

| <b>APPLICATION FOR LISTING AN IMPROVED FOREST MANAGEMENT U.S. FOREST OFFSET PROJECT</b>                                                                                                                                                                                                                                                                       |                            |                                                       |                                                       |                                                                                       |
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| <b>OPR<br/>Staff Use<br/>Only</b>                                                                                                                                                                                                                                                                                                                             | Date Application Received: | OPR Tracking Number:                                  | Date Application Reviewed:                            | <b>OPR<br/>Staff Use<br/>Only</b>                                                     |
| <b>PART I. ENTITY APPLYING FOR LISTING</b>                                                                                                                                                                                                                                                                                                                    |                            |                                                       |                                                       |                                                                                       |
| <b>Is this form being submitted by the Offset Project Operator (OPO) or by the Authorized Project Designee (APD)?</b><br>Notes:<br>1. The person completing this form should be an OPO/APD employee.<br>2. If the APD is submitting this form, the OPO should submit the form <i>Designation of Authorized Project Designee</i> simultaneously.               |                            |                                                       |                                                       | <input type="checkbox"/> <b>OPO</b><br><input checked="" type="checkbox"/> <b>APD</b> |
| Name of Person Completing Form:<br>James D. Clark                                                                                                                                                                                                                                                                                                             |                            | Organization, if applicable:<br>NCRM, Inc.            |                                                       |                                                                                       |
| Date Form Completed:<br>2/20/2015                                                                                                                                                                                                                                                                                                                             |                            | Phone Number:<br>707-485-7211                         | Email Address:<br>jimclark@ncrm.com                   |                                                                                       |
| <b>PART II. OFFSET PROJECT INFORMATION</b>                                                                                                                                                                                                                                                                                                                    |                            |                                                       |                                                       |                                                                                       |
| Offset Project Name:<br>Willits Woods IFM                                                                                                                                                                                                                                                                                                                     |                            |                                                       |                                                       |                                                                                       |
| Offset Project Commencement Date:<br>December 22, 2003                                                                                                                                                                                                                                                                                                        |                            | First Reporting Period Start Date:<br>January 1, 2015 | First Reporting Period End Date:<br>December 31, 2015 |                                                                                       |
| Provide an explanation and justification for the commencement date. Specify the action(s) that identify the offset project commencement date.<br>The offset project commencement date is the initiation date of Early Action Project CAR661, the date that Coastal Ridges LLC purchased the Willits Woods property.                                           |                            |                                                       |                                                       |                                                                                       |
| <b>PART III. OPO / APD INFORMATION</b>                                                                                                                                                                                                                                                                                                                        |                            |                                                       |                                                       |                                                                                       |
| <b>A. OPO</b>                                                                                                                                                                                                                                                                                                                                                 |                            |                                                       |                                                       |                                                                                       |
| OPO Name:<br>Coastal Ridges LLC, a California Limited Liability Company                                                                                                                                                                                                                                                                                       |                            |                                                       | OPO's CITSS ID#:<br>CA <u>1 1 5 0</u>                 |                                                                                       |
| Mailing Address:<br>PO Box 537                                                                                                                                                                                                                                                                                                                                |                            | City:<br>Willits                                      | State:<br>CA                                          | Zip:<br>95490                                                                         |
| Contact Person:<br>Lori Withey                                                                                                                                                                                                                                                                                                                                |                            | Phone Number:<br>(707) 459-3096                       | Email Address:<br>loriwithey@sbcglobal.net            |                                                                                       |
| <b>B. APD (if applicable)</b> <span style="float: right;"><input type="checkbox"/> No APD / Not Applicable</span>                                                                                                                                                                                                                                             |                            |                                                       |                                                       |                                                                                       |
| APD Name:<br>James D. Clark                                                                                                                                                                                                                                                                                                                                   |                            |                                                       | APD's CITSS ID#:<br>CA <u>1 5 6 9</u>                 |                                                                                       |
| Mailing Address:<br>PO Box 435                                                                                                                                                                                                                                                                                                                                |                            | City:<br>Calpella                                     | State:<br>CA                                          | Zip:<br>95418                                                                         |
| Contact Person:<br>James D. Clark                                                                                                                                                                                                                                                                                                                             |                            | Phone Number:<br>(707) 485-7211                       | Email Address:<br>jimclark@ncrm.com                   |                                                                                       |
| <b>PART IV. LAND OWNERSHIP</b>                                                                                                                                                                                                                                                                                                                                |                            |                                                       |                                                       |                                                                                       |
| <b>A. Is the Offset Project Operator (OPO) the owner in fee for the Project Area?</b><br>Further documentation is required for all projects. Submit as attachment labeled "Attachment A." See Part X of this listing document for more information.<br>If "no," explain how the entity identified as the OPO has the right to undertake and list the project. |                            |                                                       |                                                       | <input checked="" type="checkbox"/> <b>Yes</b><br><input type="checkbox"/> <b>No</b>  |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                           |                                                                                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| <b>B. 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.).</b><br>The OPO is the only Forest Owner with property interests within the Project Area that affect the trees and standing timber located on the Project Area.                                                                                                                                                                                                                                                                                                                                                                                                     |                                                           |                                                                                                                                           |
| <b>C. Does the offset project occur on public or private lands?</b><br><i>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 as attachment labeled "Attachment B." See Part X of this listing document for more information.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                           | <input checked="" type="checkbox"/> <b>Private</b><br><input type="checkbox"/> <b>Public</b>                                              |
| <b>1. Describe the public process that has been used to approve forest management activities and baseline.</b><br>N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                           |                                                                                                                                           |
| <b>2. Describe the documentation being submitted with this listing document demonstrating approval of planned forest management activities and baseline.</b><br>N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                           |                                                                                                                                           |
| <b>D. Will the project employ a Qualified Conservation Easement (QCE)?</b><br><i>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 listing document for more information.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                           | <input type="checkbox"/> <b>QCE</b><br><input type="checkbox"/> <b>Public Ownership</b><br><input checked="" type="checkbox"/> <b>N/A</b> |
| <b>1. Date that the QCE was or will be recorded.</b><br>N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                           |                                                                                                                                           |
| <b>2. Will the project take place 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?</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                           | <input type="checkbox"/> <b>Yes</b><br><input type="checkbox"/> <b>No</b><br><input checked="" type="checkbox"/> <b>N/A</b>               |
| <b>3. Provide the terms within the easement that affect forest management.</b><br>N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                           |                                                                                                                                           |
| <b>E. Does the offset project occur on any of the following categories of land? (check all that apply)</b><br><input type="checkbox"/> Land that is owned by, or subject to, an ownership of possessory interest of a Tribe<br><input type="checkbox"/> Land that is "Indian lands" of a Tribe as defined by 25 U.S.C. §81(a)(1)<br><input type="checkbox"/> Land that is owned by any person, entity, or Tribe, within the external borders of such Indian lands<br><input checked="" type="checkbox"/> <b>None of the above</b><br><i>If "none of the above," skip to Part V. Otherwise, proceed to 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 listing document for more information.</i> |                                                           |                                                                                                                                           |
| <b>1. Does a limited waiver of sovereign immunity between ARB and the governing body of the Tribe exist?</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                           | <input type="checkbox"/> <b>Yes</b><br><input type="checkbox"/> <b>No</b><br><input checked="" type="checkbox"/> <b>N/A</b>               |
| <b>2. Describe how the land within the Project Area is owned.</b><br>N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                           |                                                                                                                                           |
| <b>PART V. OFFSET PROJECT AREA</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                           |                                                                                                                                           |
| <i>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 listing document for more information.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                           |                                                                                                                                           |
| <b>Latitude of Offset Project Location:</b><br>39.3435                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Longitude of Offset Project Location:</b><br>-123.4378 | <b>Project Area Total Acreage:</b><br>18,008                                                                                              |
| <b>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.</b><br>See Addendum to Application for Listing V.A.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                           |                                                                                                                                           |
| <b>B. Identify the governing jurisdiction(s) applicable to the Project Area.</b><br>See Addendum to Application for Listing V.B.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                           |                                                                                                                                           |
| <b>C. Describe how the Project Area was determined.</b><br>See Addendum to Application for Listing V.C..                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                           |                                                                                                                                           |
| <b>D. Describe the existing land cover, and land use of the Project Area.</b><br>See Addendum to Application for Listing V.D.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                           |                                                                                                                                           |
| <b>E. Describe the forest vegetation types within the Project Area boundary.</b><br>See Addendum to Application for Listing V.E.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                           |                                                                                                                                           |
| <b>F. Describe the site classes within the Project Area boundary.</b><br>See Addendum to Application for Listing V.F.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                           |                                                                                                                                           |

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| <b>G. Describe the land pressures and climate zone/classification applicable to the Project Area.</b><br>See Addendum to Application for Listing V.G.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                               |
| <b>H. Describe the historical land uses, current zoning, and projected land use within the Project Area and surrounding areas.</b><br>See Addendum to Application for Listing V.H.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                               |
| <b>I. Describe generally the forest conditions within the Project Area, including species composition, age class distribution, and management history.</b><br>See Addendum to Application for Listing V.I.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                               |
| <b>PART VI. OFFSET PROJECT ELIGIBILITY</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                               |
| <b>A. Does the project take place on land that has greater than 10 percent tree canopy cover?</b><br><i>Supporting documentation is required. Submit as attachment labeled "Attachment F." See Part X of this listing document for more information.</i><br>See Addendum to Application for Listing VI.A.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <input checked="checked" type="checkbox"/> Yes<br><input type="checkbox"/> No                                 |
| <b>B. Indicate how the offset project meets (or will meet) the definition of Natural Forest Management per Table 3.2 in the Compliance Offset Protocol US Forest Offset Projects, November 14, 2014:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                               |
| <b>1. Native species:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                               |
| <b>a) Will the project consist of at least 95 % native species based on the estimated sum of carbon in the standing live carbon pool?</b><br><i>If "no," proceed to question 1b. Otherwise, skip to question B2.</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <input checked="checked" type="checkbox"/> Yes<br><input type="checkbox"/> No                                 |
| <b>b) Describe how the project will meet this requirement. (Improved Forest Management Projects will be assessed using estimates of basal area per acre.)</b><br>See Addendum to Application for Listing VI.B.1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                               |
| <b>2. Composition of native species:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                               |
| <b>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?</b><br><i>If "no," proceed to questions 2b and 2c. Otherwise skip to question B3.</i><br>See Addendum to Application for Listing VI.B.2.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <input checked="checked" type="checkbox"/> Yes<br><input type="checkbox"/> No                                 |
| <b>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.</b><br>N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                               |
| <b>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.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <input type="checkbox"/> Yes<br><input type="checkbox"/> No<br><input checked="checked" type="checkbox"/> N/A |
| <b>3. Distribution of age classes/sustainable management:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                               |
| <b>a) Indicate how the project will meet the requirement for sustainable management if commercial harvesting is either planned or ongoing 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).</b><br><input type="checkbox"/> Not applicable; no commercial harvesting is occurring within the Project Area.<br><input type="checkbox"/> 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.<br><input checked="checked" type="checkbox"/> 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.<br><input type="checkbox"/> 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).<br>See Addendum to Application for Listing VI.B.3(a). |                                                                                                               |
| <b>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?</b><br><i>If "no," proceed to question 3c. Otherwise, skip to question B4.</i><br>See Addendum to Application for Listing VI.B.3(b).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <input checked="checked" type="checkbox"/> Yes<br><input type="checkbox"/> No                                 |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| <p>c) Explain how the project intends to show continuous progress toward meeting this requirement within the next 25 years.<br/>N/A</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                        |
| <p>4. Structural elements (standing and lying dead wood):<br/>How will the project ensure that structural elements are retained in sufficient quantities throughout the project life?<br/>See Addendum to Application for Listing VI.B.4.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                        |
| <p>C. Describe the management activities that will lead to increased carbon stocks in the Project Area, compared to the baseline.<br/>See Addendum to Application for Listing VI.C.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                        |
| <p>D. Is this project being implemented and conducted as the result of any law, statute, regulation, court order, or other legally binding mandate?<br/>If "yes," explain:<br/>N/A</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <input type="checkbox"/> Yes<br><input checked="" type="checkbox"/> No |
| <p>E. Will the offset project employ broadcast fertilization?</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <input type="checkbox"/> Yes<br><input checked="" type="checkbox"/> No |
| <p>F. Does the offset project take place on land that was part of a previously listed and verified Forest Offset Project?<br/><i>If "yes," proceed to questions E1 and E2. Otherwise, skip to Part VII.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <input checked="" type="checkbox"/> Yes<br><input type="checkbox"/> No |
| <p>1. Was the previous Forest Offset Project terminated due to an Unintentional Reversal?</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <input type="checkbox"/> Yes<br><input checked="" type="checkbox"/> No |
| <p>2. Is the project transitioning to the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014, after previously being listed as an early action offset project?</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <input checked="" type="checkbox"/> Yes<br><input type="checkbox"/> No |
| <p><b>PART VII. CARBON STOCK INVENTORY</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                        |
| <p>A. Provide a general description of the inventory methodology to be 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 the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014.</p> <p>IFM-1 Standing Live:<br/>See Addendum to Application for Listing VII.A.</p> <p>IFM-3 Standing Dead:<br/>See Addendum to Application for Listing VII.A.</p> <p>IFM-6 Soil (if applicable):<br/>See Addendum to Application for Listing VII.A.</p> <p>IFM-7 Carbon in in-use forest products:<br/>See Addendum to Application for Listing VII.A.</p> <p>IFM-8 Forest product carbon in landfills (if applicable):<br/>See Addendum to Application for Listing VII.A.</p> <p>IFM- 9 Biological emissions from site preparation:<br/>See Addendum to Application for Listing VII.A.</p> <p>IFM-14 Biological emissions/removals from change in harvesting on forestland outside project area:<br/>See Addendum to Application for Listing VII.A.</p> <p>IFM-17 Biological emissions from decomposition of forest products:<br/>See Addendum to Application for Listing VII.A.</p> |                                                                        |
| <p>B. Describe the calculation methodologies to be used to determine metric tons per acre for each of the carbon pools included in the Offset Project Data Report.</p> <p>IFM-1 Standing Live:<br/>See Addendum to Application for Listing VII.B.</p> <p>IFM-3 Standing Dead:<br/>See Addendum to Application for Listing VII.B.</p> <p>IFM-6 Soil (if applicable):<br/>See Addendum to Application for Listing VII.B.</p> <p>IFM-7 Carbon in in-use forest products:<br/>See Addendum to Application for Listing VII.B.</p> <p>IFM-8 Forest product carbon in landfills (if applicable):<br/>See Addendum to Application for Listing VII.B.</p> <p>IFM- 9 Biological emissions from site preparation:<br/>See Addendum to Application for Listing VII.B.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                        |

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

See Addendum to Application for Listing VII.B.

**IFM-17 Biological emissions from decomposition of forest products:**

See Addendum to Application for Listing 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 Application for Listing VII.C.

**IFM-3 Standing Dead:**

See Addendum to Application for Listing VII.C.

**IFM-6 Soil (if applicable):**

See Addendum to Application for Listing VII.C.

**IFM-7 Carbon in in-use forest products:**

See Addendum to Application for Listing VII.C.

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

See Addendum to Application for Listing VII.C.

**IFM- 9 Biological emissions from site preparation:**

See Addendum to Application for Listing VII.C.

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

See Addendum to Application for Listing VII.C.

**IFM-17 Biological emissions from decomposition of forest products:**

See Addendum to Application for Listing VII.C.

**D. Provide a summary of the estimated inventory confidence statistics.**

See Addendum to Application for Listing VII.D.

**E. Provide the calculation of the offset project's reversal risk rating and expected contribution to the Forest Buffer Account.**

See Addendum to Application for Listing 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 Compliance Offset Protocol U.S. Forest Projects, November 14, 2014.**

Please see the Modeling Plan included as Attachment K.

**2. Describe and estimate the project's baseline onsite carbon stocks. Explain any annual changes in baseline carbon stocks over time.**

This information is contained in the Modeling plan included as Attachment K

*A graph portraying the baseline onsite carbon stocks, labeled "Attachment G," and a diagram of the baseline incorporating all required carbon stocks, labeled "Attachment H," are required. See Part X of this listing document for more information.*

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

Cryptos Emulator and/or FORSEE

**4. Harvest Planning**

**a. Is harvesting planned in the Project Area?**

*If "yes," proceed to question 4b. Otherwise, skip to question A5.*

☒ **Yes**

☐ **No**

**b. Will the project use a harvest schedule model?**

*If "yes," proceed to question 4c. Otherwise, skip to question A5.*

☐ **Yes**

☒ **No**

**c. How do you plan to address 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 Application for Listing VIII.A.5.

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

**1. Provide the estimated initial above ground standing live carbon stock per acre for the project, if known.**

Estimated to be approximately 112.38 MgCO<sub>2</sub>e per acre.

**2. Provide the estimated adjusted above ground standing live carb stock per acre, if known.**

Estimated to be approximately 110.24 MgCO<sub>2</sub>e per acre.

**3. Provide the Common Practice statistic associated with the Project Area.**

The Common Practice statistic for the Project Area is 170 MgCO<sub>2</sub>e per acre.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| <p><b>4. Are the Project Area's initial above-ground standing live carbon stocks per acre above or below Common Practice?</b><br/>         At the Project's commencement date of 12/22/2003, the Project's initial above-ground standing live carbon stocks were below the Common Practice statistic listed above.</p> <p><b>If below Common Practice, what is the High Stocking Reference for the Project Area?</b><br/>         See Addendum to Application for Listing VIII.B.4.</p> <p><i>Further documentation is required if project below Common Practice. Submit supporting documents as attachments labeled "Attachment I." See Part X of this listing document for more information.</i></p>                                                                                                                                                                                                                                                                                                              | <input type="checkbox"/> Above<br><input checked="" type="checkbox"/> Below                                          |
| <p><b>5. Does the Forest Owner(s) and its affiliate(s) own land in fee or hold timber rights on land outside the Project Area?</b><br/> <i>If "no," skip to question B.6.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <input checked="" type="checkbox"/> Yes<br><input type="checkbox"/> No                                               |
| <p><b>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)?</b><br/> <i>If "no," skip to question B.6.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> Yes<br><input checked="" type="checkbox"/> No                                               |
| <p><b>If "yes," is inventory data available for the LMU or will the OPO use a stratified vegetation analysis?</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <input type="checkbox"/> Data available for LMU<br><input type="checkbox"/> Stratified Vegetation Analysis           |
| <p><b>6. Provide a general description of the legal constraints affecting forest management activities in the Project Area; include a description of each constraint (referring to Section 6.2.1.2 in the Protocol) as well as a narrative those constraints have on forest management.</b><br/>         This information is included in the Modeling Plan included as Attachment K.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                      |
| <p><b>7. Provide a description of the modeling techniques used to simulate the effects of the constraint.</b><br/>         This information is included in the Modeling Plan included as Attachment K.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                      |
| <p><b>8. How does the OPO demonstrate financial feasibility of the growth and harvesting regime assumed for the baseline? (check one of the boxes)</b><br/> <input checked="" type="checkbox"/> 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<br/> <input type="checkbox"/> 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<br/> <i>Supporting documentation is required. Submit as attachment labeled "Attachment J." See Part X of this listing document for more information.</i><br/>         See Addendum to Application for Listing VIII.B.8.</p> |                                                                                                                      |
| <p><b>C. Required for Improved Forest Management Projects on <u>Public Lands ONLY</u></b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                      |
| <p><b>1. Has an initial forest carbon inventory been conducted for the Project Area?</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <input type="checkbox"/> Yes<br><input type="checkbox"/> No<br><input checked="" type="checkbox"/> N/A               |
| <p><b>2. Provide a projection of future changes to Project Area forest carbon stocks extrapolating from historical trends.</b><br/>         N/A</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                      |
| <p><b>3. Explain how current public policy will affect onsite carbon stocks and how the baseline modeling incorporates constraints imposed by all applicable statutes, regulations, policies, plans, and activity-based funding.</b><br/>         N/A</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                      |
| <p><b>4. Have carbon stocks in the Project Area been increasing or declining over the preceding ten-year period?</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <input type="checkbox"/> Increasing<br><input type="checkbox"/> Declining<br><input checked="" type="checkbox"/> N/A |
| <p><b>PART IX. ADDITIONAL QUESTIONS</b></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                      |
| <p><b>A. Have any lands within the Project Area ever been listed or registered with an offset project registry or program in the past?</b><br/> <i>If "yes," identify the registry or program and provide details on the issued credits below.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <input checked="" type="checkbox"/> Yes<br><input type="checkbox"/> No                                               |
| <p><b>B. 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?</b><br/> <i>If "yes," identify the registry or program and provide details on the issued credits below.</i></p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <input checked="" type="checkbox"/> Yes<br><input type="checkbox"/> No                                               |

| Registry/Program:      | Reporting Period(s): | Vintage(s): | Number of Credits Issued: |
|------------------------|----------------------|-------------|---------------------------|
| Climate Action Reserve | 2004                 | 2004        | 45,859                    |
| Climate Action Reserve | 2005                 | 2005        | 108,940                   |
| Climate Action Reserve | 2006                 | 2006        | 117,275                   |
| Climate Action Reserve | 2007                 | 2007        | 126,078                   |
| Climate Action Reserve | 2008                 | 2008        | 135,375                   |
| Climate Action Reserve | 2009                 | 2009        | 145,194                   |
| Climate Action Reserve | 2010                 | 2010        | 155,565                   |
| Climate Action Reserve | 2011                 | 2011        | 166,517                   |
| Climate Action Reserve | 2012                 | 2012        | 163,731                   |
| Climate Action Reserve | 2013                 | 2013        | 162,354                   |

## 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. ☒ N/A
- C. If a Qualified Conservation Easement (QCE) has been recorded, provide a copy. The listing information contained in this form and the documents attached to it will eventually be submitted to ARB so submitting a copy of the QCE as an attachment to this listing document fulfills the requirement in 9.1.1.1(18)(a) of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014 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(I) 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 (4<sup>th</sup> 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<sub>2</sub>e depicted on the y-axis.
- H. Attach a diagram of the baseline incorporating all required carbon stocks.
- I. For 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 and a summary of volume harvested over the past 10 years. ☐ N/A
- J. 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. ATTESTATIONS AND OPO SIGNATURE**

|                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                        |                                 |                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|---------------------------------|-------------------------------|
| <br>-----<br>Initial                                                                                                                                                              | <b>I certify under penalty of perjury under the laws of the State of California the GHG reductions and/or GHG removal enhancements for</b>                                                                                                                                                                                                                                                                                                                                                            |                                        |                                 |                               |
|                                                                                                                                                                                                                                                                    | Project Name:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                        | Crediting Period<br>Start Date: | Crediting Period<br>End Date: |
|                                                                                                                                                                                                                                                                    | Willits Woods IFM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | from                                   | 01/01/2015                      | to 12/31/2039                 |
|                                                                                                                                                                                                                                                                    | <b>will be measured in accordance with the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014, and all information required to be submitted to ARB is true, accurate, and complete.</b>                                                                                                                                                                                                                                                                                               |                                        |                                 |                               |
| <br>-----<br>Initial                                                                                                                                                              | <b>I understand I am voluntarily participating in the California Greenhouse Gas Cap-and-Trade Program under title 17, article 5, and by doing so, I am now subject to all regulatory requirements and enforcement mechanisms of this program and subject myself to the jurisdiction of California as the exclusive venue to resolve any and all disputes arising from the enforcement of provisions in this article.</b>                                                                              |                                        |                                 |                               |
| <br>-----<br>Initial                                                                                                                                                              | <b>I understand that the offset project activity and implementation of the offset project must be in accordance with all applicable local, regional, and national environmental and health and safety laws and regulations that apply to the offset project location. I understand that offset projects are not eligible to receive ARB or registry offset credits for GHG reductions and GHG removal enhancements that are not in compliance with the requirements of the cap-and-trade program.</b> |                                        |                                 |                               |
| <b>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).</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                        |                                 |                               |
| <b>SIGNATURE:</b><br>                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>PRINTED NAME:</b><br>James D. Clark |                                 |                               |
| <b>TITLE:</b><br>APD                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>DATE:</b><br>2/20/2015              |                                 |                               |

## **Background for Application of Listing an Improved Forest Management U.S. Forest Offset Project**

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Section 95975 of the Cap-and-Trade Regulation describes the requirements and process for an Offset Project Operator (OPO) or Authorized Project Designee (APD) to list an offset project with an approved Offset Project Registry. This form is designed to help an OPO or APD fulfill the requirements of Section 95975 of the Cap-and-Trade Regulation and of Section 9.1.1 of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014, for listing an offset project. The U.S. Forest protocol designates three project types: Avoided Conversion, Improved Forest Management, and Reforestation. This form is designed for Improved Forest Management projects only. The information in the completed form should be submitted to the approved Offset Project Registry with which the OPO or APD would like their offset project listed.

