	Common chokecherry	27	27	27	27	35
768	Bitter cherry	27	27	27	27	27
771	Sweet cherry	27	--	--	--	--

HARDWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF BARK

(continued)

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
801	California live oak	--	--	--	--	--
805	Canyon live oak	--	--	--	--	--
807	Blue oak	--	--	--	--	--
811	Englemann oak	--	--	--	--	--
815	Oregon white oak	--	35	--	35	--
818	California black oak	--	--	--	--	--
821	California white oak	--	--	--	--	--
826	Chinkapin oak	--	--	--	--	--
839	Interior live oak	--	--	--	--	--
850	Oak-evergreen	--	--	--	--	--
901	Black locust	--	--	--	29	--
920	Willows	34	34	34	34	--
922	Black willow	--	--	--	--	--
926	Balsam willow	34	--	--	--	--
927	White willow	34	34	--	--	--
929	Weeping willow	--	--	34	--	--
981	California-laurel	--	--	--	--	--
990	Desert ironwood	--	--	--	--	--
997	Russian-olive	--	29	--	29	--
998	Unknown hardwood	20	20	20	20	--
999	Unknown Tree	39	39	39	39	--

Hardwood volume for SPECIES 312, 313, 320, 333, 361, 431, 492, 542, 600, 603, 604, 631, 801, 805, 807, 811, 815, 818, 821, 826, 839, 901, 920, 922, 981, 997 are calculated with Pillsbury equations in western Oregon, western Washington and California; 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. Refer to the Volume Equation document for species assignments to individual equations.

HARDWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF LIVE BRANCHES

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
312	Bigleaf maple	--	27	--	27	--
313	Boxelder	--	16	--	16	--
321	Rocky Mountain maple	--	--	--	--	--
333	California buckeye	--	--	--	--	--
341	Tree of heaven	16	--	16	--	--
351	Red alder	16	16	16	16	16
352	White alder	16	16	16	16	16
361	Pacific madrone	--	28	--	--	--
374	Water birch	25	25	25	25	25
376	paper birch	25	25	25	25	25
431	Golden chinkapin	--	29	--	--	--
475	Curlleaf mountain-mahogany	--	--	--	--	--
492	Pacific dogwood	16	16	16	16	--
500	Hawthorn	16	16	16	16	--
510	Eucalyptus	--	--	--	--	28
542	Oregon ash	--	16	--	16	--
590/591	Holly	26	26	26	26	26
600	Walnut	--	--	--	--	--
603	N. California black walnut	--	--	--	--	--
604	S. California black walnut	--	--	--	--	--
611	Sweetgum	--	--	--	--	16
631	Tanoak	--	--	--	--	--
661	Oregon crabapple	16	16	16	16	--
730, 731	California sycamore	--	--	--	--	--
746	Quaking aspen	14	14	14	14	14
747	Black cottonwood	15	15	15	15	15
748	Fremont poplar	--	--	--	--	5
755	Mesquite	--	--	--	--	--
756	Honey mesquite	--	--	--	--	--
758	Screwbean mesquite	--	--	--	--	--
760	Cherry	25	25	25	25	25
763	Common chokecherry	25	25	25	25	16
768	Bitter cherry	25	25	25	25	25
771	Sweet cherry	25	--	--	--	--

HARDWOOD BIOMASS EQUATION ASSIGNMENTS

BIOMASS OF LIVE BRANCHES

(continued)

Code	Species	Halfstate				
		WOR	WWA	EOR	EWA	CA
801	California live oak	--	--	--	--	--
805	Canyon live oak	--	--	--	--	--
807	Blue oak	--	--	--	--	--
811	Englemann oak	--	--	--	--	--
815	Oregon white oak	--	--	--	--	--
818	California black oak	--	--	--	--	--
821	California white oak	--	--	--	--	--
826	Chinkapin oak	--	--	--	--	--
839	Interior live oak	--	--	--	--	--
901	Black locust	--	--	--	--	--
920	Willows	--	--	--	--	--
922	Black willow	--	--	--	--	--
926	Balsam willow	16	--	--	--	--
927	White willow	16	16	--	--	--
929	Weeping willow	--	--	16	--	--
981	California-laurel	--	--	--	--	--
990	Desert ironwood	--	--	--	--	--
997	Russian-olive	--	16	--	16	--
998	Unknown hardwood	16	16	16	16	--
999	Unknown Tree	16	16	16	16	--