## **Where to Submit Information Contained in This Form**

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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 Application for Listing an Improved Forest Management U.S. Forest Offset Project**

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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 Applying for Listing:**

- Indicate whether the Offset Project Operator (OPO) or Authorized Project Designee (APD) is submitting the information for project listing. Section 95975(a) of the Cap-and-Trade Regulation requires that the OPO and, if applicable, the APD must register with ARB for the Cap-and-Trade Program prior to listing a project. It also requires that neither the OPO nor APD be subject to any Holding Account restrictions imposed as part of an enforcement action. To register with ARB, please visit the website for Compliance Instrument Tracking System Services (CITSS): <https://www.wci-citss.org/>
- 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. Indicate the offset project commencement date and the start and end dates of the first reporting period; approximations are acceptable if precise dates are unknown.
- 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 when the Project Area is transferred to public ownership, when a conservation easement on the Project Area is recorded, or when submitting the offset project listing information.

### **Part III. OPO/APD Information:**

- Enter contact information for the OPO and APD requesting the offset project listing. 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 listing form 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 listing form for more information on the precise requirements.
- The Project Area should be determined following the requirements of Section 4 of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014.
- 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 listing form 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 Compliance Offset Protocol U.S. Forest Project, November 14, 2014.
- Details on the Natural Forest Management criteria can be found in Table 3.2 in the Compliance Offset Protocol U.S. Forest Project, November 14, 2014.

#### **Part VII. Carbon Stock Inventory:**

- Projects are not required to have completed a full carbon stock inventory at the time of listing, but OPOs/APDs should be familiar with Appendix A and have a plan for how they will meet the requirements therein. Therefore, a general description of the project's inventory methods and procedures, consistent with the requirements in Appendix A.3, is required at the time of listing. ARB recognizes that some information provided will be preliminary and based on best estimates. If the project's inventory methodology changes between the time of listing and submission of the first OPDR, this should be reported as a change to the information submitted at project listing when submitting the first OPDR.
- Section 6.2 of 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.
- Follow the steps in Appendix D of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014 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. An approximation of the contribution to the Forest Buffer Account is acceptable.

#### **Part VIII. Offset Project Baseline:**

- Projects are not required to have a finalized baseline at the time of listing, but OPOs/APDs should be familiar with Appendix B and have a plan for how they will meet the requirements therein. A complete modeling plan reflecting the requirements in Appendix B.3 is therefore required at the time of listing. ARB recognizes that some information provided will be preliminary or based on best estimates. If the project's modeling plan or baseline estimates change between the time of listing and submission of the first OPDR, this 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.

- Section 6.2 of 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 of the Protocol.
- ARB approved growth models can be found in Appendix B, Section B.1 of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014.
- When a requirement 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 question was not inadvertently left unanswered.

**Part IX. Additional Questions:**

- Answer both questions. If the answer to either 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 application for listing.
- 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. Attestations and OPO Signature:**

- Section 95975(c) of the Cap-and-Trade Regulation requires three attestations for listing an offset project. The required attestations are provided in this section. Each attestation should be initialed by the person signing the form.
- The first attestation requires the applicant to provide the offset project name and the start and end dates of the crediting period to complete the statement. The offset project name should match the name entered in Part II. The dates for the offset project's crediting period must also be provided. Please note that the dates provided in the attestation are for the crediting period, not for the first reporting period provided in Part II. The crediting period dates may be approximate if precise dates are not known.
- Amendments adopted in April 2014 to section 95975(d) require the attestations "be provided to an Offset Project Registry with the listing information, if being listed with an Offset Project Registry."
- The individual signing the document must be registered in CITSS as the OPO's Primary Account Representative or Alternate Account Representative. 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 person's signature, printed name, corporate title, and date signed.

Please contact your Offset Project Registry with any questions.



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# Willits Woods

**Offset Project Name: Willits Woods IFM**

**Addendum to Application for Listing Form**

**Under**

**Air Resources Board**

**Compliance Offset Protocol – U.S. Forest Projects**

**Adopted: November 14, 2014**

**Prepared February 5, 2015**

| <b>Offset Project Operator</b>                                                                                               | <b>Authorized Project Designee</b>                                         |
|------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| <b>Coastal Ridges LLC, a California Limited Liability Company<br/>96 North Main St. Willits, CA 95490<br/>(707) 459-3096</b> | <b>James D. Clark<br/>PO Box 435 Calpella, CA 95418<br/>(707) 485-7211</b> |

## Reporting Period

The reporting period for this Application is from 1/1/2015 to 12/31/2015.

## Protocol Version

Air Resources Board

Compliance Offset Protocol – U.S. forest Projects

Adopted: November 14, 2014

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## Introduction

Willits Woods is a CAR 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 Coastal Ridges, LLC. The Project is approximately 18,008 acres in size. The Willits Woods project is an Early Action project that was initially registered under the Climate Action Reserve's Forest Project Protocol Version 3.2. With this listing, the Willits Woods project is seeking to transition to the Compliance Offset Protocol.

### V.A.

The Project is located within the Northern California Coast Supersection, and the Coast Redwood/Douglas-fir Mixed Conifer Assessment Area. The Project area is classified as both "High" and "Low" Site Class within the Assessment Area.

### 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 title report 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 application.

### V.D.

The existing land cover on the Willits Woods Project Area is generally timberland with small areas of brush land, grasslands and rock outcroppings. The Willits Woods property is zoned Timber Production (TP). The permitted uses on TP land are timber production,

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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 Willits

Woods:

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

The majority of the Project Area is classified as the RDW “Redwood” type. Primary conifer species are coastal redwood and Douglas-fir. The principal hardwood species is tanoak with a mixture of madrone, oak (i.e. *Quercus*), California laurel, and other California hardwoods. On most sites redwood would dominate if vegetation succession were allowed to proceed naturally.

#### V.F.

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

#### V.G.

The Willits Woods Project Area as well as much of the surrounding land is utilized for timber production, recreation, agriculture and rural residential uses. Land pressures associated with these uses are typically conversion of timberland to home sites or agricultural uses such as vineyards. Certificates of Compliance for the 92 separate legal parcels comprising the Willits Woods Project Area have been obtained, thus allowing for the sale and development of these parcels to rural residential home and/or vineyard sites. Residential uses would involve the development of home sites while road use and human activity on the property would increase. Historically, increased human activity has

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resulted in the disruption and displacement of native plants and animals.

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

#### V.H.

There is a long history of human occupation and use within the Project Area. Homesteading began in the mid-1800's and small ranches in the area raised pigs, sheep, horses, and cows. Clearings on the landscape that were flat to gently sloped were planted to annual grains or pasture for forage and hay. Fruit trees and small gardens were common near homesteads. Since early in its history the region was grazed and its timber harvested. Roads and fences and a few foundations are evidence of this agrarian past. Some of the worn fences have been replaced, and some wagon roads updated to graded gravel roads that meander about the property. Modern timber harvesting operations in the Project Area began in the 1930's and continued intermittently until modern times.

The Willits Woods, beginning with the ownership of Coastal Ridges LLC, has been managed under a policy of reduced timber harvesting during the period 12/22/2003 to 12/31/2014. This policy was followed in spite of the fact that there were approved timber harvest plans on portions of the property and timber prices were sufficiently high during most of this period to harvest timber at a profit. As a result of the management decision to forego timber harvesting, carbon stocks within the Project Area increased relative to baseline levels. The reduction in timber harvesting during this period had the combined effect of (i) increasing the overall age of the forest by increasing rotation ages, and (ii) increasing the stocking of trees on understocked areas of the property thus increasing site occupation and increasing forest productivity.

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## V.I.

The Willits Woods Project Area is characterized by a mix of predominantly redwood, Douglas-fir, and tanoak with some ponderosa pine, nutmeg, and hardwoods, consisting of Pacific madrone, bigleaf maple, interior live oak, California bay laurel, black oak, white oak, and other native hardwoods and conifers. It is estimated that, as of 1/1/2015, the Project Area is composed of approximately 27% Douglas-fir, 23% redwood, 2% other conifers, 36% tanoak, 5% Pacific madrone, and 7% other hardwoods by basal area. The Willits Woods owner intends to manage to reduce the hardwood component and increase the component of 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 80 years to 20 years. There has been no timber harvesting on the Project Area since 2003. Presently, the Project Area is covered by several approved timber harvest plans.

## VI.A.

The Willits Woods 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.B.1.

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

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### VI.B.2.

The Willits Woods Project Area is characterized by a mix of predominantly redwood, tanoak, and Douglas-fir, with some ponderosa pine, nutmeg, and hardwoods, consisting of Pacific madrone, bigleaf maple, interior live oak, California bay laurel, black oak, white oak, and other native hardwoods and conifers. It is estimated that, as of 1/1/2015, the Project Area is composed of approximately 27% Douglas-fir, 23% redwood, 2% other conifers, 36% tanoak, 5% Pacific madrone, and 7% other hardwoods by basal area. The Willits Woods owner intends to manage the timber stands to maintain or 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.B.3.

- (a) Commercial harvesting is planned within the Project Area however, since the Project's start date, no commercial harvest activity has taken place. Coastal Ridges obtained approval of an Option A from the California Department of Forestry and Fire Protection ("Cal-Fire") for its Willits Woods ownership. The Option A document describes how Coastal Ridges' timberlands will demonstrate sustainable long-term timber harvesting. All harvest documents currently approved on the Willits Woods Project Area have been approved subject to the provisions of Coastal Ridges' Option A document. The Brant Tract timber cutting rights, the only other property owned by Coastal Ridges, is not included in Coastal Ridges, Option A document, but will meet this sustainable management requirements of this section by employing uneven-aged silvicultural practices and by maintaining canopy retention averaging at least 40% across the forest, as measured on any 20 acres.
- (b) The project proposes to employ uneven-aged management which will maintain no more than 40% of the Project's forested acreage in ages less than 20 years at a

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watershed scale up to 10,000 acres. As the Project Area is larger than 10,000 acres, the Project Area has been split by CALWATER planning watershed groups in order to determine compliance with the above requirement. The Project is located within ten CALWATER planning watersheds with approximately 48% of its timbered acreage within the Olds Creek (1113.200102), James Creek (1113.300301), Broadus Creek (1111.610103), Upper North Fork Big River (1113.300305), East Branch North Fork Big River (1113.300303), Baechtel Creek (1111.610101), or Russell Brook (1113.300202) watershed group, and 52% of its timbered acreage within the Martin Creek (1113.300201), Rice Creek (1113.300203), or Mill Creek (1114.330101) watershed group. Due to past unevenaged management, no more than 40% of the forested area in each watershed group described above is currently less than 20 years in age.

#### VI.B.4.

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

In the case of the Willits Woods Project, the project area has not undergone any salvage harvesting. Therefore, all that must be demonstrated is that the greater of one metric ton of carbon per acre or 1% of standing live carbon stocks is present in standing dead wood, or that progress towards these targets is ongoing. The project currently contains an average of 0.29 Mg

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C per acre and 0.42% 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.C.

Since 2003 there has been no commercial timber harvesting within the Project Area leading to a significant increase in carbon stocks. The forest owner chose to forgo all conifer harvesting during this period in order to allow both conifer and carbon stocking to increase. The projected target stand condition for the Willits Woods Project, will be characterized by a multi-aged conifer stand containing between 180 to 210 square feet of conifer basal area per acre, and approximately 32,000 board feet per acre of conifer volume. At that time hardwoods will comprise approximately 35% of the stand basal area.

The Forest Owner intends to allow conifer and hardwood 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 impliments 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 Forest Owner 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 specific terms of the Forest Project Protocol will guide carbon stock levels over time.

#### VII.A.

IFM-1 Standing Live:

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Standing live carbon will be inventoried based on sample plots installed as part of a forest inventory in 2015. The inventory specifications are included as Attachment L. The cruise design consists of the installation of sample points on a systematic grid 25.4 chains by 25.4 chains in size anchored with a random starting location.

The sample design includes the installation of fixed area plots to measure both live and dead conifers and hardwoods. A 1/250<sup>th</sup> acre fixed area plot was installed at each sample point to sample conifer and hardwood trees 1" DBH to 3.5" DBH; a 1/50<sup>th</sup> acre fixed area plot was installed at each sample point to sample conifer trees 3.5" DBH to 10.4" DBH, and hardwood trees 3.5" DBH and larger; and, a 1/5<sup>th</sup> acre fixed area plot was installed at each sample point to sample conifer trees 10.5" DBH and larger.

Attachment L 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 is 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.

As timber management activities take place on the Willits Woods Project Area, or disturbances such as fire or mortality resulting from pathogens or other factors occur, 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 for the new inventory conducted in 2015 will have been remeasured regardless of

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whether or not the plot had been harvested, treated for hardwood reduction, or subject to other disturbance. On this basis, Willits Woods will maintain a forest inventory system that will meet the inventory specifications and requirements contained in Appendix A of the Protocol, with plots which are no more than 12 years old.

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

1. Any newly installed inventory plots will be incorporated into the inventory estimate.
2. Existing inventory plots will be updated using the CRYPTOS Emulator. Plot data will then be exported to FORSEE for the calculation of the final carbon stock values as described in the modeling plan.
3. Updating the forest inventory for harvests, hardwood reduction or disturbances that have occurred during the previous year through the installation of new plots, or adjustments to previous plot data.
4. Where necessary, the inventory update process may result in restratification of portions of the timber strata.
5. Inventory updates following harvest, hardwood reduction or disturbance will be re-measured within 12 months of the harvest or disturbance.
6. A revised inventory confidence deduction will be calculated following the update process in years when a field verification will be conducted, otherwise the last verified inventory confidence deduction shall be applied.

IFM-3 Standing Dead:

As described above, and in Attachment L, 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

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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 has occurred since the Offset Project Commencement Date. Part B below will include 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 as no harvesting has occurred since the Offset Project Commencement Date. Part B below will include 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 will include documentation of analytic methods and biomass equations used to translate 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.

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## 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 M . 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:

| <b>Species</b>    | <b>Bole Cubic Ft Volume</b> | <b>Bark Biomass</b> | <b>Live Branches Biomass</b> |
|-------------------|-----------------------------|---------------------|------------------------------|
| Redwood           | Equation 24                 | Equations 13 & 17   | Equation 10                  |
| Douglas-fir       | Equation 3                  | Equation 8          | Equation 6                   |
| Cypress           | Equation 19                 | Equation 13         | Equation 10                  |
| 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                  |
| White fir         | Equation 23                 | Equation 1          | Equation 1                   |
| 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                         |
| Live oak          | Equation 44                 | None                | None                         |
| Black oak         | Equation 38                 | None                | None                         |
| White oak         | Equation 41                 | None                | None                         |
| California laurel | Equation 33                 | None                | None                         |
| Golden chinkapin  | Equation 32                 | None                | None                         |
| Bigleaf maple     | Equation 37                 | None                | None                         |
| Red Alder         | Equation 26                 | Equation 20         | Equation 16                  |
| Other hardwood    | Equation 41                 | None                | None                         |

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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 1/3<sup>rd</sup> 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 1/3<sup>rd</sup> of the calculated tree height was less than the measured top height, then the break was assumed to be above the bottom 3<sup>rd</sup> of the tree. Likewise, if 2/3<sup>rd</sup>s of the calculated tree height was less than the measured tree height, the break was assumed to be in the top 3<sup>rd</sup> of the tree.

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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 1/3<sup>rd</sup>, 25% in the middle 1/3<sup>rd</sup>, and 10% in the top 1/3<sup>rd</sup>. 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 Cairnes et. al. specified on page 89 of Appendix A of the Protocol. The formula has as its input, above-ground live biomass in Mg per hectare, and outputs below-ground biomass in Mg per hectare. Total net above-ground live carbon in Kg per acre for each plot is converted to Mg of biomass per hectare by multiplying by 2.471, and then dividing by 1000. After calculating the below ground component in Mg per hectare using the Cairnes model, the results are converted to Kg per acre by multiplying by 1000 and dividing by 2.471.

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 CO<sub>2</sub>-equivalent by multiplying by 3.664.

### IFM-3 Standing Dead:

Data on standing dead trees will be collected as a part of the 2015 Willits Woods 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'.

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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). 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.

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Missing volume of each tree is recorded as a percentage missing by 1/3<sup>rd</sup> 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 1/3<sup>rd</sup> of the calculated tree height is less than the measured top height, then the break is assumed to be above the bottom 3<sup>rd</sup> of the tree. Likewise, if 2/3<sup>rd</sup>s of the calculated tree height is less than the measured tree height, the break is assumed to be in the top 3<sup>rd</sup> 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 1/3<sup>rd</sup> , 25% in the middle 1/3<sup>rd</sup>, and 10% in the top 1/3<sup>rd</sup>. 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:

| Species                 | Decay Class (DC) |       |       |       |       |
|-------------------------|------------------|-------|-------|-------|-------|
|                         | 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 |
| California Nutmeg       | 0.994            | 0.951 | 0.902 | 0.605 | 0.605 |
| Knobcone pine           | 0.953            | 0.950 | 0.927 | 0.598 | 0.598 |
| California black oak    | 1.020            | 0.700 | 0.858 | 0.591 | 0.591 |
| California-laurel       | 0.982            | 0.793 | 0.618 | 0.525 | 0.525 |
| Interior live oak       | 1.02             | 0.841 | 0.705 | 0.591 | 0.591 |
| Pacific madrone         | 0.982            | 0.793 | 0.618 | 0.525 | 0.525 |
| California white oak    | 1.02             | 0.841 | 0.705 | 0.591 | 0.591 |
| Bigleaf maple           | 0.979            | 0.766 | 0.565 | 0.450 | 0.450 |
| Tanoak                  | 0.982            | 0.793 | 0.618 | 0.525 | 0.525 |
| Other Coastal Hardwoods | 1.020            | 0.700 | 0.858 | 0.591 | 0.591 |

Below-ground standing dead carbon is calculated at the plot level using the model provided by Cairnes et. al. specified on page 89 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 CO<sub>2</sub>- 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.

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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 CVTS values derived from the FIA equations listed above. Bark and branch biomass are not included in the volume harvested. The wood densities utilized are those for the Douglas-fir forest type and are included in Table C.1 of Appendix C of the Protocol. The dry weight is multiplied by 0.5 to convert the weight to carbon weight only. The weight of carbon in lbs is divided by 2,204.6 to get the carbon weight in metric tonnes (Mg).

Mg of carbon is then multiplied by 0.675 to account for mill efficiencies, taken from the 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%  |

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**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 |
| Weighted Average       | 0.310 |

Average carbon stored in in-use wood products is calculated using equation C.1. Carbon is converted to CO<sub>2</sub>-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 6.1 and the resulting calculation is multiplied by 80% to account for the “Market Response”.

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

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

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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 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.3 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 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 |
| Weighted Average       | 0.199 |

Average wood products carbon stored in landfills is calculated using equation C.2. Carbon is converted to CO<sub>2</sub>-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.

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

IFM-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.

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## VII.C.

IFM-1 Standing Live: This carbon pool will be calculated each year as described in parts A and B above. A preliminary estimate of the current standing live carbon pool is 4,562,302 MgCO<sub>2</sub>e.

IFM-3 Standing Dead: This carbon pool will be calculated each year as described in parts A and B above. A preliminary estimate of the current standing dead carbon pool is 19,292 MgCO<sub>2</sub>e.

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 is planned 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 is planned 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. A preliminary estimate of biological emissions/removals due to this leakage is 18,627 MgCO<sub>2</sub>e annually.

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

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#### VII.D.

Stratified random sampling formulas taken from Shiver and Borders (1996) will be used to calculate the sampling error for the Willits Woods Project once mean standing live and standing dead pools have been determined for the new 2015 inventory. Preliminary estimates of the inventory confidence statistics, based on the confidence statistics as of 12/31/2010, are as follows:

|                                                   |        |                     |
|---------------------------------------------------|--------|---------------------|
| <b>Mean standing live and standing dead pools</b> | 56.62  | Mg C per acre       |
| <b>SE of mean</b>                                 | 2.389  | Mg C per acre       |
| <b>SE of mean as %</b>                            | 4.219% | $2.389 \div 56.62$  |
| <b>Sampling Error of 90% CI</b>                   | 6.941% | $(4.219\%) * 1.645$ |
| <b>Inventory Confidence Deduction</b>             | 1.9%   | $6.941\% - 5.0\%$   |

#### 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<br>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:*

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

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#### VIII.A.5.

Following the calculation methodologies described in section VII B above, the baseline modeling presented in the Modeling Plan (Attachment K) 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 will be generated by the baseline analysis.

| <b>Woods Products Class</b>                                            | <b>Mg C/ acre</b> | <b>Total Mg CO<sub>2</sub>e</b> |
|------------------------------------------------------------------------|-------------------|---------------------------------|
| Average Annual Carbon 100-year In-Use                                  | 0.240             | 15,871                          |
| Average Annual Carbon 100-year Landfill                                | 0.155             | 10,247                          |
| Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill | 0.141             | 93,133                          |

#### VIII.B.4.

Based on the information available to the Offset Project Operator at this time, the highest value for above-ground standing live carbon stocks per acre within the Project Area during the 10-year period preceding the Project commencement date was equal to the above-ground standing live carbon stocks at the end of the last year of this 10-year period, which is equal to the Project’s initial above-ground standing live carbon stocks (ICS). Therefore the “High Stocking Reference” (HSR) is equal to 80% of the Project’s ICS value of 112.38 MgCO<sub>2</sub>e per acre as reported in Part VIII.B.1 of this application, or 89.90 MgCO<sub>2</sub>e per acre.

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#### VIII.B.8.

In modeling the baseline for standing live carbon stocks, the Forest Owner must incorporate financial constraints that could affect baseline growth and harvesting scenarios. The Willits Woods Project utilized 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 was included as Attachment E to the Willits Woods Project Design Document dated March 14, 2012. This financial analysis has been included as Attachment J of this listing application. 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.

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## **X Attachments**

The following attachments are included as a part of this application for listing:

**Attachment A** - Title Report for the Willits Woods.

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

**Attachment F** – Orthophoto Map of the Project Area.

**Attachment G** – A Graph Portraying the Project’s Baseline.

**Attachment H** – A Diagram of the Project’s Baseline.

**Attachment I** – High Stocking Reference Affidavit.

**Attachment J** – Financial Analysis of the Baseline Scenario

**Attachment K** –Modeling Plan

**Attachment L** –Inventory Specification

**Attachment M** – Volume and Biomass Equations

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

# ATTACHMENT A



# Redwood Empire Title Company of Mendocino County

405 S. Orchard Avenue, P. O. Box 238  
Ukiah, CA 95482  
Phone: (707)462-8666 • Fax: (707)462-5010

Our No.: 20140511DN  
Your No.:  
Seller: Coastal Ridges, LLC  
Buyer: Chevron

When replying Please Contact:  
ESCROW OFFICER: Debbie Niesen  
dniesen@redwoodtitle.com

## PRELIMINARY REPORT

Property Address: **"Willits Woods", Mendocino County, Ca, Willits, CA 95490**

In response to the above referenced application for a policy of title insurance, **Redwood Empire Title Company of Mendocino County** hereby reports that it is prepared to issue, or cause to be issued, as of the date hereof, a Policy or Policies of Title Insurance describing the land and the estate or interest therein hereinafter set forth, insuring against loss which may be sustained by reason of any defect, lien or encumbrance not shown or referred to as an Exception below or not excluded from coverage pursuant to the printed Schedules, Conditions and Stipulations of said Policy forms.

The printed Exceptions and Exclusions from the coverage and Limitations on Covered Risks of said Policy or Policies are set forth in Exhibit A attached. Copies of the Policy forms should be read. They are available from the office which issued this report.

**Please read the exceptions shown or referred to below and the exceptions and exclusions set forth in Exhibit A of this report carefully. The exceptions and exclusions are meant to provide you with notice of matters which are not covered under the terms of the title insurance policy and should be carefully considered.**

**It is important to note that this preliminary report is not a written representation as to the condition of title and may not list all liens, defects and encumbrances affecting title to the land.**

This report (and any supplements or amendments hereto) is issued solely for the purpose of facilitating the issuance of a policy of title insurance and no liability is assumed hereby. If it is desired that liability be assumed prior to the issuance of a policy of title insurance, a Binder or Commitment should be requested.

Dated as of April 8, 2014 at 07:30AM.

John Baron  
Chief Title Officer

jbaron@redwoodtitle.com

The form of policy of title insurance contemplated by this report is:  
CLTA Standard 1990 Owners Policy

Underwritten by Old Republic National Title Insurance Company

## **SCHEDULE A**

1. The estate or interest in the land hereinafter described or referred to covered by this Report is:  
  
a Fee as to Parcels One through Fifty Six and Tracts One through Eight and Parcel One of Tract Nine and Tracts Ten and 11 through 35; an easement as to Parcel Two of Tract Nine and Tract 36
2. Title to said estate or interest at the date hereof is vested in:  
  
Coastal Ridges, LLC, a California limited liability company
3. The land referred to in this report is situated in the State of California, County of Mendocino and is described as follows:

**See Exhibit A attached hereto and made a part hereof.**

## **SCHEDULE B**

At the date hereof exceptions to coverage in addition to the printed Exceptions and Exclusions in the said policy form would be as follows:

1. Taxes and assessments, general and special, for the fiscal year 2014 - 2015, a lien not yet due or ascertainable.
2. The lien of supplemental taxes, if any, assessed pursuant to the provisions of Section 75, et seq. of the Revenue and Taxation Code of the State of California.
3. Rights of the public, County and/or City, in and to that portion of said land lying within the lines of any public road or highway.
4. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: June 20, 1903 in Book 93 of Deeds, Page 320  
For: road
5. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: July 16, 1903 in Book 94 of Deeds, page 66  
For: road
6. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: September 15, 1903 in Book 94 of Deeds, Page 122  
For: right of way
7. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: May 28, 1906 in Book 99 of Deeds, Page 595  
For: right of way for road
8. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: November 9, 1910 in Book 118 of Deeds, Page 102  
For: road
9. Easement(s) for the purposes stated herein and incidental purposes as provided in the following instrument  
Recorded: June 24, 1912 in Book 118 of Deeds, Page 196  
In Favor of: County of Mendocino  
For: road
10. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: April 29, 1921 in Book 164 of Deeds, Page 344  
For: right of way
11. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: October 7, 1939 in Book 132, Page 410 and November 4, 1943 in Book 168, Page 89, Official Records  
For: right of way
12. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: October 5, 1940 in Book 144, Page 91, Official Records  
For: all purposes
13. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: November 26, 1941 in Book 152, Page 380, Official Records  
For: all purposes

14. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: November 8, 1946 in Book 206, Page 18, Official Records  
For: all purposes
15. Terms and provisions as contained in an instrument,  
Entitled : Deed  
Recorded: March 24, 1948 in Book 232, Page 293, Official Records
16. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: November 12, 1948 in Book 236, Page 469, Official Records  
For: right of way for road
17. Easement(s) for the purposes stated herein and incidental purposes as provided in the following instrument  
Recorded: April 3, 1950 in Book 262, page 311, Official Records  
In Favor of: Pacific Gas and Electric Company  
For: public utilities
18. Easement(s) for the purposes stated herein and incidental purposes as provided in the following instrument  
Recorded: May 3, 1950 in Book 262, Pages 385 and 390, Official Records  
In Favor of: County of Mendocino and State of California  
For: road
19. Easement(s) for the purposes stated herein and incidental purposes as provided in the following instrument  
Recorded: June 5, 1951 in Book 290, Page 440 and June 25, 1951 in Book 292, Page 130, Official Records  
In Favor of: County of Mendocino  
For: road
20. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: March 18, 1952 in Book 311, Page 386, Official Records  
For: roads
21. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: March 18, 1952 in Book 311, Page 388, Official Records  
For: road
22. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: May 7, 1953 in Book 343, Page 340, Official Records  
For: all purposes
23. Reservation of all oil, gas and minerals and any implied right to enter upon a portion of the land for the development of oil, gas and minerals as contained the deed recorded May 7, 1953 in Book 343, Page 340, Official Records.
24. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: November 2, 1955 in Book 412, Page 456, Official Records  
For: transporting men, materials and forest products
25. Reservation of all oil, gas and minerals and any implied right to enter upon a portion of the land for the development of oil, gas and minerals as contained the deed recorded November 2, 1955 in Book 412, Page 456, Official Records.

26. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: June 26, 1957 in Book 463, Page 159, Official Records  
For: right to cross
  - a. Terms and provisions contained in the document above referred to.
27. Any facts, rights, interests or claims that may exist or arise by reason of matters, if any, disclosed by those certain Record of Survey maps filed March 29, 1960 in Map Case 2, Drawer 1, Page 34, February 14, 1962 in Map Case 2, Drawer 1, Page 128, February 14, 1962 in Map Case 2, Drawer 1, Page 129 and February 28, 1962 in Map Case 2, Drawer 8, Page 26, Mendocino County Records.
28. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: December 12, 1967 in Book 754, Page 330, Official Records  
For: all purposes
29. Reservation of oil and gas and appurtenances thereto by the United States of America recorded December 31, 1985 in Book 1539, Page 38, Official Records.
30. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: April 3, 1989 in Book 1742, Page 715, Official Records  
For: ingress, egress, public utilities
31. Easement(s) for the purposes stated herein and incidental purposes as provided in the document:  
Recorded: March 13, 1992 in Book 1974, Page 450, Official Records  
For: ingress, egress, public utilities
32. Covenants, Conditions and Restrictions contained in the deed recorded March 13, 1992 in Book 1974, Page 450, Official Records.
33. Any claim or loss arising from any defect or invalidity in, or unenforceability of, the rights described as Parcel Two of Tract Nine, Parcel Two of Tract 12 and Tract 36 herein occasioned by the failure of the instrument which created said rights to contain a sufficient description for the location of such easement, anything contained in the policy or endorsements thereto to the contrary notwithstanding.
34. Easement, terms and provisions as contained in an instrument,  
Entitled : Easement Agreement  
Executed By : Coastal Ridges, LLC and Climate Action Reserve  
Recorded: June 6, 2012 as 2012-08545, Official Records
35. Terms and provisions as contained in an instrument,  
Entitled : Restrictive Covenant and Project Implementation Agreement  
Executed By : Climate Action Reserve and Coastal Ridges, LLC  
Recorded: June 6, 2012 as 2012-08546, Official Records
  - a. First Amendment of Restrictive Covenant and Project Implementatin Agreement recorded April 3, 2013 as 2013-04950, Official Records.
  - b. Second Amendment of Restrictive Covenant and Project Implementatin Agreement recorded March 4, 2014 as 2014-02532, Official Records.

36. Deed of Trust to secure an indebtedness of the amount stated below and any other amounts payable under the terms thereof,  
Amount : \$15,000,000.00  
Trustor/Borrower : Coastal Ridges, LLC, a California limited liability company  
Trustee: Redwood Empire Title Company of Mendocino County  
Beneficiary/Lender: Umpqua Bank  
Dated: December 26, 2013  
Recorded: December 27, 2013 as 2013-19098, Official Records
37. Financing Statement (UCC-1) as follows:  
Debtor: Coastal Ridges, LLC  
Secured Party: Umpqua Bank  
Recorded: December 27, 2013 as 2013-19099, Official Records

**END OF SCHEDULE B**

**INFORMATIONAL NOTES:**

1. Taxes and assessments, general and special, for the fiscal year 2013 - 2014, are paid.
2. NOTE: According to the public records, there have been no deeds conveying the property described in this report recorded within a period of 24 months prior to the date hereof except as follows:  
NONE

## **EXHIBIT "A"**

All that certain real property situated in the County of Mendocino, State of California, more particularly described as follows:

### **PARCEL ONE**

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

#### **SECTION 4:**

THE SOUTH HALF OF THE SOUTHEAST QUARTER; THE SOUTH HALF OF THE NORTH HALF OF THE SOUTHEAST QUARTER; AND THE EAST ONE-HALF OF THE SOUTHWEST ONE-QUARTER.

#### **SECTION 9:**

THE NORTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 147-010-25

### **PARCEL TWO**

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

#### **SECTION 5:**

GOVERNMENT LOT 12.

#### **SECTION 6:**

THE SOUTHWEST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER AND THE NORTH ONE-HALF OF THE SOUTHEAST ONE-QUARTER.

APN: 147-010-11

### **PARCEL THREE**

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

#### **SECTION 5:**

GOVERNMENT LOT 13.

#### **SECTION 7:**

THE NORTHEAST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER.

#### **SECTION 8:**

GOVERNMENT LOTS 4 AND 5.

APN: 147-010-16

### **PARCEL FOUR**

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 5:

GOVERNMENT LOT 14.

SECTION 8:

GOVERNMENT LOTS 2, 3 AND 7.

APN: 147-010-17

PARCEL FIVE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 6:

GOVERNMENT LOTS 5, 6, AND 7 AND THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 147-010-09

PARCEL SIX

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 6:

THE SOUTH ONE-HALF OF THE SOUTHEAST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

SECTION 7:

GOVERNMENT LOT 1 AND THE NORTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER. EXCEPTING THEREFROM THOSE PORTIONS OF SAID LOT 1 LYING WESTERLY OF THE SUMMIT OF THE RIDGE WHICH DIVIDES THE WATERSHEDS OF TWO ROCK CREEK AND THE EAST BRANCH OF BIG RIVER.

APN: 147-010-12

PARCEL SEVEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 5:

LOT 4.

SECTION 6:

GOVERNMENT LOTS 1 AND 2.

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 31:

GOVERNMENT LOT 4 AND THE SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 38-120-96, 147-010-10, X04

PARCEL EIGHT

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 7:

THE WEST ONE-HALF OF THE NORTHEAST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 147-010-13

PARCEL NINE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 7:

THE SOUTHEAST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER AND THE NORTH ONE-HALF OF THE SOUTHEAST ONE-QUARTER.

SECTION 8:

THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER.

APN: 147-010-15

PARCEL TEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 7:

GOVERNMENT LOTS 2, 3 AND 4 AND THE SOUTH ONE-HALF OF THE SOUTHEAST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

EXCEPTING THEREFROM THOSE PORTIONS OF SAID LOTS 2, 3 AND 4 LYING WESTERLY OF THE SUMMIT OF THE RIDGE WHICH DIVIDES THE WATERSHEDS OF TWO ROCK CREEK AND THE EAST BRANCH OF BIG RIVER.

SECTION 18:

GOVERNMENT LOT 1 AND THE NORTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 147-010-14, 147-020-04

PARCEL ELEVEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 8:

THE WEST ONE-HALF OF THE SOUTHEAST ONE-QUARTER.

SECTION 17:

THE NORTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER AND THE NORTH ONE-HALF OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 147-010-19, 147-020-12

PARCEL TWELVE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 8:

GOVERNMENT LOTS 8, 9 AND 16.

SECTION 17:

GOVERNMENT LOT 1.

APN: 147-010-20, 147-020-13

PARCEL THIRTEEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 9:

THE WEST ONE-HALF OF THE NORTHWEST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 147-010-21

PARCEL FOURTEEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 9:

THE WEST ONE-HALF OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 147-010-22

PARCEL FIFTEEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 9:

THE NORTHEAST ONE-QUARTER.

APN: 147-010-26

PARCEL SIXTEEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 9:

THE NORTHEAST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

SECTION 10:

GOVERNMENT LOTS 4, 5, 6, 9 AND 10.

APN: 147-010-27, 147-061-19

PARCEL SEVENTEEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 9:

THE SOUTHEAST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

SECTION 10:

THE SOUTH ONE-HALF OF THE SOUTHWEST ONE-QUARTER.

SECTION 15:

THE NORTHWEST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 147-010-28, 147-061-20, 147-051-05

PARCEL EIGHTEEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 10:

GOVERNMENT LOTS 7 AND 8.

SECTION 11:

GOVERNMENT LOT 7.

APN: 147-061-24, 147-065-01

PARCEL NINETEEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 10:

GOVERNMENT LOTS 13, 14, 15 AND 16.

SECTION 11:

GOVERNMENT LOTS 22 AND 23.

APN: 147-061-25, 147-065-02

PARCEL TWENTY

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 14:

GOVERNMENT LOTS 16, 17, 18 AND 21.

APN: 147-052-03, 16

PARCEL TWENTY-ONE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 14:

GOVERNMENT LOTS 19 AND 20.

SECTION 22:

GOVERNMENT LOT 9.

SECTION 23:

THE NORTHWEST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 147-052-15, 147-054-11

PARCEL TWENTY-TWO

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 14:

GOVERNMENT LOT 10.

SECTION 15:

GOVERNMENT LOTS 9 AND 10 AND THE WEST ONE-HALF OF THE NORTHEAST ONE-QUARTER.

EXCEPTING THEREFROM THAT PORTION CONVEYED TO RICHARD WOOD IN INSTRUMENT RECORDED AUGUST 31, 1984 IN BOOK 1472 AT PAGE 505 OF THE OFFICIAL RECORDS OF MENDOCINO COUNTY, CALIFORNIA.

APN: 147-051-08, 147-052-01

PARCEL TWENTY-THREE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 15:

GOVERNMENT LOTS 2, 3, 4, 5, 6, 7 AND 8.

APN: 147-051-06, 07

PARCEL TWENTY-FOUR

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 15:

GOVERNMENT LOTS 11 AND 12 AND THE WEST ONE-HALF OF THE SOUTHEAST ONE-QUARTER.

APN: 147-051-09

PARCEL TWENTY-FIVE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 16: ALL.

APN: 147-020-17, 18

PARCEL TWENTY-SIX

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 17:

GOVERNMENT LOTS 7, 8, 9 AND 16.

APN: 147-020-14

PARCEL TWENTY-SEVEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 17:

GOVERNMENT LOTS 14 AND 15.

SECTION 20:

GOVERNMENT LOTS 3 AND 6.

APN: 147-020-15

PARCEL TWENTY-EIGHT

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 18:

GOVERNMENT LOT 2.

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 13:

THE EAST ONE-HALF OF THE NORTHEAST ONE-QUARTER AND THE NORTHEAST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 21-390-21, 147-020-05

PARCEL TWENTY-NINE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 18:

THE NORTHEAST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 147-020-06

PARCEL THIRTY

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 18:

GOVERNMENT LOTS 3 AND 4 AND THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 147-020-07

PARCEL THIRTY-ONE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 18:

THE EAST ONE-HALF OF THE SOUTHEAST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 147-020-08

PARCEL THIRTY-TWO

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 19:

GOVERNMENT LOTS 3 AND 4.

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 24:

THE NORTH ONE-HALF OF THE NORTHEAST ONE-QUARTER.

APN: 21-390-13, 147-020-09

PARCEL THIRTY-THREE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 19:

THE EAST ONE-HALF OF THE NORTHWEST ONE-QUARTER AND THE WEST ONE-HALF OF THE NORTHEAST ONE-QUARTER.

APN: 147-020-10

PARCEL THIRTY-FOUR

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 19:

THE EAST ONE-HALF OF THE NORTHEAST ONE-QUARTER.

SECTION 20:

GOVERNMENT LOTS 4, 5, 11 AND 12.

APN: 147-020-11

PARCEL THIRTY-FIVE

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 20:

GOVERNMENT LOTS 1, 2, 7, 8, 9 AND 10.

APN: 147-020-16

PARCEL THIRTY-SIX

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 21:

THE NORTH ONE-HALF OF THE NORTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 147-020-19

PARCEL THIRTY-SEVEN

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 21:

THE EAST ONE-HALF OF THE EAST ONE-HALF AND THE NORTHWEST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER.

APN: 147-020-20, 21

PARCEL THIRTY-EIGHT

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 29:

GOVERNMENT LOTS 2, 7, 9, 10 AND 11.

APN: 147-032-02

PARCEL THIRTY-NINE

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 1:

GOVERNMENT LOTS 2, 3 AND 4 AND THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER.

APN: 21-380-21

PARCEL FORTY

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 1:

THE SOUTHWEST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER.

APN: 21-380-22

PARCEL FORTY-ONE

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION I:

GOVERNMENT LOT 1 AND THE SOUTHEAST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER.

APN: 21-380-23

PARCEL FORTY-TWO

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 2:

GOVERNMENT LOTS 1 AND 2 AND THE SOUTH ONE-HALF OF THE NORTHEAST ONE-QUARTER.

APN: 21-380-20

PARCEL FORTY-THREE

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 12:

THE SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

EXCEPTING THEREFROM THAT PORTION LYING NORTHERLY AND WESTERLY OF THE SUMMIT OF THE RIDGE WHICH DIVIDES THE WATERSHEDS OF TWO ROCK CREEK AND THE EAST BRANCH OF BIG RIVER.

APN: 21-380-14

PARCEL FORTY-FOUR

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 13:

THE NORTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER,

EXCEPTING THEREFROM THAT PORTION OF THE NORTH ONE-HALF OF THE NORTHWEST ONE-QUARTER LYING NORTHERLY AND WESTERLY OF THE SUMMIT OF THE RIDGE WHICH DIVIDES THE WATERSHEDS OF TWO ROCK CREEK AND THE EAST BRANCH OF BIG RIVER.

APN: 21-390-19

PARCEL FORTY-FIVE

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 13:

THE WEST ONE-HALF OF THE NORTHEAST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER AND THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 21-390-20

PARCEL FORTY-SIX

TOWNSHIP 17 NORTH, RANGE 15 WEST, MDB&M

SECTION 13:

THE SOUTH ONE-HALF OF THE SOUTH ONE-HALF.

APN: 21-390-22

PARCEL FORTY-SEVEN

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 30:

THE WEST ONE-HALF OF THE SOUTHEAST ONE-QUARTER AND THE SOUTH ONE-HALF OF THE SOUTHWEST ONE-QUARTER AND THAT PORTION OF THE WEST ONE-HALF OF THE NORTHEAST

ONE-QUARTER DESCRIBED AS: BEGINNING AT THE QUARTER SECTION CORNER BETWEEN SECTIONS 19 AND 30, T18N, R14W, MDB&M; THENCE SOUTH, ON THE WEST SIDE OF SAID WEST ONE-HALF OF THE NORTHEAST ONE-QUARTER, A DISTANCE OF 43.69 CHAINS; THENCE NORTH 83° 34' EAST A DISTANCE OF 19.81 CHAINS TO THE SOUTHEAST CORNER OF SAID WEST ONE-HALF OF THE NORTHEAST ONE-QUARTER; THENCE NORTH 14 AND ONE-HALF DEGREES WEST A DISTANCE OF 42.85 CHAINS; THENCE WEST A DISTANCE OF 9 CHAINS TO THE PLACE OF BEGINNING.

EXCEPTING THEREFROM 2.65 ACRES IN SAID NORTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER AND 1.58 ACRES IN SAID SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AS RESERVED AND EXCEPTED IN THE DEED FROM JASPER M. WILLIAMS ET UX TO BOLTON INVESTMENT COMPANY, A CORPORATION, DATED MAY 29, 1903, RECORDED IN BOOK 94 AT PAGE 122 OF DEEDS OF MENDOCINO COUNTY, CALIFORNIA.

APN: 38-120-90

PARCEL FORTY-EIGHT

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 31:

GOVERNMENT LOTS 1, 2 AND 3 AND THE EAST ONE-HALF OF THE NORTHWEST ONE-QUARTER.