Hardwood volume for SPECIES 312, 313, 320, 333, 361, 431, 492, 542, 600, 603, 604, 631, 801, 805, 807, 811, 815, 818, 821, 826, 839, 901, 920, 922, 981, 997 are calculated with Pillsbury equations in western Oregon, western Washington and California; 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. Refer to the Volume Equation document for species assignments to individual 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

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

EQUATION 2 BIOPAK EQUATION 887

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

EQUATION 3 BIOPAK EQUATION 917

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

EQUATION 4 BIOPAK EQUATION 382

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

EQUATION 5 BIOPAK EQUATION 251

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

EQUATION 6 BIOPAK EQUATION 845

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

EQUATION 7 BIOPAK EQUATION 875

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

EQUATION 8 BIOPAK EQUATION 5

$$\mathrm{BB} = \exp\left(-4.3103 + 2.4300 \times \log\left(DBH\right)\right)$$

EQUATION 9 BIOPAK EQUATION 705

$$\mathrm{BB} = \exp\left(-3.6263 + 1.34077 \times \log\left(DBH\right) + 0.8567 \times \log\left(HT\right)\right)$$

EQUATION 10 BIOPAK EQUATION 391

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

EQUATION 11 BIOPAK EQUATION 899

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

EQUATION 12 (updated) BIOPAK EQUATION 385

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

EQUATION 13 BIOPAK EQUATION 461

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

EQUATION 14 BIOPAK EQUATION 904

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

EQUATION 15 BIOPAK EQUATION 174

$$\mathrm{BB} = \exp\left(-4.371 + 2.259 \times \log\left(DBH\right)\right)$$

EQUATION 16 BIOPAK EQUATION 54

$$\mathrm{BB} = \exp\left(-10.175 + 2.6333 \times \log\left(DBH \times \pi\right)\right)$$

EQUATION 17 BIOPAK EQUATION 394

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

EQUATION 18 BIOPAK EQUATION 942

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

EQUATION 19

$$\mathrm{BB} = 0.0$$

EQUATION 20 BIOPAK EQUATION 275

$$\mathrm{BB} = \exp\left(-4.6424 + 2.4617 \times \log\left(DBH\right)\right)$$

EQUATION 21 BIOPAK EQUATION 911

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

EQUATION 22 BIOPAK EQUATION 881

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

EQUATION 23 BIOPAK EQUATION 923

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

EQUATION 24 BIOPAK EQUATION 893

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

EQUATION 25 BIOPAK EQUATION 857

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

EQUATION 26 BIOPAK EQUATION 455

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

EQUATION 27 BIOPAK EQUATION 948

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

EQUATION 28 BIOPAK EQUATION 930

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

EQUATION 29 (Bigleaf maple)

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

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

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

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

EQUATION 30 (California Black Oak)

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

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

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

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

EQUATION 31 (Canyon Live Oak)

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

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

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

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

EQUATION 32 (Golden Chinkapin)

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

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

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

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

EQUATION 33 (California Laurel)

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

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

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

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

EQUATION 34 (Pacific Madrone)

$$ADBH = \frac{(DBH + 0.03425)}{0.98155} \quad 1$$

$$OUTERVOL = 0.0000378129 \times \left(ADBH^{1.99295}\left(HT^{1.01532}\right)\right) \quad 2$$

$$INNERVOL = 0.0000378129 \times \left(DBH^{1.99295}\left(HT^{1.01532}\right)\right) \quad 3$$

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

EQUATION 35 (Oregon White Oak)

$$ADBH = \frac{(DBH + 0.78034)}{0.95956} \quad 1$$

$$OUTERVOL = 0.0000236325 \times \left(ADBH^{2.25575}\left(HT^{0.87108}\right)\right) \quad 2$$

$$INNERVOL = 0.0000236325 \times \left(DBH^{2.25575}\left(HT^{0.87108}\right)\right) \quad 3$$

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

EQUATION 36 (Tanoak)

$$ADBH = \frac{(DBH + 4.1177)}{0.95354} \quad 1$$

$$OUTERVOL = 0.0000081905 \times \left(ADBH^{2.19576}\left(HT^{1.14078}\right)\right) \quad 2$$

$$INNERVOL = 0.0000081905 \times \left(DBH^{2.19576}\left(HT^{1.14078}\right)\right) \quad 3$$

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

EQUATION 37 (Blue oak)

$$ADBH = \frac{(DBH + 0.44003)}{0.95354} \quad 1$$

$$OUTERVOL = 0.0000204864 \times \left(ADBH^{2.53987}\left(HT^{0.50591}\right)\right) \quad 2$$

$$INNERVOL = 0.0000204861 \times \left(DBH^{2.53987}\left(HT^{0.50591}\right)\right) \quad 3$$