APN: 38-120-19, 94

PARCEL FORTY-NINE

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 31:

THE WEST ONE-HALF OF THE NORTHEAST ONE-QUARTER AND THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 38-120-95

PARCEL FIFTY

TOWNSHIP 18 NORTH, RANGE 15 WEST, MDB&M

SECTION 24:

GOVERNMENT LOTS 6 AND 7 AND THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 21-330-06, 07

PARCEL FIFTY-ONE

TOWNSHIP 18 NORTH, RANGE 15 WEST, MDB&M

SECTION 24:

GOVERNMENT LOTS 14, 15, 16, 17 AND 18.

APN: 21-330-08

PARCEL FIFTY-TWO

TOWNSHIP 18 NORTH, RANGE 15 WEST, MDB&M

SECTION 25:

GOVERNMENT LOTS 1, 2, 3, 4, 5, 9 AND 10.

APN: 21-340-21

PARCEL FIFTY-THREE

TOWNSHIP 18 NORTH, RANGE 15 WEST, MDB&M

SECTION 25:

GOVERNMENT LOTS 8, 11, 12, 13, 14, 16, 17, 18, 19 AND 20,

EXCEPTING THEREFROM THAT PORTION OF GOVERNMENT LOT 14 CONVEYED TO WILLIAM W. BAREFOOTE IN INSTRUMENT RECORDED JANUARY 11, 1978 IN BOOK 1127 AT PAGE 106 OF THE OFFICIAL RECORDS OF MENDOCINO COUNTY, CALIFORNIA.

APN: 21-340-22

PARCEL FIFTY-FOUR

TOWNSHIP 18 NORTH, RANGE 15 WEST, MDB&M

SECTION 26:

THE EAST ONE-HALF OF THE NORTHEAST ONE-QUARTER AND THE EAST ONE-HALF OF THE SOUTHEAST ONE-QUARTER.

APN: 21-310-03

PARCEL FIFTY-FIVE

TOWNSHIP 18 NORTH, RANGE 15 WEST, MDB&M

SECTION 36:

GOVERNMENT LOTS 4, 5, 6, 7, 14, 15, 16 AND 17 AND THE SOUTHWEST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER.

APN: 21-340-10, 11, 13, 23, 24

PARCEL FIFTY-SIX

TOWNSHIP 18 NORTH, RANGE 15 WEST, MDB&M

SECTION 36:

GOVERNMENT LOTS 1, 2, 3, 8, 9, 10, 11, 12, 13, 18, 19 AND 20.

APN: 21-340-25

TRACT ONE:

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 29: THE NORTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE SOUTH ONE-HALF OF THE NORTHWEST ONE-QUARTER.

SECTION 30: THE EAST ONE-HALF OF THE SOUTHEAST ONE-QUARTER.

APN: 38-120-91

TRACT TWO:

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 29: THE EAST ONE-HALF OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHWEST ONE-QUARTER SOUTHWEST ONE-QUARTER.

SECTION 32: THE NORTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 38-120-92

TRACT THREE:

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 29: THE NORTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE SOUTH ONE-HALF OF THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE SOUTH ONE-HALF OF THE SOUTHWEST ONE-QUARTER.

SECTION 32: THE NORTH ONE-HALF OF THE NORTHEAST ONE-QUARTER.

APN: 38-120-93

TRACT FOUR:

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 31: THE EAST ONE-HALF OF THE NORTHEAST ONE-QUARTER.

SECTION 32: THE WEST ONE-HALF OF THE NORTHWEST ONE-QUARTER.

APN: 38-120-X86, X87, X88

TRACT FIVE:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 5:

GOVERNMENT LOTS 3 AND 4.

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 31:

THE EAST ONE-HALF OF THE SOUTHWEST ONE-QUARTER.

SECTION 32:

SOUTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 38-120-X86, X87; 147-010-X04, X05

TRACT SIX:

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 32: THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER AND THE NORTH ONE-HALF OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 38-120-X87, X88

TRACT SEVEN:

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 32: THE SOUTHWEST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER AND THE NORTHWEST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER AND THE SOUTH ONE-HALF OF THE SOUTHEAST ONE-QUARTER.

APN: 38-120-97

TRACT EIGHT:

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 32: THE SOUTHEAST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER AND THE NORTHEAST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

SECTION 33: THE NORTH ONE-HALF OF THE SOUTHWEST ONE-QUARTER.

APN: 38-120-98

TRACT NINE:

PARCEL ONE:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 4:

GOVERNMENT LOTS 3 AND 4.

TOWNSHIP 18 NORTH, RANGE 14 WEST, MDB&M

SECTION 33:

THE SOUTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

APN: 38-120-99; 147-010-23, X07

PARCEL TWO:

THE EASEMENT RESERVED BY R. AND J. TIMBER CO., A CALIFORNIA CORPORATION IN THE DEED TO ARTHUR A. HASCHAK RECORDED MAY 31, 1990 IN BOOK 1833 OF OFFICIAL RECORDS, PAGE 111, MENDOCINO COUNTY RECORDS.

TRACT TEN:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 5:

GOVERNMENT LOTS 5, 6 AND 11.

SECTION 6:

THE SOUTHEAST ONE-QUARTER OF THE NORTHEAST ONE-QUARTER.

APN: 147-010-X04, X05

TRACT 11:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MOUNT DIABLO BASE AND MERIDIAN.

SECTION 4:

NORTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

SECTION 5:

GOVERNMENT LOTS 1, 2, 7, 8, 9 AND 10.

APN: 147-010-06, X05, X07

TRACT 12:

PARCEL ONE:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MOUNT DIABLO BASE AND MERIDIAN.

SECTION 4:

THE SOUTH ONE-HALF OF THE NORTHWEST ONE-QUARTER.

APN: 147-010-24

PARCEL TWO:

THE EASEMENT RESERVED BY R. & J. TIMBER CO., A CAUFORNIA CORPORATION IN THE DEED TO ARTHUR A. HASCHAK RECORDED MAY 31, 1990 IN BOOK 1833 OF OFFICIAL RECORDS AT PAGE 111, MENDOCINO COUNTY RECORDS.

TRACT 13:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MOUNT DIABLO BASE AND MERIDIAN.

SECTION 4:

SOUTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER.

SECTION 5:

GOVERNMENT LOTS 15 AND 16.

SECTION 8:

GOVERNMENT LOT 1.

APN: 147-010-18

TRACT 14:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

THOSE PORTIONS OF SECTION, 3 AND 10 DESCRIBED AS FOLLOWS:

BEGINNING AT THE NORTHWEST CORNER OF GOVERNMENT LOT 5 OF SECTION 3 OF SAID TOWNSHIP AND RANGE; THENCE SOUTH, ALONG THE WEST LINE OF SAID SECTION 3, A DISTANCE OF 3960 FEET TO THE SECTION CORNER COMMON TO SECTIONS 3, 4, 9 AND 10 OF SAID TOWNSHIP AND RANGE; THENCE, CONTINUING SOUTH, ALONG THE SECTION LINE, TO THE SOUTHWEST CORNER OF GOVERNMENT LOT 4 OF SAID SECTION 10; THENCE EAST, ALONG THE SOUTH LINE OF SAID LOT 4 AND GOVERNMENT LOT 3, A DISTANCE OF 2096.9 FEET; THENCE NORTH TO A POINT ON THE SOUTH LINE OF GOVERNMENT LOT 14 OF SAID SECTION 3, WHERE IT IS INTERSECTED BY A FENCE LINE RUNNING IN A NORTHERLY AND SOUTHERLY DIRECTION; THENCE NORTH 16a 42" WEST, ALONG SAID FENCE LINE, 4134.4 FEET TO THE NORTH LINE OF GOVERNMENT LOT 5 OF SAID SECTION 3; THENCE WEST, ALONG SAID NORTH LINE, 857 FEET TO THE POINT OF BEGINNING, EXCEPTING THEREFROM GOVERNMENT LOT 4 OF SAID SECTION 10.

ALSO EXCEPTING THEREFROM THAT PORTION DESCRIBED IN THE DEED TO ARTHUR A. HASCHAK RECORDED MAY 31, 1990 IN BOOK 1833 OF OFFICIAL RECORDS AT PAGE 111, MENDOCINO COUNTY RECORDS.

APN: 147-061-18

TRACT 15:

TOWNSHIP 16 NORTH, RANGE 14 WEST, MDB&M

SECTION 3:

GOVERNMENT LOTS 3 AND 4 AND THE NORTH ONE-HALF OF THE SOUTHWEST ONE QUARTER.

SECTION 4:

NORTHEAST ONE-QUARTER OF THE SOUTHEAST ONE-QUARTER.

APN: 148-170-01, 148-180-01, 148-140-03

TRACT 16:

THOSE PORTIONS OF THE FOLLOWING DESCRIBED PROPERTY LYING NORTHERLY AND EASTERLY OF THE SOUTHERLY AND WESTERLY LINE OF THE PARCEL DESCRIBED IN TRACT THREE, PARCEL ONE OF THE DEED FROM RICHARD L PADULA AND THOMAS F. BLANCHFIELD TO PIONEER RESOURCES UNDER RECORDING NO. 1998-12079 OF THE MENDOCINO COUNTY OFFICIAL RECORDS:

TOWNSHIP 16 NORTH, RANGE 14 WEST, MDB&M

SECTION 4:

GOVERNMENT LOTS 1, 2, 3, 6, 7 AND 8.

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 34:

GOVERNMENT LOTS 21 AND 22.

APN: 147-041-14, 148-130-04

TRACT 17:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 22:

THE NORTHWEST ONE-QUARTER.

APN: 147-054-19, 20

TRACT 18:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 22:

GOVERNMENT LOT5 10,11, 14 AND 15.

APN: 147-054-14, 15, 16

TRACT 19:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 22:

GOVERNMENT LOTS 5, 6, 7 AND 8.

APN: 147-054-13

TRACT 20:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 22:

GOVERNMENT LOTS 12, 13 AND 16.

SECTION 23:

GOVERNMENT LOT 13 AND THE NORTHWEST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER  
AND THE SOUTHWEST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

APN: 147-054-17, I8

TRACT 21:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 23:

GOVERNMENT LOTS 14 AND 15 AND THE NORTHEAST ONE-QUARTER OF THE SOUTHWEST ONE-QUARTER AND THE SOUTHEAST ONE-QUARTER OF THE NORTHWEST ONE-QUARTER.

SECTION 26:

GOVERNMENT LOTS 3, 6 AND 11.

APN: 147-041-10, 147-055-02

TRACT 22:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 23:

GOVERNMENT LOTS 5, 6, 11 AND 12.

APN: 147-055-01

TRACT 23:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 26:

GOVERNMENT LOTS 4, 5, 12 AND 13.

SECTION 27:

GOVERNMENT LOTS 1, 8, 9 AND 16.

APN: 147-041-09

TRACT 24:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 26:

GOVERNMENT LOT 14.

SECTION 34:

GOVERNMENT LOT 1.

SECTION 35:

GOVERNMENT LOTS 3 AND 4.

APN: 147-041-17

TRACT 25:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 27:

GOVERNMENT LOTS 2, 7, 10 AND 11.

APN: 147-041-07

TRACT 26:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 27:

GOVERNMENT LOTS 3, 4, 5, 6, 12 AND 13.

APN: 147-041-01

TRACT 27:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 27:

GOVERNMENT LOTS 14 AND 15.

SECTION 34:

GOVERNMENT LOT 2.

APN: 147-041-08

TRACT 28:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 28:

GOVERNMENT LOTS 1, 4, 5, 6 AND 7.

APN: 147-033-03, 06

TRACT 29:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 28:

GOVERNMENT LOT 8.

SECTION 33:

GOVERNMENT LOTS 5 AND 6.

SECTION 34:

GOVERNMENT LOTS 11 AND 12.

APN: 147-033-07, 147-036-02, 03, 09, 147-041-11

TRACT 30:

THOSE PORTIONS OF THE FOLLOWING DESCRIBED PROPERTY LYING NORTHERLY AND EASTERLY OF THE SOUTHERLY AND WESTERLY LINE OF THE PARCEL DESCRIBED IN TRACT THREE, PARCEL ONE OF THE DEED FROM RICHARD L. PADULA AND THOMAS F. BLANCHFIELD TO PIONEER RESOURCES UNDER RECORDING NO. 1998-12079 OF THE MENDOCINO COUNTY OFFICIAL RECORDS:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 32:

GOVERNMENT LOTS 1 AND 2.

SECTION 33:

GOVERNMENT LOTS 1, 7, 10, 11 AND 12 AND THE EAST ONE-HALF OF THE NORTHWEST ONE-QUARTER.

APN: 147-035-02, 147-036-08

TRACT 31:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 33:

GOVERNMENT LOTS 8 AND 9.

SECTION 34:

GOVERNMENT LOTS 19 AND 20.

APN: 147-036-07, 147-041-13

TRACT 32:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 34:

GOVERNMENT LOTS 9, 10, 13, 14, 15 AND 16.

APN: 147-041-12

TRACT 33:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 34:

GOVERNMENT LOTS 3, 4 AND 6.

SECTION 35:

GOVERNMENT LOT 5.

APN: 147-041-16

TRACT 34:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 34:

GOVERNMENT LOTS 17, 18, 23 AND 24.

APN: 147-041-15

TRACT 35:

TOWNSHIP 17 NORTH, RANGE 14 WEST, MDB&M

SECTION 34:

GOVERNMENT LOTS 5, 7 AND 8.

SECTION 35:

GOVERNMENT LOTS 10, 11, 12 AND 13.

APN: 147-041-18

TRACT 36:

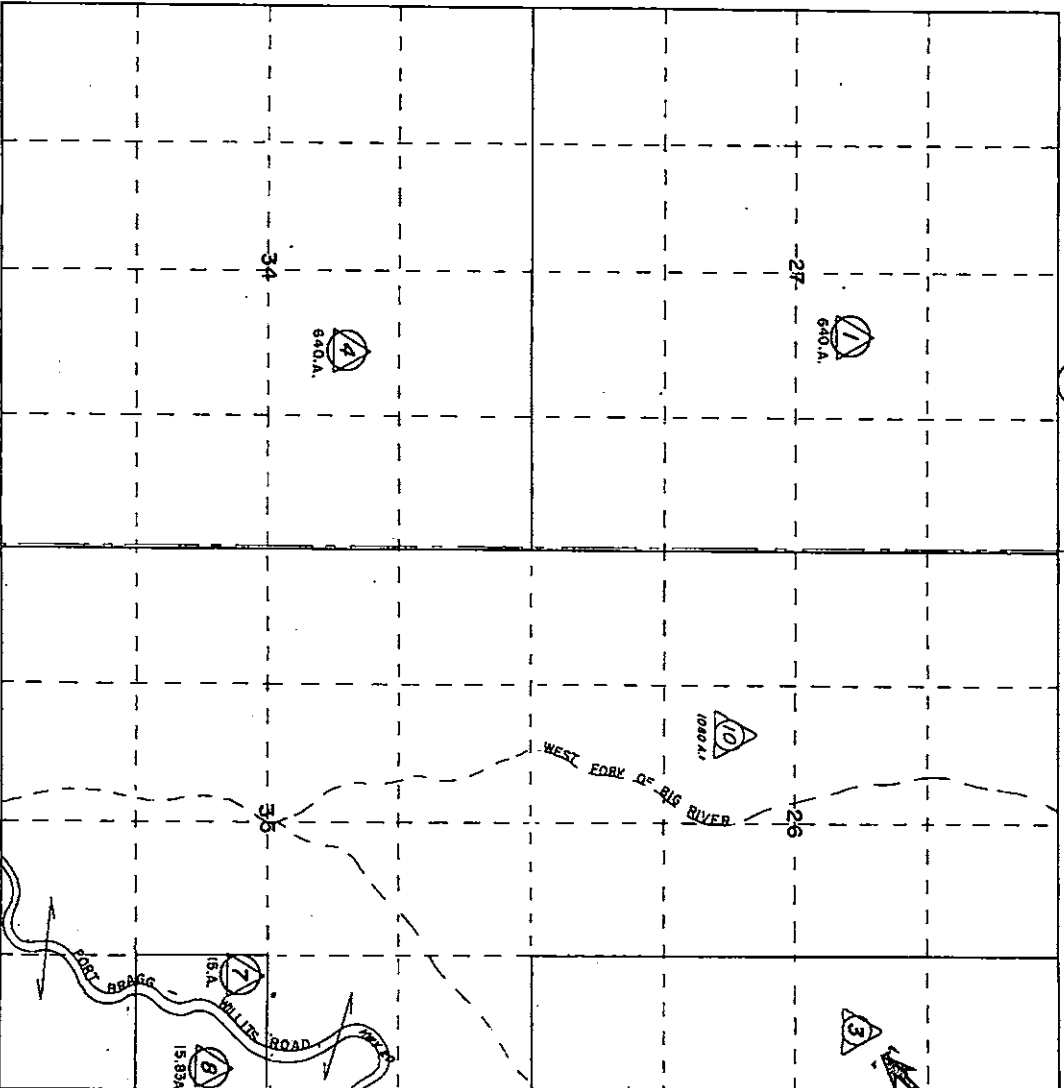
THE EASEMENTS CONVEYED IN THE DEED FROM SONOMA MOUNTAIN CO., TO RICHARD L PADULA, ET AL RECORDED MARCH 13, 1992 IN BOOK 1974 OF OFFICIAL RECORDS AT PAGE 450, MENDOCINO COUNTY RECORDS.

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Sec. 26, 27, 34, 35 T. 18 N. R. 15 W., M. D. B. & M.

153-003  
104-013

21-31



NOTE: This map was prepared for  
assessor's purposes only. No liability  
is assumed for the data delineated  
hereon.

104-013  
153-003

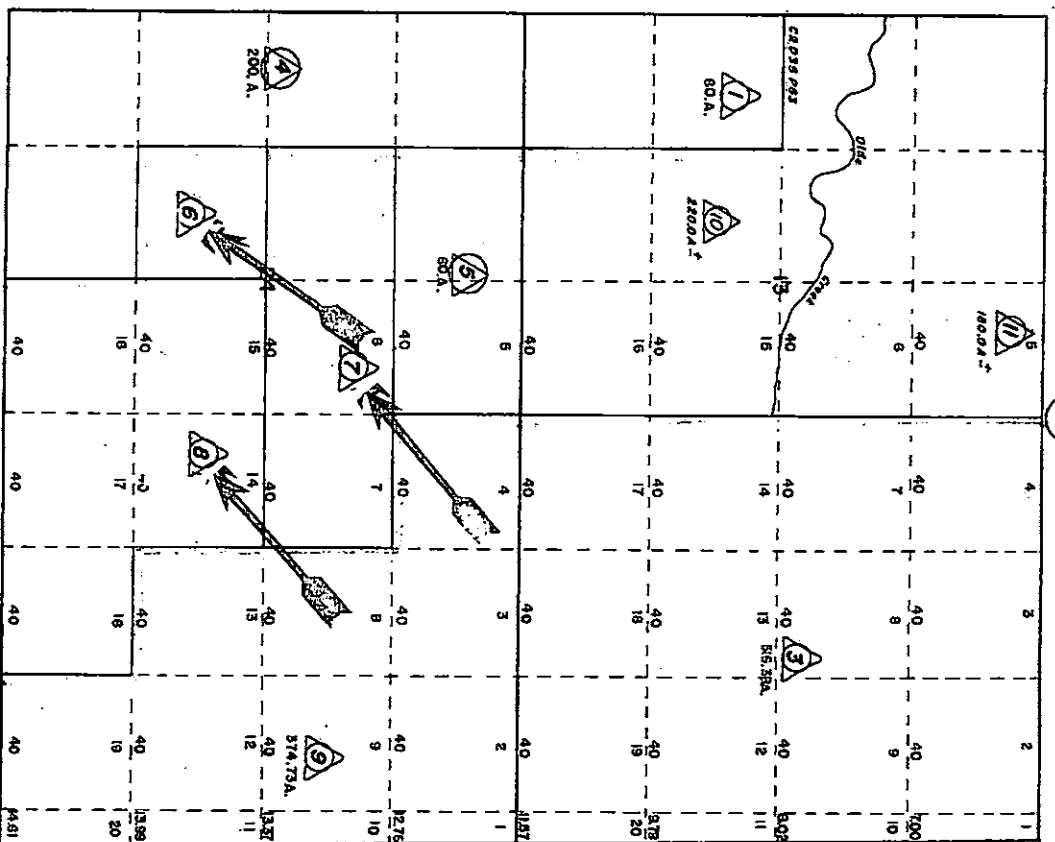
Assessor's Map  
County of Mendocino, Calif.  
March, 1950 MAY 02 1997

Sec. 13, 24 T. 18 N. R. 15 W., M.D.B. & M.

153 - 006

21 - 33

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Assessor's Map  
County of Mendocino, Calif.  
March, 1950

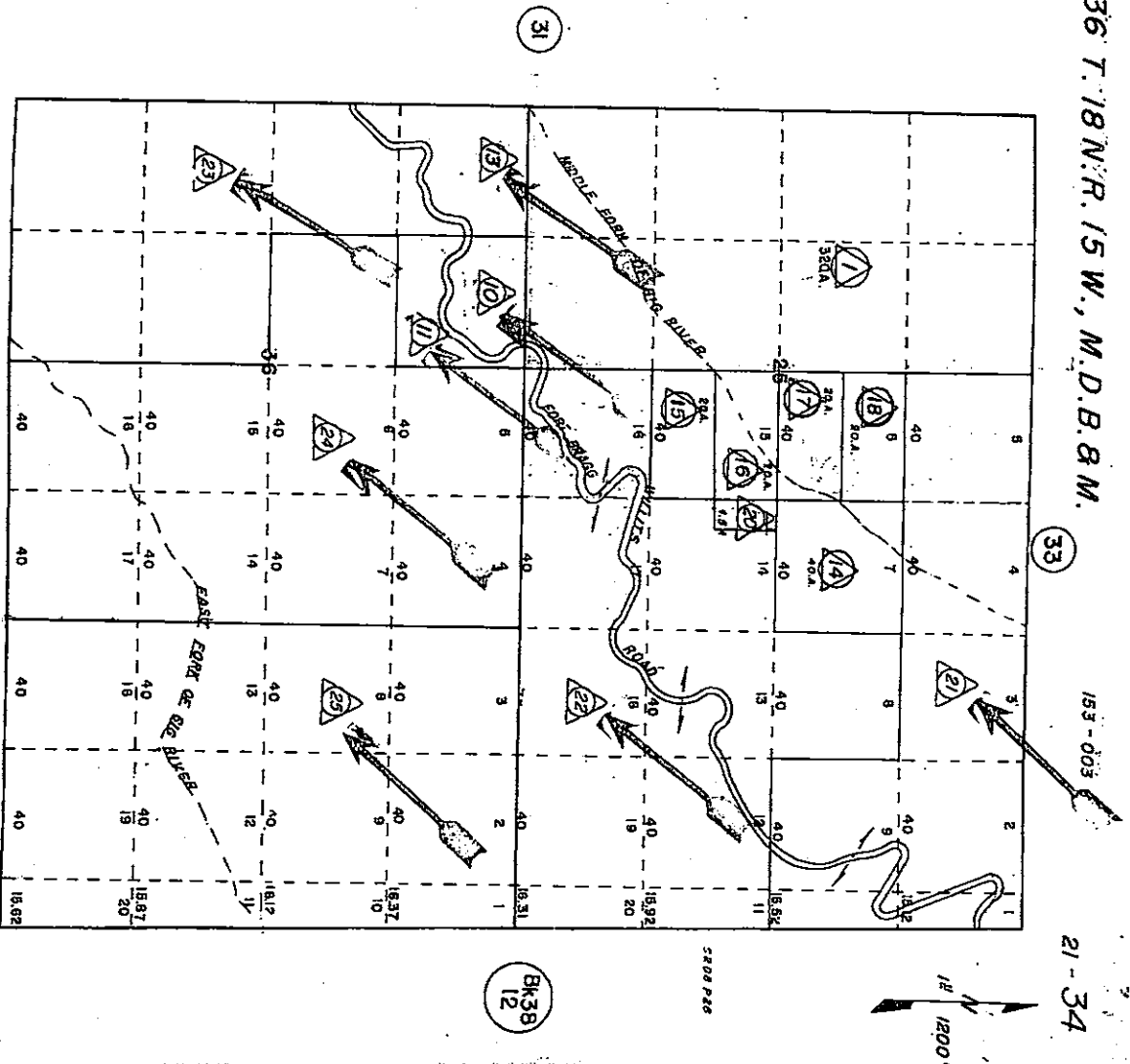
29

32

BK38  
11

Sec. 25, 36 T.18 N. R. 15 W., M.D.B. & M.

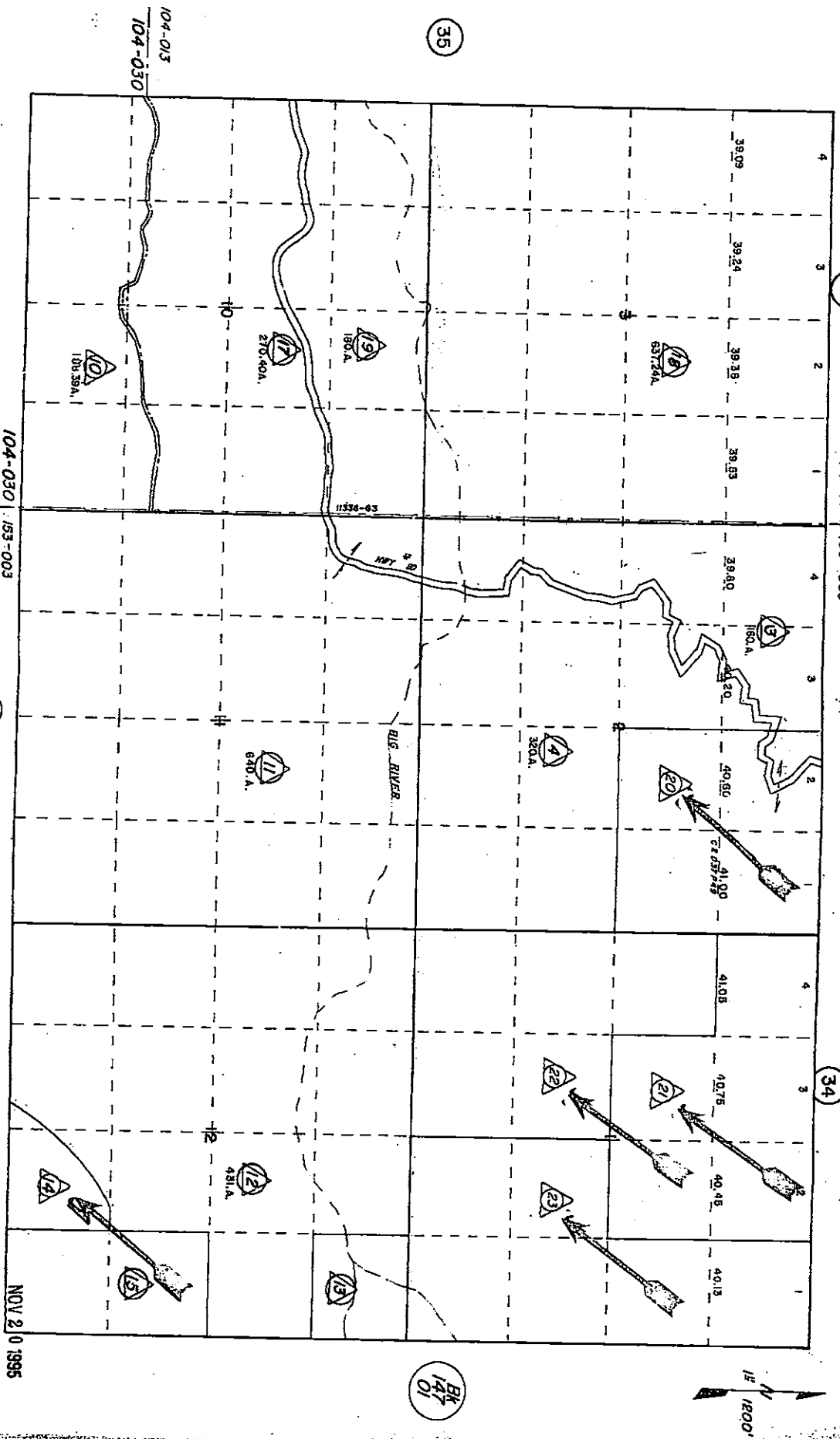
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NOTE: This map was prepared for  
Assessor's Map NOV 2 0 1995  
County of Mendocino, Calif.  
March, 1950

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 merely as a convenience to aid you in locating, and  
 indicated hereon with reference to streets and other land.  
 No liability is assumed by reason of any reliance hereon."

Sec. 1, 2, 3, 10, 11, 12 T. 17 N. R. 15 W., M.D.B. & M.



NOTE: This map was prepared for  
 assessment purposes only. No liability  
 is assumed for the data indicated  
 hereon.

Assessor's Map  
 County of Mendocino, Calif.  
 March, 1950

NOV 20 1995

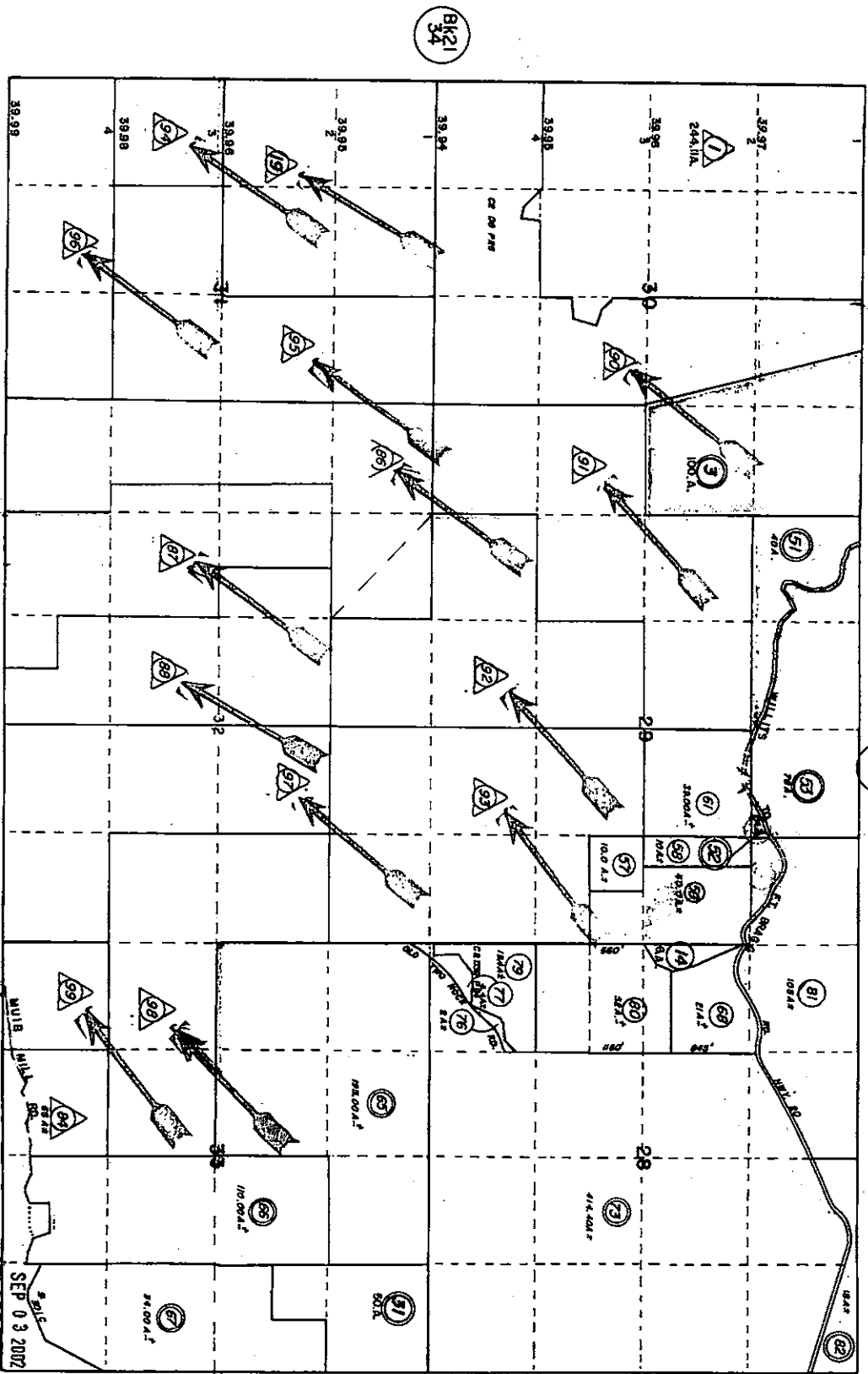


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Sec. 28, 29, 30, 31, 32, 33, T. 18 N. R. 14 W. M.D.B. & M.

153 ± 0.4'

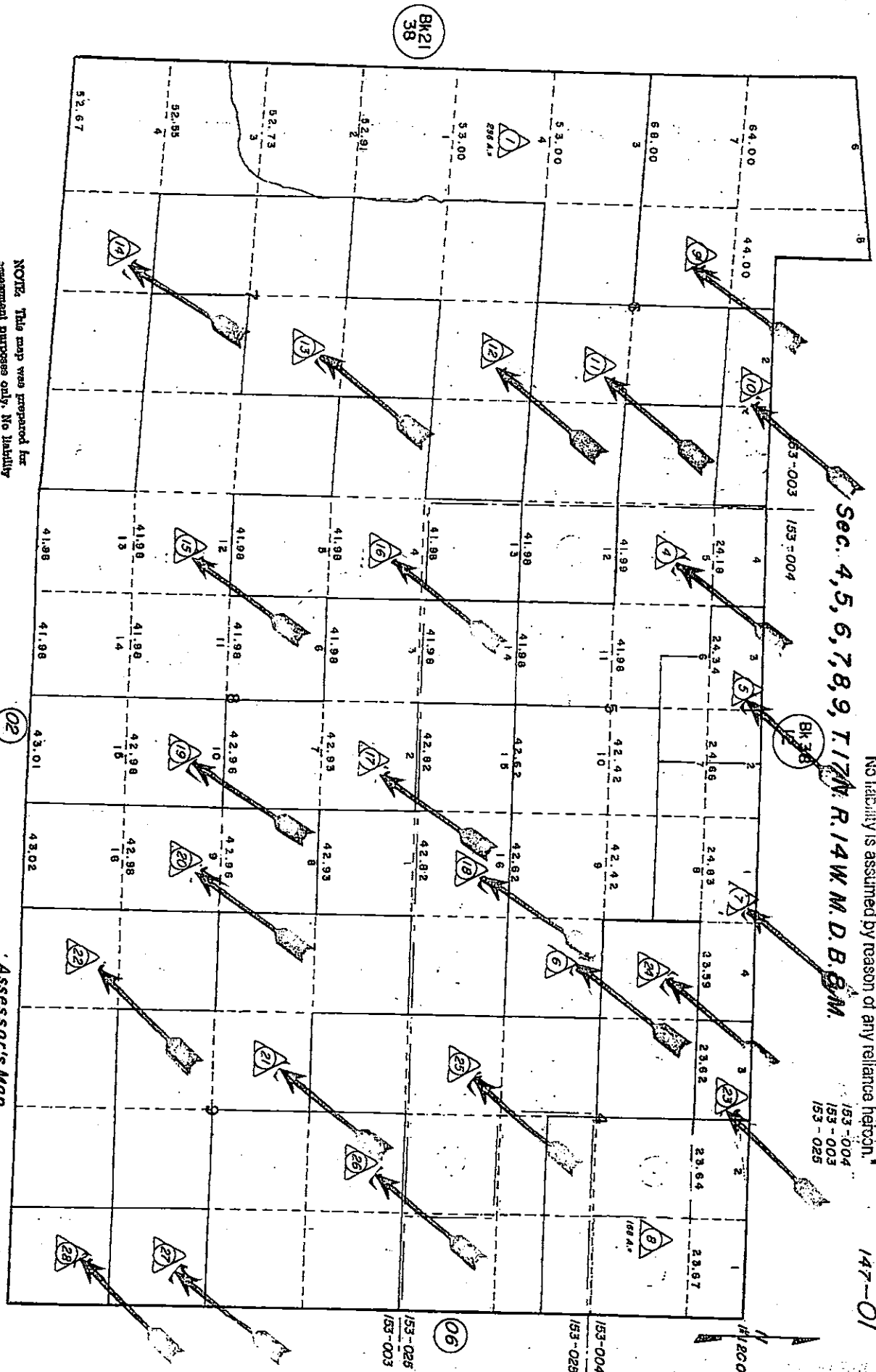
38 - 12



NOTE: This map was prepared for assessment purposes only. No liability is assumed for the data delineated hereon.

Assessor's Map  
Mendocino County, Calif.  
March, 1981

SEP 03 2002



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Sec. 4, 5, 6, 7, 8, 9, T. 17 N. R. 14 W. M. D. B. 8 M.

NOTE: This map was prepared for assessment purposes only. No liability is assumed for the data delineated hereon.

Assessor's Map  
County of Mendocino, Calif.  
March 1969

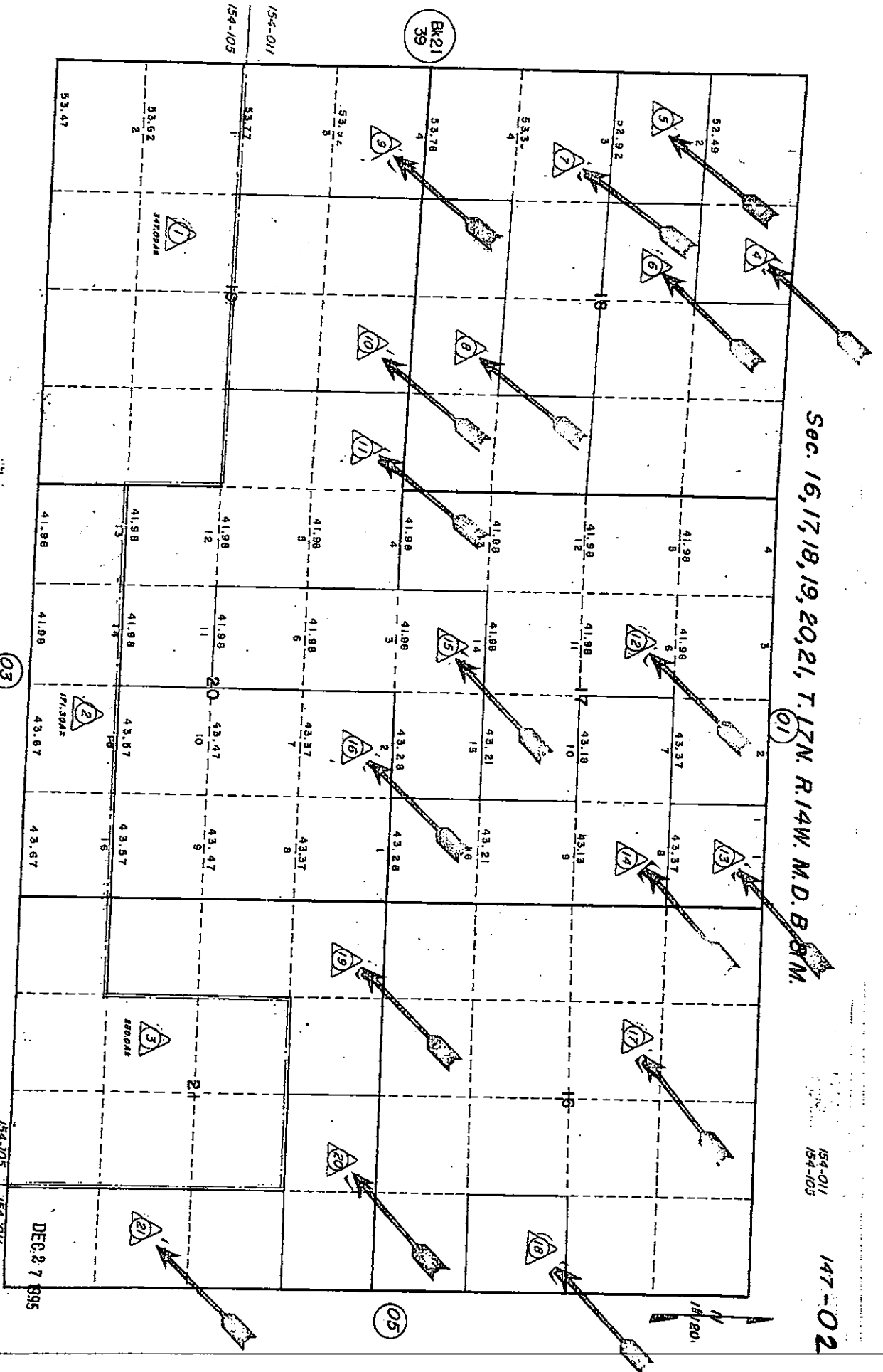
DEC 27 1995

BK 21  
38

BK 36  
12

BK 36  
12

BK 36  
12



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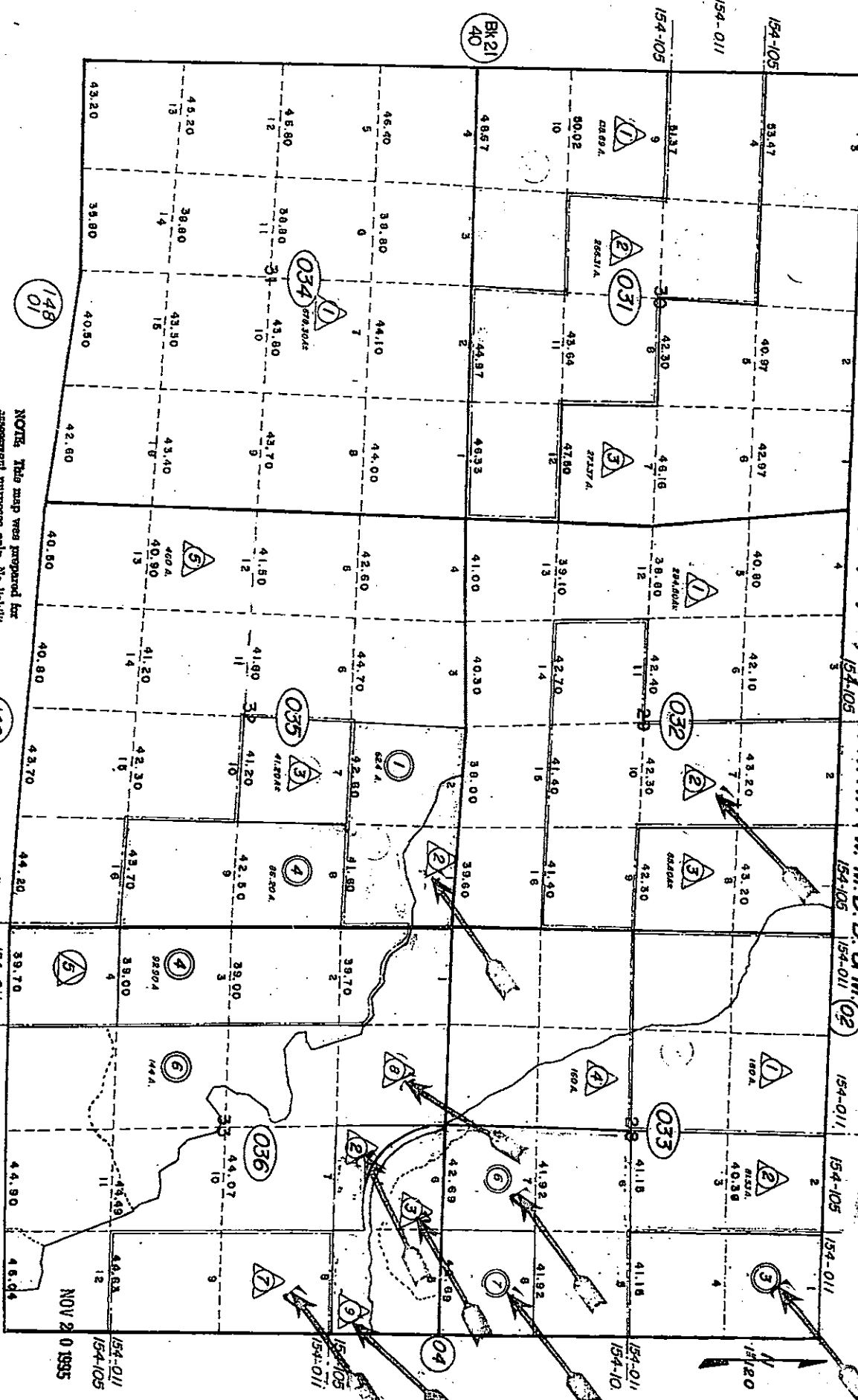
NOTES: This map was prepared for assessment purposes only. No liability is assumed for the data delineated hereon.

Assessor's Map  
County of Mendocino, Calif.  
March 1969

DEC 27 1995

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Sec. 28, 29, 30, 31, 32, 33 T. 17N. R. 14W. M.D.B. & M. (02)



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County of Mendocino, Calif.  
Assessor's Map  
March 1969

Sec. 25,26,27,34,35,36 T.17N. R.14W. M.D.B.&M.