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

EQUATION 38 BIOPAK EQUATION

$$\mathrm{BB} = 3.3 + 9.0 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

EQUATION 39 BIOPAK EQUATION 936

$$\mathrm{BB} = -1.2 + 24.0 \times \left(\frac{DBH}{100}\right)^2 \times HT$$

WHERE

Log	= NATURAL LOG
DBH	= DIAMETER OF TREE IN CENTIMETERS
HT	= HEIGHT OF TREE IN METERS
DENSFAC	= DENSITY FACTOR FOR SPECIES
BB	= BIOMASS OF BARK, WEIGHT IN KILOGRAMS, OF THE BARK ON THE TREE BOLE
π	= 3.141593

BIOMASS OF LIVE BRANCHES

All equations produce Biomass of Live Branches in Kilograms --- to convert to tons multiply by 0.0011023

Log in the equations is = NATURAL LOG

Log = natural log

EQUATION 1 BIOPAK EQUATION 889

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

EQUATION 2 BIOPAK EQUATION 919

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

EQUATION 3 BIOPAK EQUATION 28

$$\mathrm{BLB} = \exp\left(-4.1817 + 2.3324 \times \log\left(DBH\right)\right)$$

EQUATION 4 BIOPAK EQUATION 877

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

EQUATION 5 BIOPAK EQUATION 847

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

EQUATION 6 BIOPAK EQUATION 2

$$\mathrm{BLB} = \exp\left(-3.6941 + 2.1382 \times \log\left(DBH\right)\right)$$

EQUATION 7 BIOPAK EQUATION 702

$$\mathrm{BLB} = \exp\left(-4.1068 + 1.5177 \times \log\left(DBH\right) + 1.0424 \times \log\left(HT\right)\right)$$

EQUATION 8

$$\mathrm{BLB} = \exp\left(-7.637 + 3.3648 \times \log\left(DBH\right)\right)$$

EQUATION 9 BIOPAK EQUATION 901

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

EQUATION 10 BIOPAK EQUATION 459

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

EQUATION 11 BIOPAK EQUATION 907

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

EQUATION 12

$$\mathrm{BLB} = \exp\left(-4.570 + 2.271 \times \log\left(DBH\right)\right)$$

EQUATION 13 BIOPAK EQUATION 51

$$\mathrm{BLB} = \exp\left(-7.2775 + 2.3337 \times \log\left(DBH \times \pi\right)\right)$$

EQUATION 14 BIOPAK EQUATION 944

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

EQUATION 15 BIOPAK EQUATION 932

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

EQUATION 16

$$\mathrm{BLB} = \exp\left(-4.5648 + 2.6232 \times \log\left(DBH\right)\right) - BF$$

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

EQUATION 17

$$\mathrm{BLB} = \exp\left(-5.2581 + 2.6045 \times \log\left(DBH\right)\right)$$

EQUATION 18 BIOPAK EQUATION 883

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

EQUATION 19 BIOPAK EQUATION 925

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

EQUATION 20 BIOPAK EQUATION 895

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

EQUATION 21 BIOPAK EQUATION 446

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

EQUATION 22 BIOPAK EQUATION 859

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

EQUATION 23 Weyerhaeuser Co Equation

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

EQUATION 24 BIOPAK EQUATION 913

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

EQUATION 25 BIOPAK EQUATION 950

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

EQUATION 26 BIOPAK EQUATION 938

$$\mathrm{BLB} = 8.1 + 21.5 \times \left(\frac{DBH}{100} \right)^2 \times HT$$

EQUATION 27 Snell et.al 1983, bigleaf maple

$$\mathrm{BLB} = \exp\left(4.0543553 + 2.1505 \times \log\left(DBH\right)\right)\left(1 - \frac{1}{(4.6762 + 0.0163 \times DBH^{2.039})}\right) \Big/ 1000$$

EQUATION 28 Snell et.al 1983, pacific madrone

$$BLB = \exp\left(3.0136553 + 2.4839 \times \log(DBH)\right)\left(1 - \frac{1}{(1.6013 + 0.1060 \times DBH^{1.309})}\right) \Big/ 1000$$

EQUATION 29 Snell et.al 1983, giant chinkapin

$$BLB = \exp\left(3.1980553 + 2.2699 \times \log(DBH)\right)\left(1 - \frac{1}{1.6048 + 0.2979 \times DBH^{0.6828}}\right) \Big/ 1000$$

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