154-008  
154-064

147-04

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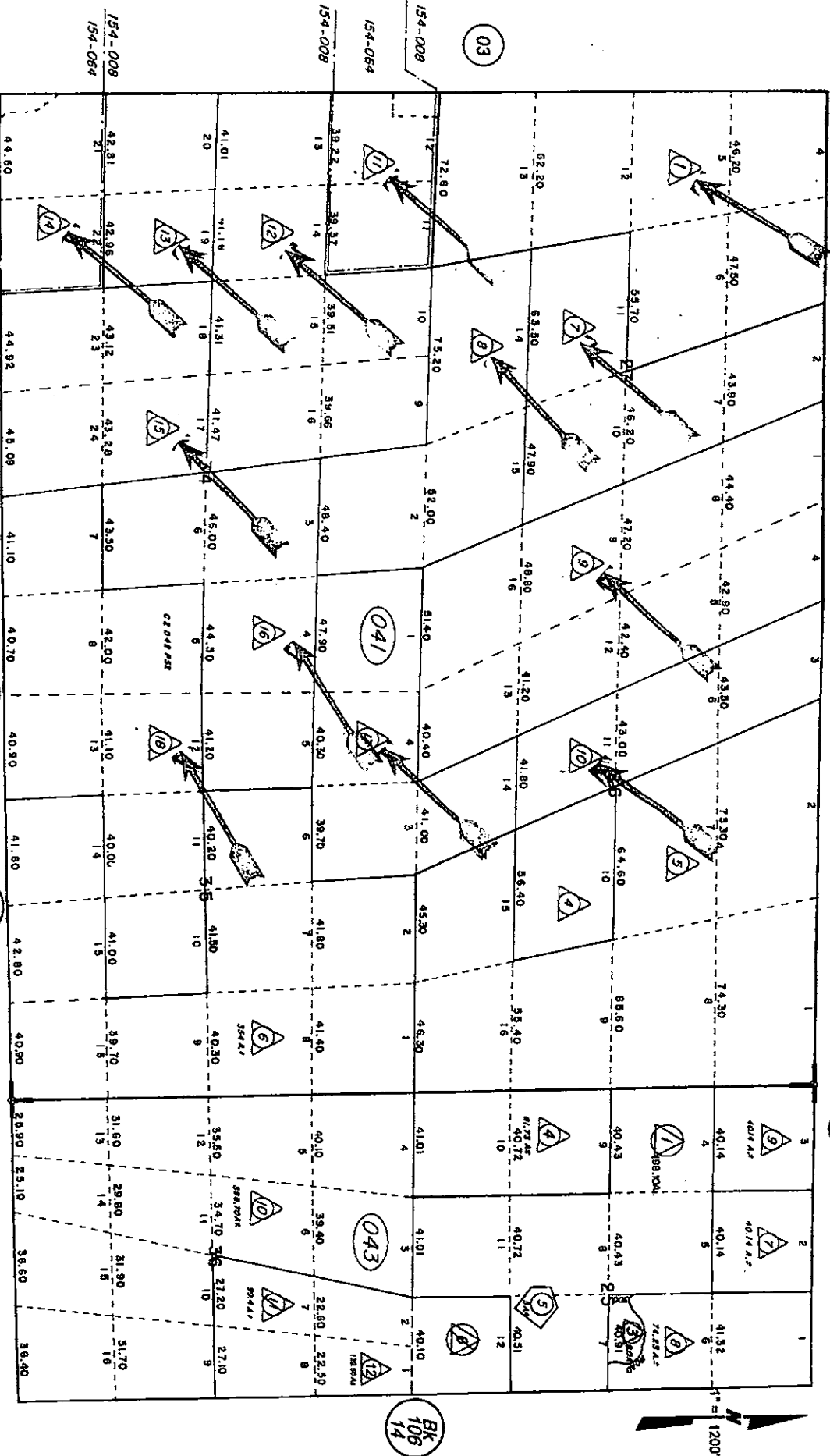
Bk 148  
13

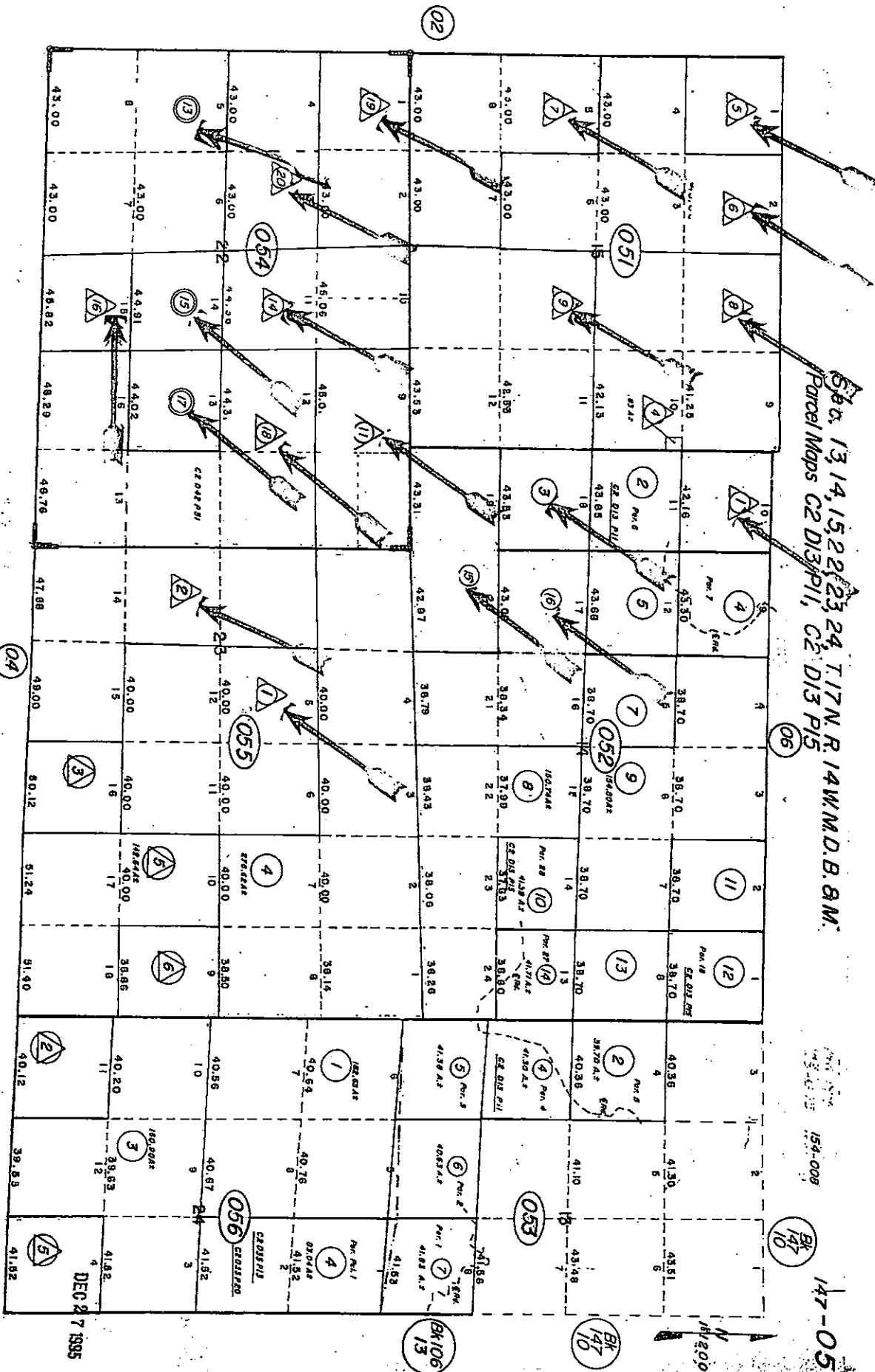
Bk 148  
17

Bk 148  
21

Assessor's Map  
WAT 0 8 2007 County of Mendocino, Calif.  
Updated February 28, 2007

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Notice: This is neither a plat nor a survey. It is furnished merely as a convenience to aid you in locating the land indicated hereon with reference to streets and other land. No liability is assumed by reason of any reliance hereon.

NOTE: This map was prepared by County of Mendocino, Calif. assessment purposes only. No liability is assumed for the data delineated hereon.

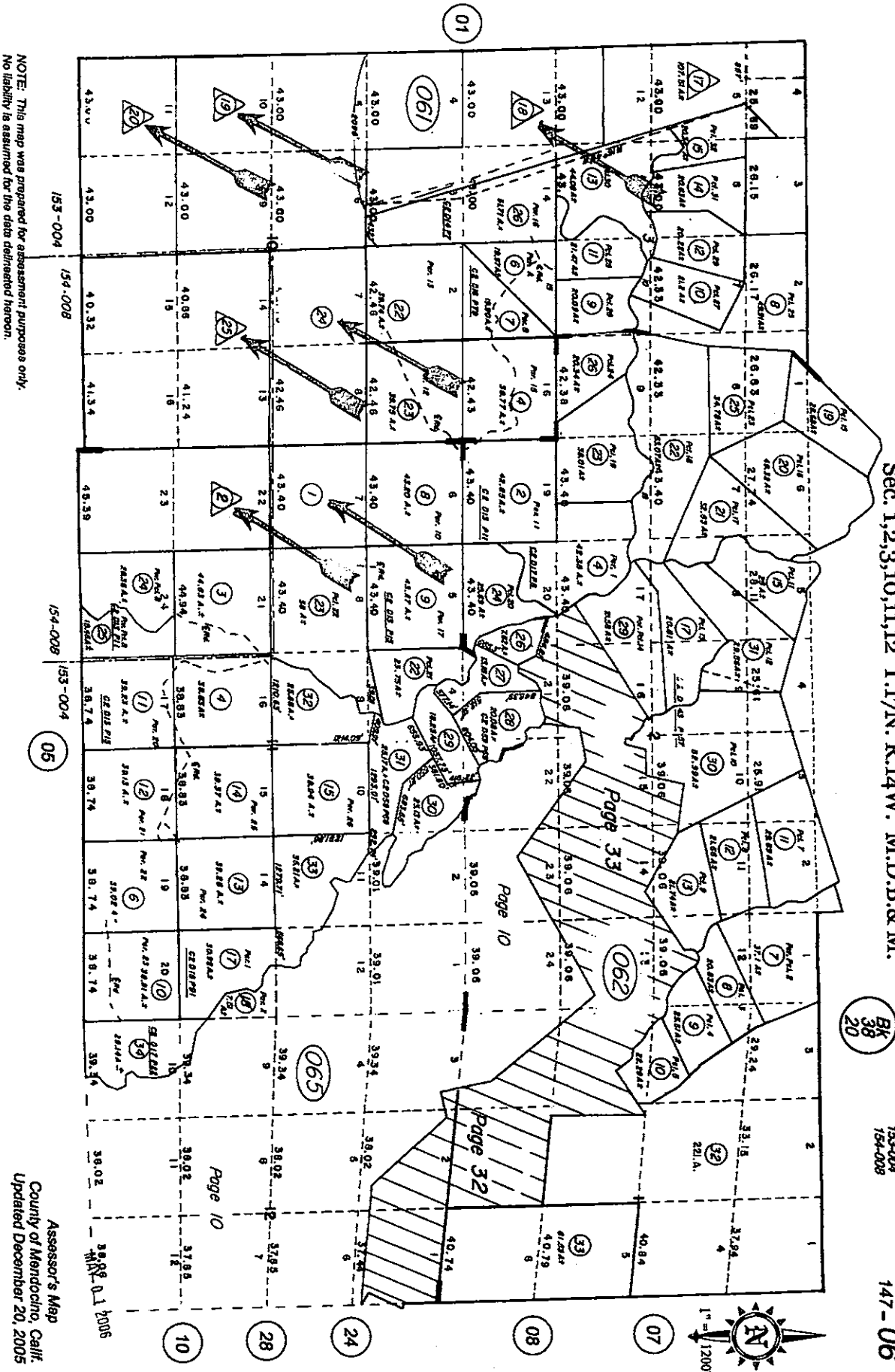
Assessor's Map

March, 1969

DEC 27 1995

Sec. 1,2,3,10,11,12 T.17N. R.14W. M.D.B.&M.

147-06



**NOTE: This map was prepared for assessment purposes only. No liability is assumed for the data delineated hereon.**

**Assessor's Map  
County of Mendocino, Calif.  
Updated December 20, 2005**

N.1/2 Sec. 4, T.16N. R.14W, MDBAM

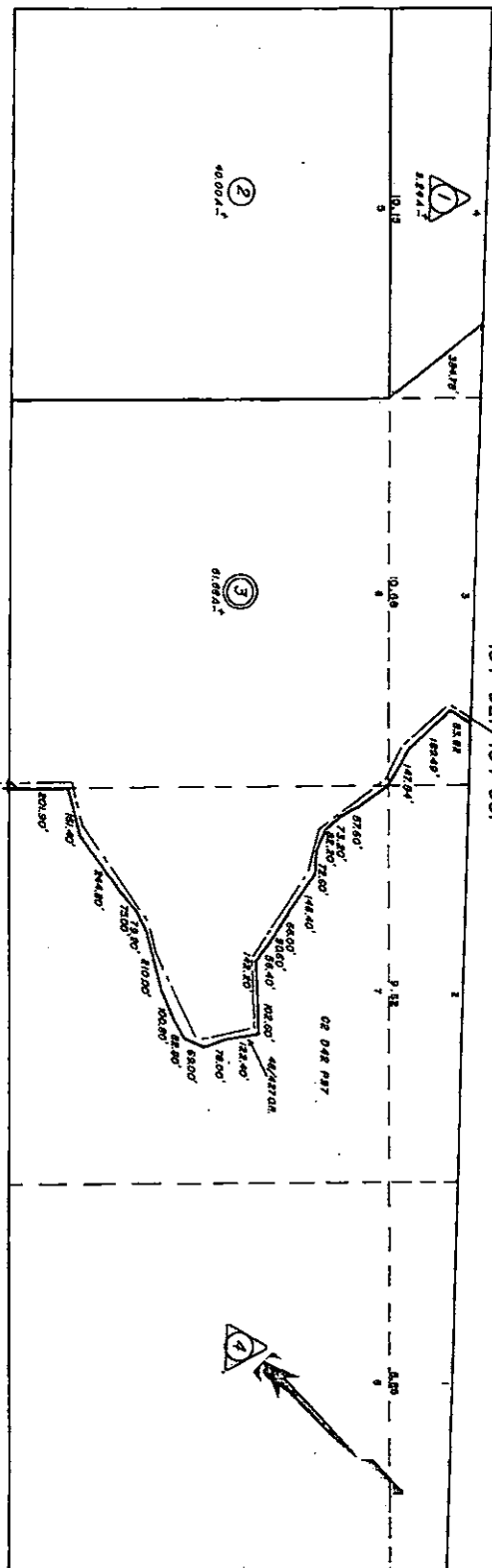
104-02/  
104-031

148-13

"Notice: This is neither a plat nor a survey. It is furnished merely as a convenience to aid you in locating the land. No person with reference to streets and other land. No liability is assumed by reason of any reliance hereon."

68.147  
03

N  
1" = 1400'



09

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14

17

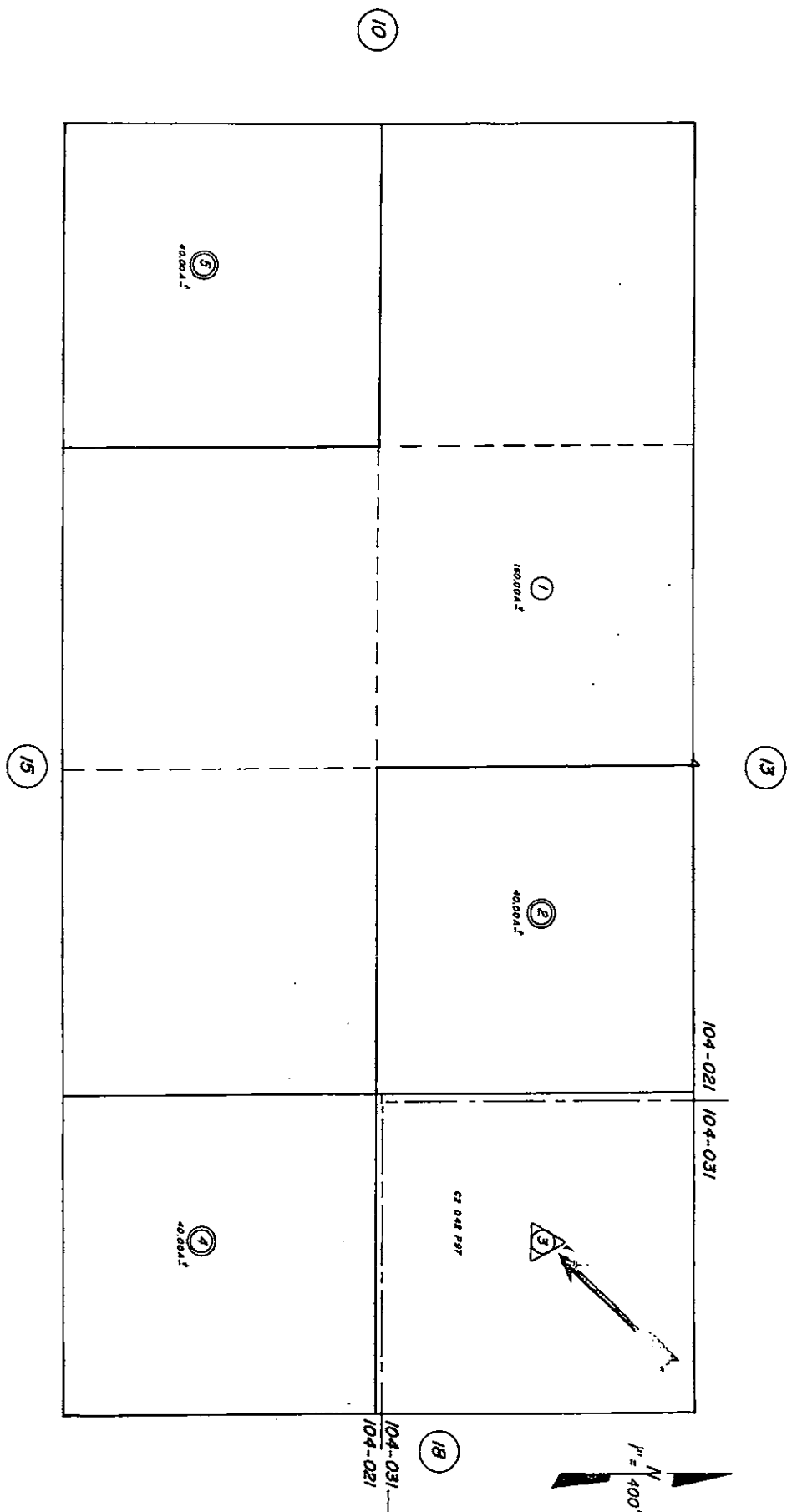
NOTE: This map was prepared for assessment purposes only. No liability is assumed for the data delineated hereon.

Assessor's Map  
County of Mendocino, Calif.  
REVISED 5-20-85

S.I/2 Sec. 4, T.16N. R.14W, MDBAM

104-021  
104-031

148-14

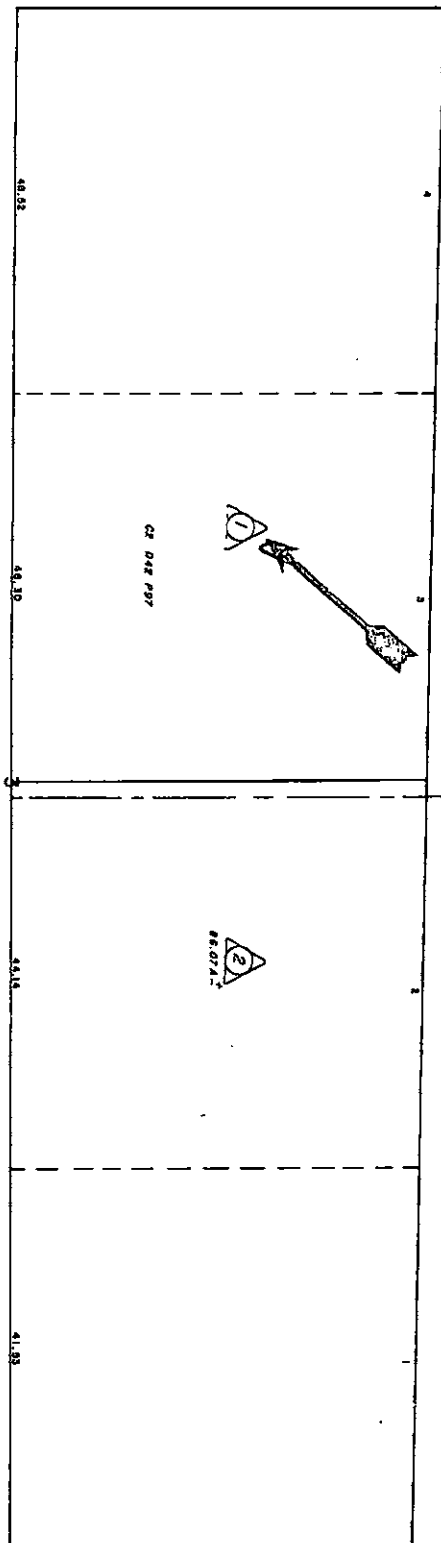


**NOTE:** This map was prepared for assessment purposes only. No liability is assumed for the data delineated herein.

**Assessor's Map**  
**County of Mendocino, Calif.**  
**REVISED 5-20-85**

148-17

BK.147  
04



**Assessor's Map  
County of Mendocino, Calif.  
REVISED 5-20-85**

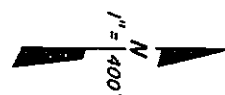
"Notice: This is neither a plat nor a survey. It is furnished merely as a convenience to aid you in locating the property located hereon with reference to streets and other land. No liability is assumed by reason of any reliance hereon."

S1/2 Sec. 3, T16N, R14W, MDBBM

104-023  
104-033

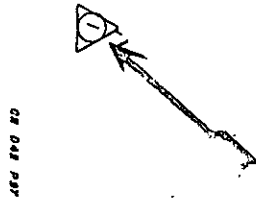
148-18

104-033 104-023 17



14

104-033  
104-023



2  
80.00 A.±

3  
160.00 A.±

19

22

NOTE: This map was prepared for assessment purposes only. No liability is assumed for the data delineated hereon.

Assessor's Map  
County of Mendocino, Calif.  
REVISED 5-20-85

**CLTA PRELIMINARY REPORT FORM (EXHIBIT A) (01-01-08)**

**CALIFORNIA LAND TITLE ASSOCIATION  
STANDARD COVERAGE POLICY - 1990**

**EXCLUSIONS FROM COVERAGE**

The following matters are expressly excluded from the coverage of this policy and the Company will not pay loss or damage, costs, attorneys' fees or expenses which arise by reason of:

1. (a) Any law, ordinance or governmental regulation (including but not limited to building or zoning laws, ordinances, or regulations) restricting, regulating, prohibiting or relating (i) the occupancy, use, or enjoyment of the land; (ii) the character, dimensions or location of any improvement now or hereafter erected on the land; (iii) a separation in ownership or a change in the dimensions or area of the land or any parcel of which the land is or was a part; or (iv) environmental protection, or the effect of any violation of these laws, ordinances or governmental regulations, except to the extent that a notice of the enforcement thereof or a notice of a defect, lien, or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.  
(b) Any governmental police power not excluded by (a) above, except to the extent that a notice of the exercise thereof or notice of a defect, lien or encumbrance resulting from a violation or alleged violation affecting the land has been recorded in the public records at Date of Policy.
2. Rights of eminent domain unless notice of the exercise thereof has been recorded in the public records at Date of Policy, but not excluding from coverage any taking which has occurred prior to Date of Policy which would be binding on the rights of a purchaser for value without knowledge.
3. Defects, liens, encumbrances, adverse claims or other matters:
  - (a) whether or not recorded in the public records at Date of Policy, but created, suffered, assumed or agreed to by the insured claimant;
  - (b) not known to the Company, not recorded in the public records at Date of Policy, but known to the insured claimant and not disclosed in writing to the Company by the insured claimant prior to the date the insured claimant became an insured under this policy;
  - (c) resulting in no loss or damage to the insured claimant;
  - (d) attaching or created subsequent to Date of Policy; or
  - (e) resulting in loss or damage which would not have been sustained if the insured claimant had paid value for the insured mortgage or for the estate or interest insured by this policy.
4. Unenforceability of the lien of the insured mortgage because of the inability or failure of the insured at Date of Policy, or the inability or failure of any subsequent owner of the indebtedness, to comply with the applicable doing business laws of the state in which the land is situated.
5. Invalidity or unenforceability of the lien of the insured mortgage, or claim thereof, which arises out of the transaction evidenced by the insured mortgage and is based upon usury or any consumer credit protection or truth in lending law.
6. Any claim, which arises out of the transaction vesting in the insured the estate of interest insured by this policy or the transaction creating the interest of the insured lender, by reason of the operation of federal bankruptcy, state insolvency or similar creditors' rights laws.

**EXCEPTIONS FROM COVERAGE - SCHEDULE B, PART I**

This policy does not insure against loss or damage (and the Company will not pay costs, attorneys' fees or expenses) which arise by reason of:

1. Taxes or assessments which are not shown as existing liens by the records of any taxing authority that levies taxes or assessments on real property or by the public records.  
Proceedings by a public agency which may result in taxes or assessments, or notices of such proceedings, whether or not shown by the records of such agency or by the public records.
2. Any facts, rights, interests, or claims which are not shown by the public records but which could be ascertained by an inspection of the land or which may be asserted by persons in possession thereof.
3. Easements, liens or encumbrances, or claims thereof, not shown by the public records.
4. Discrepancies, conflicts in boundary lines, shortage in area, encroachments, or any other facts which a correct survey would disclose, and which are not shown by the public records.
5. (a) Unpatented mining claims; (b) reservations or exceptions in patents or in Acts authorizing the issuance thereof; (c) water rights, claims or title to water, whether or not the matters excepted under (a), (b) or (c) are shown by the public records.

**2006 ALTA LOAN POLICY (06-17-06)**

**EXCLUSIONS FROM COVERAGE**

The following matters are expressly excluded from the coverage of this policy, and the Company will not pay loss or damage, costs, attorneys' fees, or expenses that arise by reason of:

1. (a) Any law, ordinance, permit, or governmental regulation (including those relating to building and zoning) restricting, regulating, prohibiting, or relating to
  - (i) the occupancy, use, or enjoyment of the Land;
  - (ii) the character, dimensions, or location of any improvement erected on the Land;
  - (iii) the subdivision of land; or
  - (iv) environmental protection;or the effect of any violation of these laws, ordinances, or governmental regulations. This Exclusion 1(a) does not modify or limit the coverage provided under Covered Risk 5.  
(b) Any governmental police power. This Exclusion 1(b) does not modify or limit the coverage provided under Covered Risk 6.
2. Rights of eminent domain. This Exclusion does not modify or limit the coverage provided under Covered Risk 7 or 8.
3. Defects, liens, encumbrances, adverse claims, or other matters:
  - (a) created, suffered, assumed, or agreed to by the Insured Claimant;

- (b) not Known to the Company, not recorded in the Public Records at Date of Policy, but Known to the Insured Claimant and not disclosed in writing to the Company by the Insured Claimant prior to the date the Insured Claimant became an Insured under this policy;
  - (c) resulting in no loss or damage to the Insured Claimant;
  - (d) attaching or created subsequent to Date of Policy (however, this does not modify or limit the coverage provided under Covered Risk 11, 13, or 14); or
  - (e) resulting in loss or damage that would not have been sustained if the Insured Claimant had paid value for the Insured Mortgage.
4. Unenforceability of the lien of the Insured Mortgage because of the inability or failure of an Insured to comply with applicable doing-business laws of the state where the Land is situated.
  5. Invalidity or unenforceability in whole or in part of the lien of the Insured Mortgage that arises out of the transaction evidenced by the Insured Mortgage and is based upon usury or any consumer credit protection or truth-in-lending law.
  6. Any claim, by reason of the operation of federal bankruptcy, state insolvency, or similar creditors' rights laws, that the transaction creating the lien of the Insured Mortgage, is
    - (a) a fraudulent conveyance or fraudulent transfer, or
    - (b) a preferential transfer for any reason not stated in Covered Risk 13(b) of this policy.
  7. Any lien on the Title for real estate taxes or assessments imposed by governmental authority and created or attaching between Date of Policy and the date of recording of the Insured Mortgage in the Public Records. This Exclusion does not modify or limit the coverage provided under Covered Risk 11(b).
- The above policy form may be issued to afford either Standard Coverage or Extended Coverage. In addition to the above Exclusions from Coverage, the Exceptions from Coverage in a Standard Coverage policy will also include the following Exceptions from Coverage:

### **EXCEPTIONS FROM COVERAGE**

This policy does not insure against loss or damage (and the Company will not pay costs, attorneys' fees or expenses) that arise by reason of:

1. (a) Taxes or assessments that are not shown as existing liens by the records of any taxing authority that levies taxes or assessments on real property or by the Public Records; (b) proceedings by a public agency that may result in taxes or assessments, or notices of such proceedings, whether or not shown by the records of such agency or by the Public Records.
2. Any facts, rights, interests, or claims that are not shown by the Public Records but that could be ascertained by an inspection of the Land or that may be asserted by persons in possession of the Land.
3. Easements, liens or encumbrances, or claims thereof, not shown by the Public Records.
4. Any encroachment, encumbrance, violation, variation, or adverse circumstance affecting the Title that would be disclosed by an accurate and complete land survey of the Land and not shown by the Public Records.
5. (a) Unpatented mining claims; (b) reservations or exceptions in patents or in Acts authorizing the issuance thereof; (c) water rights, claims or title to water, whether or not the matters excepted under (a), (b), or (c) are shown by the Public Records.

### **2006 ALTA OWNER'S POLICY (06-17-06)**

### **EXCLUSIONS FROM COVERAGE**

The following matters are expressly excluded from the coverage of this policy, and the Company will not pay loss or damage, costs, attorneys' fees, or expenses that arise by reason of:

1. (a) Any law, ordinance, permit, or governmental regulation (including those relating to building and zoning) restricting, regulating, prohibiting, or relating to
  - (i) the occupancy, use, or enjoyment of the Land;
  - (ii) the character, dimensions, or location of any improvement erected on the Land;
  - (iii) the subdivision of land; or
  - (iv) environmental protection;
 or the effect of any violation of these laws, ordinances, or governmental regulations. This Exclusion 1(a) does not modify or limit the coverage provided under Covered Risk 5.
- (b) Any governmental police power. This Exclusion 1(b) does not modify or limit the coverage provided under Covered Risk 6.
2. Rights of eminent domain. This Exclusion does not modify or limit the coverage provided under Covered Risk 7 or 8.
3. Defects, liens, encumbrances, adverse claims, or other matters:
  - (a) created, suffered, assumed, or agreed to by the Insured Claimant;
  - (b) not Known to the Company, not recorded in the Public Records at Date of Policy, but Known to the Insured Claimant and not disclosed in writing to the Company by the Insured Claimant prior to the date the Insured Claimant became an Insured under this policy;
  - (c) resulting in no loss or damage to the Insured Claimant;
  - (d) attaching or created subsequent to Date of Policy (however, this does not modify or limit the coverage provided under Covered Risk 9 and 10); or
  - (e) resulting in loss or damage that would not have been sustained if the Insured Claimant had paid value for the Title.
4. Any claim, by reason of the operation of federal bankruptcy, state insolvency, or similar creditors' rights laws, that the transaction vesting the Title as shown in Schedule A, is
  - (a) a fraudulent conveyance or fraudulent transfer; or
  - (b) a preferential transfer for any reason not stated in Covered Risk 9 of this policy.
5. Any lien on the Title for real estate taxes or assessments imposed by governmental authority and created or attaching between Date of Policy and the date of recording of the deed or other instrument of transfer in the Public Records that vests Title as shown in Schedule A.

The above policy form may be issued to afford either Standard Coverage or Extended Coverage. In addition to the above Exclusions from Coverage, the Exceptions from Coverage in a Standard Coverage policy will also include the following Exceptions from Coverage:

## EXCEPTIONS FROM COVERAGE

This policy does not insure against loss or damage (and the Company will not pay costs, attorneys' fees or expenses) that arise by reason of:

1. (a) Taxes or assessments that are not shown as existing liens by the records of any taxing authority that levies taxes or assessments on real property or by the Public Records; (b) proceedings by a public agency that may result in taxes or assessments, or notices of such proceedings, whether or not shown by the records of such agency or by the Public Records.
2. Any facts, rights, interests, or claims that are not shown in the Public Records but that could be ascertained by an inspection of the Land or that may be asserted by persons in possession of the Land.
3. Easements, liens or encumbrances, or claims thereof, not shown by the Public Records.
4. Any encroachment, encumbrance, violation, variation, or adverse circumstance affecting the Title that would be disclosed by an accurate and complete land survey of the Land and that are not shown by the Public Records.
5. (a) Unpatented mining claims; (b) reservations or exceptions in patents or in Acts authorizing the issuance thereof; (c) water rights, claims or title to water, whether or not the matters excepted under (a), (b), or (c) are shown by the Public Records.

## **Privacy Statement**

### **July 1, 2001**

We recognize and respect the privacy expectations of today's consumers and the requirements of applicable federal and state privacy laws. We believe that making you aware of how we use your non-public personal information ("Personal Information"), and to whom it is disclosed, will form the basis for a relationship of trust between us and the public we serve. This Privacy Statement provides that explanation. We reserve the right to change this Privacy Statement from time to time consistent with applicable privacy laws.

**In the course of our business, we may collect Personal Information about you from the following sources:**

- From applications or other forms we receive from you or your authorized representative;
- From your transactions with, or from the services being performed by us, our affiliates, or others;
- From our Internet web sites;
- From the public records maintained by governmental entities that we either obtain directly from those entities, or from our affiliates or others; and
- From consumer or other reporting agencies.

#### **Our Policies Regarding the Protection of the Confidentiality and Security of Your Personal Information**

We maintain physical, electronic and procedural safeguards to protect your Personal Information from unauthorized access or intrusion. We limit access to the Personal Information only to those employees who need such access in connection with providing products or services to you or for other legitimate business purposes.

#### **Our Policies and Practices Regarding the Sharing of Your Personal Information**

We may share your Personal Information with our affiliates, such as insurance companies, agents, and other real estate settlement providers. We may also disclose your Personal Information:

- to agents, brokers or representatives to provide you with services you have requested.
- to third-party contractors or service providers who provide services or perform marketing or other functions on our behalf; and
- to others with whom we enter into joint marketing agreements for products or services that we believe you may find of interest.

In addition, we will disclose your Personal Information when you direct or give us permission, when we are required by law to do so, or when we suspect fraudulent or criminal activities. We may also disclose your Personal Information when otherwise permitted by applicable privacy laws such as, for example, when disclosure is needed to enforce our rights arising out of any agreement, transaction or relationship with you.

One of the important responsibilities of some of our affiliated companies is to record documents in the public domain. Such documents may contain your Personal Information.

#### **Right to Access Your Personal Information and Ability to Correct Errors or Request Changes or Deletion**

Certain states afford you the right to access your Personal Information and, under certain circumstances, to find out to whom your Personal Information has been disclosed. Also, certain states afford you the right to request correction, amendment or deletion of your Personal Information. We reserve the right, where permitted by law, to charge a reasonable fee to cover the costs incurred in responding to such requests.

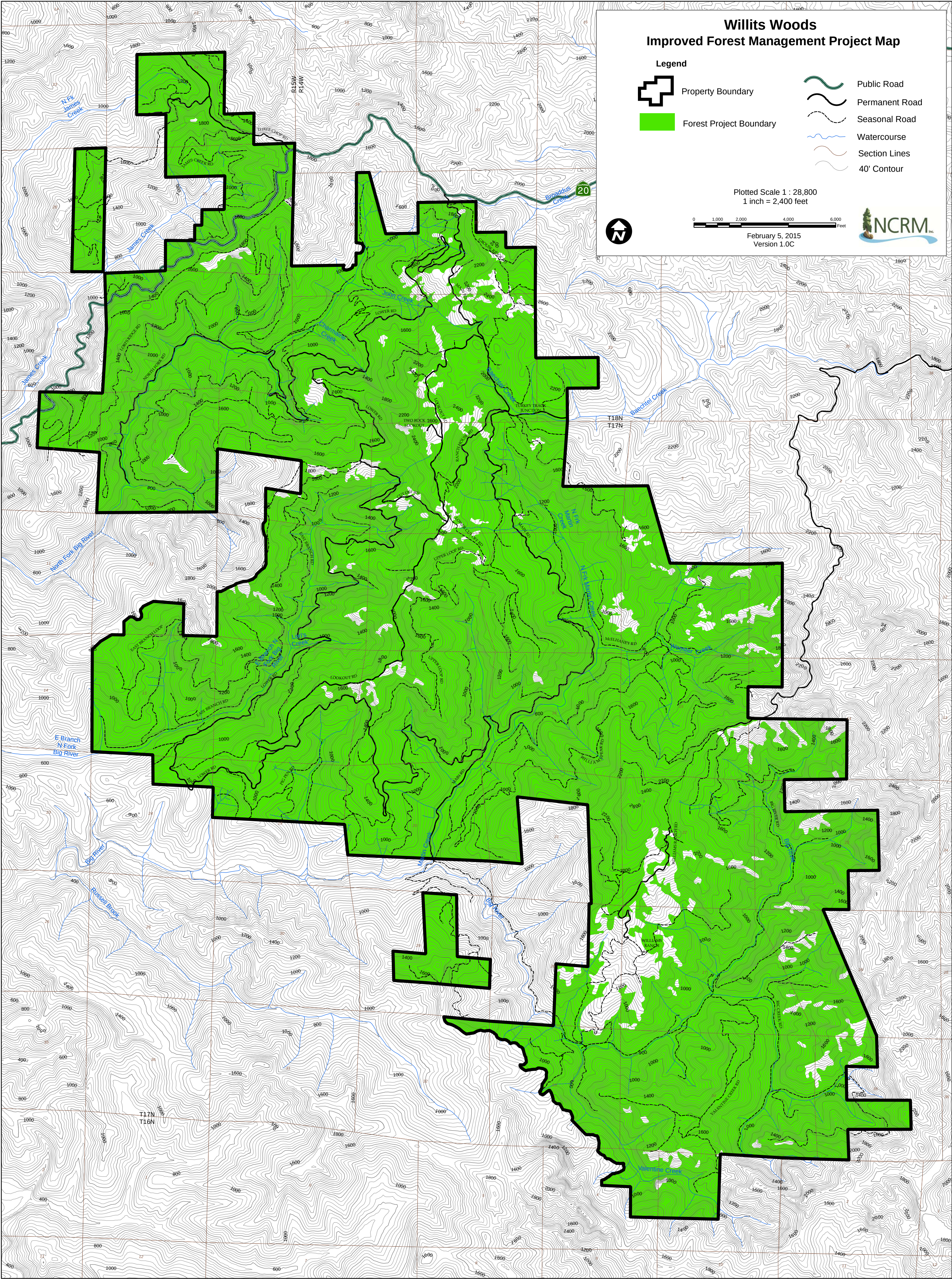
All requests must be made in writing to the following address:

Privacy Compliance Officer  
Redwood Empire Title Company  
P.O. Box 238  
Ukiah, CA 95482

#### **Multiple Products or Services**

If we provide you with more than one financial product or service, you may receive more than one privacy notice from us. We apologize for any inconvenience this may cause you.

# ATTACHMENT E



# ATTACHMENT F

# Willits Woods Improved Forest Management Project Map

## Legend



Property Boundary



Non-Timberland



Public Road



Permanent Road



Seasonal Road



Watercourse

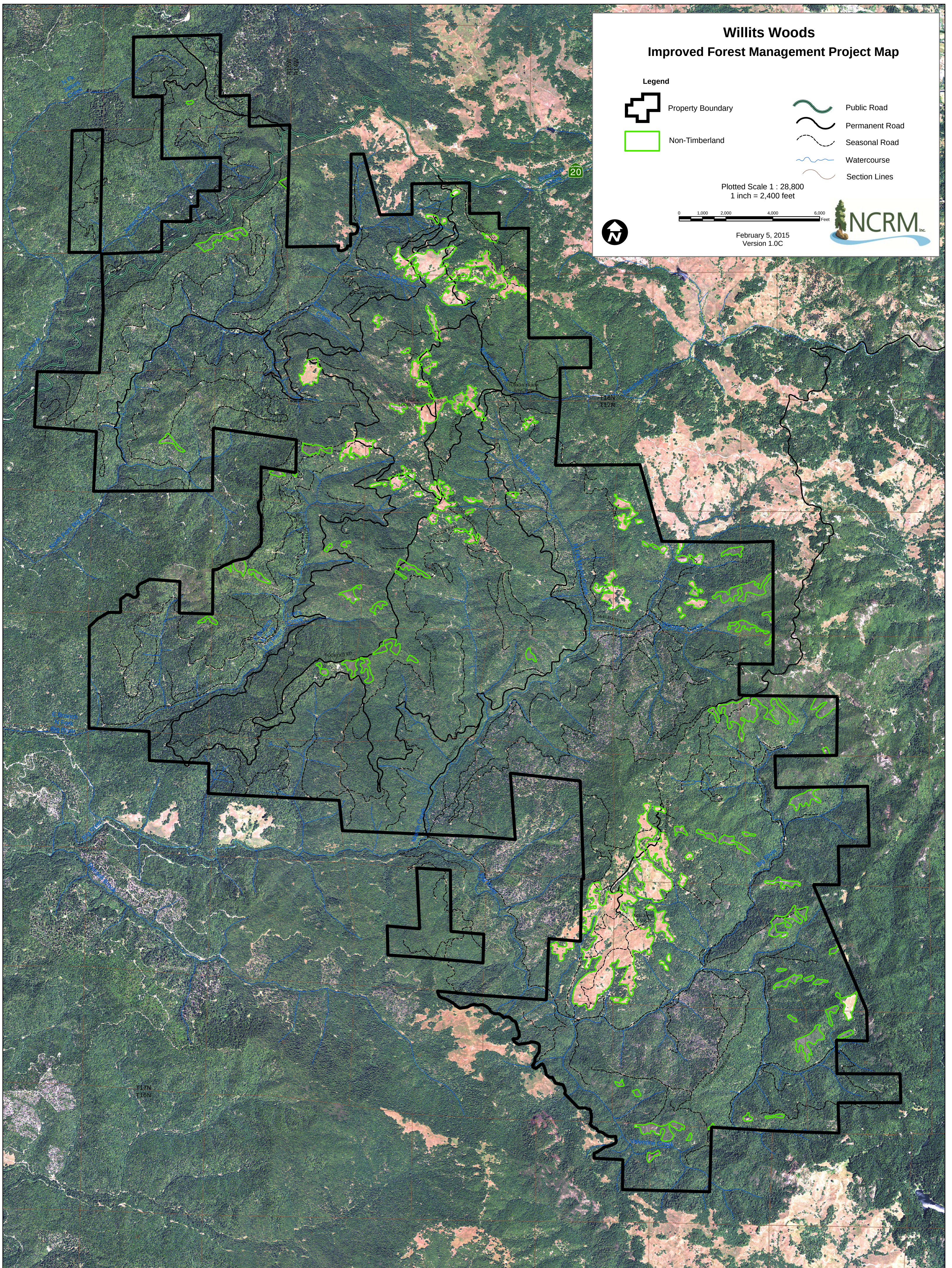


Section Lines

Plotted Scale 1 : 28,800  
1 inch = 2,400 feet

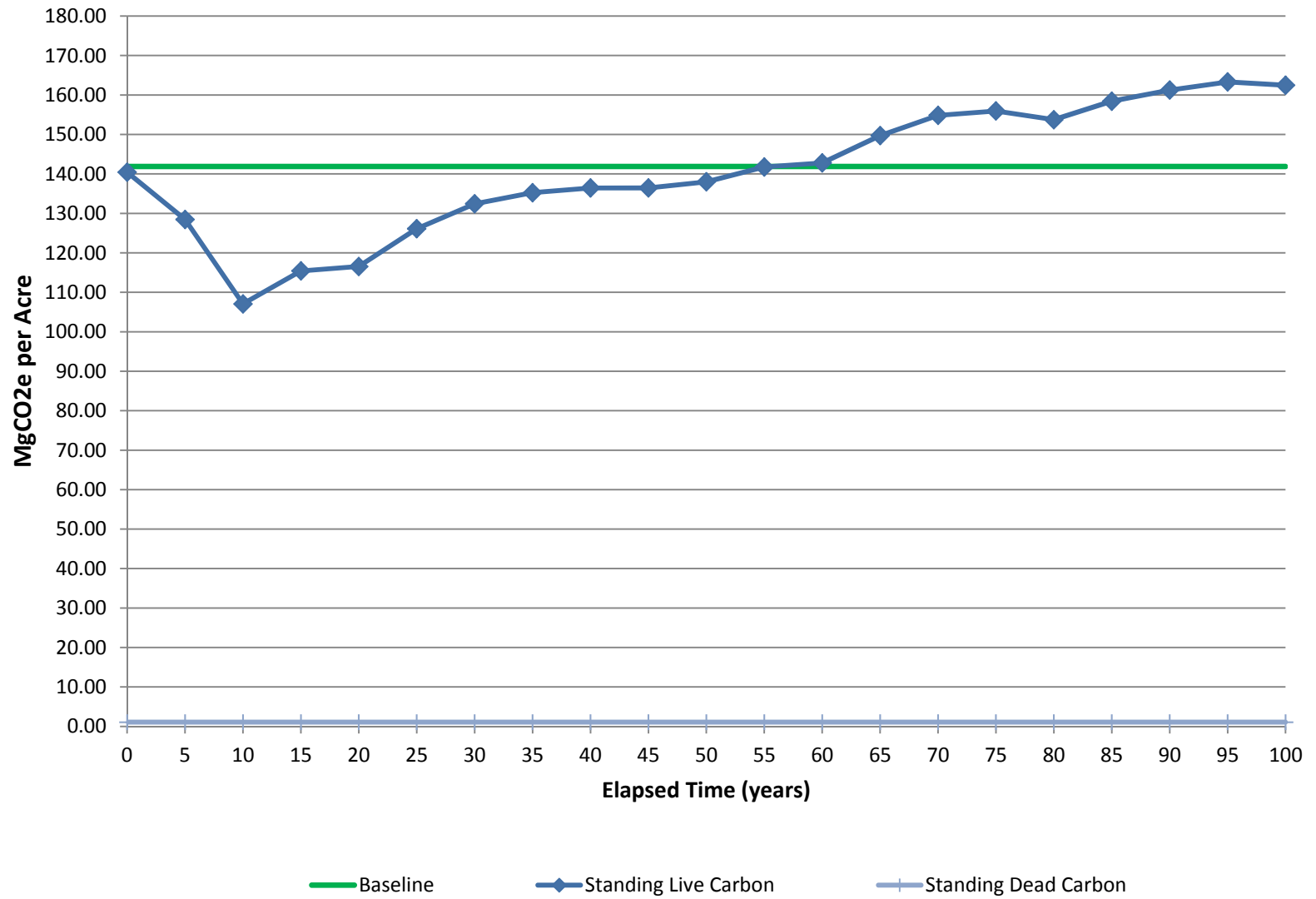


February 5, 2015  
Version 1.0C



# ATTACHMENT G

# Baseline Graph



# ATTACHMENT H

## Attachment H

### Baseline Carbon Stocks (MgCO<sub>2</sub>e per Acre)

| Elapsed Time | Standing Live Carbon Pool IFM-1 | Standing Dead Carbon Pool IFM-3 | Baseline |
|--------------|---------------------------------|---------------------------------|----------|
| 0            | 140.67                          | 1.06                            | 142.10   |
| 5            | 128.67                          | 1.06                            | 142.10   |
| 10           | 107.24                          | 1.06                            | 142.10   |
| 15           | 115.61                          | 1.06                            | 142.10   |
| 20           | 116.74                          | 1.06                            | 142.10   |
| 25           | 126.32                          | 1.06                            | 142.10   |
| 30           | 132.63                          | 1.06                            | 142.10   |
| 35           | 135.46                          | 1.06                            | 142.10   |
| 40           | 136.67                          | 1.06                            | 142.10   |
| 45           | 136.67                          | 1.06                            | 142.10   |
| 50           | 138.21                          | 1.06                            | 142.10   |
| 55           | 141.99                          | 1.06                            | 142.10   |
| 60           | 143.02                          | 1.06                            | 142.10   |
| 65           | 149.96                          | 1.06                            | 142.10   |
| 70           | 155.09                          | 1.06                            | 142.10   |
| 75           | 156.20                          | 1.06                            | 142.10   |
| 80           | 153.99                          | 1.06                            | 142.10   |
| 85           | 158.69                          | 1.06                            | 142.10   |
| 90           | 161.52                          | 1.06                            | 142.10   |
| 95           | 163.57                          | 1.06                            | 142.10   |
| 100          | 162.73                          | 1.06                            | 142.10   |
| Average      | 141.03                          | 1.06                            | 142.10   |

| Carbon Pool                                                            | Mg C/ acre | Total Mg CO <sub>2</sub> e |
|------------------------------------------------------------------------|------------|----------------------------|
| Average Standing Live and Standing Dead Pools                          | 38.720     | 2,558,969                  |
| Average Annual Carbon 100-year In-Use                                  | 0.240      | 15,871                     |
| Average Annual Carbon 100-year Landfill                                | 0.155      | 10,247                     |
| Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill | 1.410      | 93,133                     |

## Attachment H - Carbon Stocks and Baseline

Baseline (MgCO<sub>2</sub>e/ac)

148.72

Average Carbon Stocks  
(MgCO<sub>2</sub>e/ac)

141.03

■ Average Standing Live Carbon IFM-1  
■ Baseline  
■ Average Annual Carbon 100-year Landfill

■ Average Standing Dead Carbon IFM-3  
■ Average Annual Carbon 100-year In-Use  
■ Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill

0.88 1.06 0.57 5.17

# ATTACHMENT I

## Carbon Stock Estimate Affidavit for the Purpose of Determining The High Stocking Reference

The carbon stock estimates for the 10-year period preceding the Project's commencement date are shown in the table and graph below. These values are derived through the calculation of annual percent stock change based on the Project's average annual percent stock change from the beginning of 2004 to the end of 2008 which was approximately 5.6% adjusted for annual harvested carbon stocks. Harvest records in the form of California Board of Equalization yield tax reports were used to calculate the carbon stocks delivered to the mill in each year of the ten year period for the portion of the Willits Woods owned by Coastal Forestlands (approximately 14,200 acres of the Project Area). Approximately 3,800 acres of the Project Area also known as the Williams Ranch was not owned by Coastal Forestlands, and no yield tax records exist. Based on knowledge regarding harvests from 1993 through 2003 on the Williams Ranch, it is estimated that ten million board feet of conifer volume was harvested over three years, with approximately 45% being harvested each year in 1994 and 1995, and 10% in 1997. Hardwood harvests on the Williams Ranch were significantly lower than on the remainder of the Willits Woods; however, in order to be conservative the volume of hardwoods delivered to the mill for the Williams Ranch is based on the ratio of the conifer volume and hardwood volume delivered to the mill for the portion of the Project Area for which harvest records exist.

Harvested carbon was calculated using the "Harvested Wood Products Worksheet" developed by the Climate Action Reserve. The total MgCO<sub>2</sub>e in harvested wood delivered to the mill each year calculated using the worksheet was then multiplied by the ratio of carbon in wood delivered to the mill to carbon in trees harvested for wood products (prior to delivery to the mill) derived from the baseline harvested wood products values. This ratio is 1.82 for the Willits Woods Project.

### Carbon Stocks for the 10-year period preceding the Project Start Date

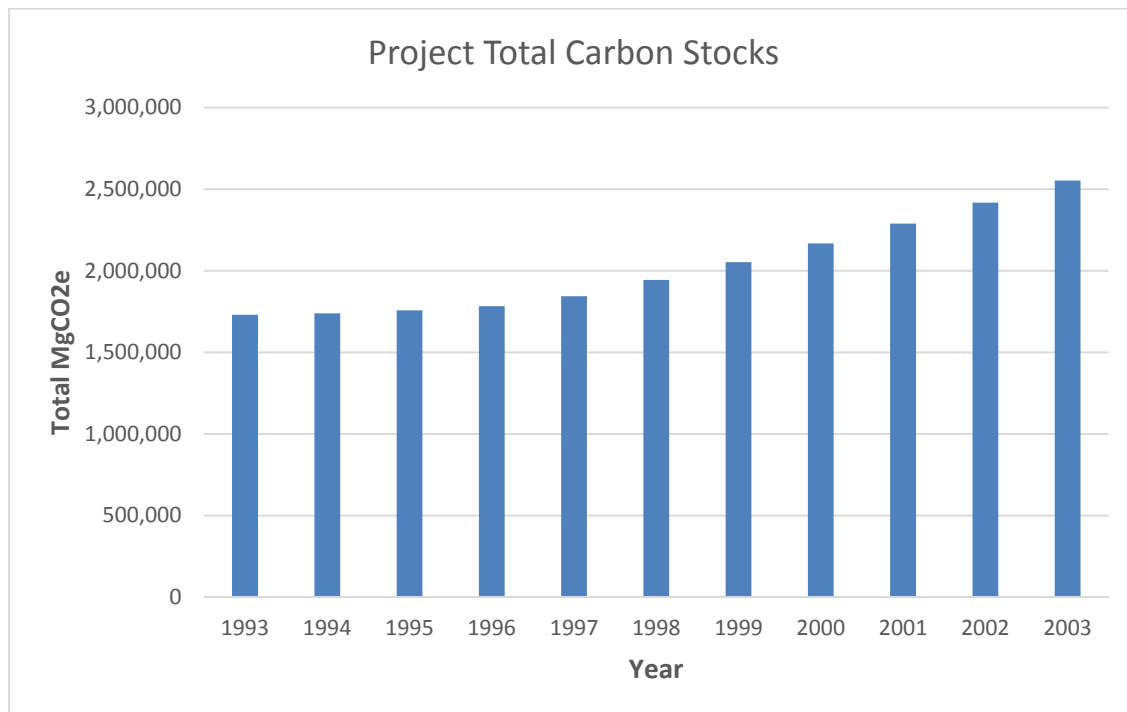
| Year                                   | 1993      | 1994      | 1995      | 1996      | 1997      | 1998      | 1999      | 2000      | 2001      | 2002      | 2003      |
|----------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Total MgCO <sub>2</sub> e <sup>1</sup> | 1,730,074 | 1,739,277 | 1,757,432 | 1,783,584 | 1,844,226 | 1,943,604 | 2,052,445 | 2,167,382 | 2,288,756 | 2,416,926 | 2,552,274 |
| Annual Carbon Growth                   |           | 92,234    | 93,197    | 94,584    | 97,800    | 103,070   | 108,842   | 114,937   | 121,373   | 128,170   | 135,348   |
| Adjusted Harvested Carbon <sup>2</sup> |           | 83,032    | 75,042    | 68,432    | 37,157    | 3,693     | 0         | 0         | 0         | 0         | 0         |
| Harvest Carbon <sup>3</sup>            |           | 45,622    | 41,232    | 37,600    | 20,416    | 2,029     | 0         | 0         | 0         | 0         | 0         |
| Net Stock Change                       |           | 0.53%     | 1.04%     | 1.49%     | 3.40%     | 5.39%     | 5.60%     | 5.60%     | 5.60%     | 5.60%     | 5.60%     |

<sup>1</sup>As of the end of the year

<sup>2</sup>Harvested Carbon times 1.82 Adjustment Factor

<sup>3</sup>Based on California Board of Equalization Records

Based on the information available to the Offset Project Operator at this time as presented above, the highest value for above-ground standing live carbon stocks per acre within the Project Area during the 10-year period preceding the Project commencement date was equal to the above-ground standing live carbon stocks at the end of the last year of this 10-year period (2003), which is equal to the Project's initial above-ground standing live carbon stocks (ICS). Therefore the "High Stocking Reference" (HSR) is equal to 80% of the Project's ICS value of 112.38 MgCO<sub>2</sub>e per acre as reported in Part VIII.B.1 of this application, or 89.90 MgCO<sub>2</sub>e per acre.



The carbon stock inventory estimates presented above, including the summary of volume harvested over the 10-year period preceding the Project's commencement date are believed to be reasonably accurate and are based on the best available data including actual harvest records where available.

Signed,

James D. Clark  
Authorized Project Designee

# ATTACHMENT J

## Coastal Ridges Willits Woods Improved Forest Management Project

This analysis is provided per section 6.2.1.2 (1) of Version 3.2 of the Forest Project Protocol, and is designed to demonstrate that the baseline growth and harvest regime is financially feasible. This analysis is overly conservative given that the test is simply financial feasibility. If herbicide treatments, tree planting and logging costs were significantly increased, the analysis would still demonstrate that the baseline growth and harvest is financially feasible. Delivered log values are below trended values based on Board of Equalization values, yet still demonstrate financial feasibility.

### Model Inputs:

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

### Production Costs:

| Item                | Cost per acre | Quantity <sup>1</sup> | Total Cost   | Cost per MBF    |
|---------------------|---------------|-----------------------|--------------|-----------------|
| THP Preparation     | \$110         | 17,258                | \$ 1,898,380 | \$22.60         |
| Logging Supervision |               |                       |              | \$7.00          |
| Property Management |               |                       |              | \$7.00          |
| Logging and Hauling |               |                       |              | \$285.00        |
| <b>Total</b>        |               |                       |              | <b>\$321.60</b> |

### Herbicide Treatment of Hardwoods:

| Period | Cost per acre | % of Acres Treated | Total Cost  | Cost per MBF |
|--------|---------------|--------------------|-------------|--------------|
| 1      | \$ 125.00     | 100%               | \$2,157,250 | \$25.68      |
| 2      | \$ 125.00     | 33%                | \$711,893   | \$6.43       |
| 3      | \$ 125.00     | 33%                | \$711,893   | \$7.21       |
| 4      | \$ 125.00     | 33%                | \$711,893   | \$5.27       |
| 5      | \$ 125.00     | 33%                | \$711,893   | \$5.83       |
| 6      | \$ 125.00     | 33%                | \$711,893   | \$5.46       |
| 7      | \$ 125.00     | 33%                | \$711,893   | \$5.97       |
| 8      | \$ 125.00     | 33%                | \$711,893   | \$4.85       |
| 9      | \$ 125.00     | 33%                | \$711,893   | \$5.38       |
| 10     | \$ 125.00     | 33%                | \$711,893   | \$4.99       |

### Tree Planting: (\$1 per tree cost)

| Period | Cost per acre | % of Acres Treated | Total Cost  | Cost per MBF |
|--------|---------------|--------------------|-------------|--------------|
| 1      | \$ 125.00     | 100%               | \$2,157,250 | \$25.68      |
| 2      | \$ 100.00     | 25%                | \$431,450   | \$3.89       |
| 3      | \$ 100.00     | 25%                | \$431,450   | \$4.37       |
| 4      | \$ 100.00     | 25%                | \$431,450   | \$3.19       |
| 5      | \$ 100.00     | 25%                | \$431,450   | \$3.53       |
| 6      | \$ 100.00     | 25%                | \$431,450   | \$3.31       |
| 7      | \$ 100.00     | 25%                | \$431,450   | \$3.62       |
| 8      | \$ 100.00     | 25%                | \$431,450   | \$2.94       |
| 9      | \$ 100.00     | 25%                | \$431,450   | \$3.26       |
| 10     | \$ 100.00     | 25%                | \$431,450   | \$3.03       |

<sup>1</sup> Unconstrained timbered acreage.

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

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

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

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

0.5% Real price appreciation applied to delivered log values.

All calculations in constant dollars without inflation.

Discount Rate 10.0% Real.

|           | Annual Harvest Volume |           |             |               | Delivered Log Values per MBF |                |                  |                     | Production        | Herbicide             | Tree                 | Yield             | Net               | Total        | Present      |
|-----------|-----------------------|-----------|-------------|---------------|------------------------------|----------------|------------------|---------------------|-------------------|-----------------------|----------------------|-------------------|-------------------|--------------|--------------|
| Year      | RW<br>MBF             | DF<br>MBF | Pine<br>MBF | Totals<br>MBF | RW<br>\$ / MBF               | DF<br>\$ / MBF | Pine<br>\$ / MBF | Camprun<br>\$ / MBF | Costs<br>\$ / MBF | Treatment<br>\$ / MBF | Planting<br>\$ / MBF | Taxes<br>\$ / MBF | Value<br>\$ / MBF | Net<br>Value | Net<br>Value |
| 2009      | 4,055                 | 4,195     | 149         | 8,399         | 900.00                       | 400.00         | 400.00           | 641.41              | 321.60            | 25.68                 | 25.68                | 18.60             | 249.84            | 2,098,496    | 1,907,724    |
| 2010      | 4,055                 | 4,195     | 149         | 8,399         | 904.50                       | 402.00         | 402.00           | 644.61              | 321.60            | 25.68                 | 25.68                | 18.69             | 252.95            | 2,124,652    | 1,755,911    |
| 2011      | 4,055                 | 4,195     | 149         | 8,399         | 909.02                       | 404.01         | 404.01           | 647.84              | 321.60            | 25.68                 | 25.68                | 18.79             | 256.08            | 2,150,939    | 1,616,032    |
| 2012      | 4,055                 | 4,195     | 149         | 8,399         | 913.57                       | 406.03         | 406.03           | 651.08              | 321.60            | 25.68                 | 25.68                | 18.88             | 259.23            | 2,177,357    | 1,487,164    |
| 2013      | 4,055                 | 4,195     | 149         | 8,399         | 918.14                       | 408.06         | 408.06           | 654.33              | 321.60            | 25.68                 | 25.68                | 18.98             | 262.39            | 2,203,908    | 1,368,453    |
| 2014      | 4,055                 | 4,195     | 149         | 8,399         | 922.73                       | 410.10         | 410.10           | 657.60              | 321.60            | 25.68                 | 25.68                | 19.07             | 265.56            | 2,230,591    | 1,259,110    |
| 2015      | 4,055                 | 4,195     | 149         | 8,399         | 927.34                       | 412.15         | 412.15           | 660.89              | 321.60            | 25.68                 | 25.68                | 19.17             | 268.76            | 2,257,407    | 1,158,400    |
| 2016      | 4,055                 | 4,195     | 149         | 8,399         | 931.98                       | 414.21         | 414.21           | 664.20              | 321.60            | 25.68                 | 25.68                | 19.26             | 271.97            | 2,284,358    | 1,065,670    |
| 2017      | 4,055                 | 4,195     | 149         | 8,399         | 936.64                       | 416.28         | 416.28           | 667.52              | 321.60            | 25.68                 | 25.68                | 19.36             | 275.19            | 2,311,443    | 980,278      |
| 2018      | 4,055                 | 4,195     | 149         | 8,399         | 941.32                       | 418.36         | 418.36           | 670.85              | 321.60            | 25.68                 | 25.68                | 19.45             | 278.43            | 2,338,664    | 901,656      |
| 2019      | 3,728                 | 7,132     | 219         | 11,078        | 946.03                       | 420.46         | 420.46           | 597.30              | 321.60            | 6.43                  | 3.89                 | 17.32             | 248.05            | 2,747,996    | 963,156      |
| 2020      | 3,728                 | 7,132     | 219         | 11,078        | 950.76                       | 422.56         | 422.56           | 600.28              | 321.60            | 6.43                  | 3.89                 | 17.41             | 250.95            | 2,780,122    | 885,832      |
| 2021      | 3,728                 | 7,132     | 219         | 11,078        | 955.51                       | 424.67         | 424.67           | 603.28              | 321.60            | 6.43                  | 3.89                 | 17.50             | 253.87            | 2,812,408    | 814,654      |
| 2022      | 3,728                 | 7,132     | 219         | 11,078        | 960.29                       | 426.79         | 426.79           | 606.30              | 321.60            | 6.43                  | 3.89                 | 17.58             | 256.80            | 2,844,856    | 749,139      |
| 2023      | 3,728                 | 7,132     | 219         | 11,078        | 965.09                       | 428.93         | 428.93           | 609.33              | 321.60            | 6.43                  | 3.89                 | 17.67             | 259.74            | 2,877,466    | 688,842      |
| 2024      | 3,728                 | 7,132     | 219         | 11,078        | 969.91                       | 431.07         | 431.07           | 612.38              | 321.60            | 6.43                  | 3.89                 | 17.76             | 262.70            | 2,910,238    | 633,353      |
| 2025      | 3,728                 | 7,132     | 219         | 11,078        | 974.76                       | 433.23         | 433.23           | 615.44              | 321.60            | 6.43                  | 3.89                 | 17.85             | 265.67            | 2,943,175    | 582,292      |
| 2026      | 3,728                 | 7,132     | 219         | 11,078        | 979.64                       | 435.39         | 435.39           | 618.52              | 321.60            | 6.43                  | 3.89                 | 17.94             | 268.66            | 2,976,277    | 535,310      |
| 2027      | 3,728                 | 7,132     | 219         | 11,078        | 984.54                       | 437.57         | 437.57           | 621.61              | 321.60            | 6.43                  | 3.89                 | 18.03             | 271.66            | 3,009,544    | 492,084      |
| 2028      | 3,728                 | 7,132     | 219         | 11,078        | 989.46                       | 439.76         | 439.76           | 624.72              | 321.60            | 6.43                  | 3.89                 | 18.12             | 274.68            | 3,042,977    | 452,319      |
| 2029      | 3,185                 | 6,562     | 122         | 9,869         | 994.41                       | 441.96         | 441.96           | 620.28              | 321.60            | 7.21                  | 4.37                 | 17.99             | 269.10            | 2,655,680    | 358,864      |
| 2030      | 3,185                 | 6,562     | 122         | 9,869         | 999.38                       | 444.17         | 444.17           | 623.38              | 321.60            | 7.21                  | 4.37                 | 18.08             | 272.11            | 2,685,399    | 329,890      |
| 2031      | 3,185                 | 6,562     | 122         | 9,869         | 1004.37                      | 446.39         | 446.39           | 626.49              | 321.60            | 7.21                  | 4.37                 | 18.17             | 275.14            | 2,715,267    | 303,236      |
| 2032      | 3,185                 | 6,562     | 122         | 9,869         | 1009.40                      | 448.62         | 448.62           | 629.63              | 321.60            | 7.21                  | 4.37                 | 18.26             | 278.18            | 2,745,284    | 278,717      |
| 2033      | 3,185                 | 6,562     | 122         | 9,869         | 1014.44                      | 450.86         | 450.86           | 632.77              | 321.60            | 7.21                  | 4.37                 | 18.35             | 281.24            | 2,775,451    | 256,163      |
| 2034      | 3,185                 | 6,562     | 122         | 9,869         | 1019.52                      | 453.12         | 453.12           | 635.94              | 321.60            | 7.21                  | 4.37                 | 18.44             | 284.31            | 2,805,769    | 235,419      |
| 2035      | 3,185                 | 6,562     | 122         | 9,869         | 1024.61                      | 455.38         | 455.38           | 639.12              | 321.60            | 7.21                  | 4.37                 | 18.53             | 287.40            | 2,836,238    | 216,342      |
| 2036      | 3,185                 | 6,562     | 122         | 9,869         | 1029.74                      | 457.66         | 457.66           | 642.31              | 321.60            | 7.21                  | 4.37                 | 18.63             | 290.50            | 2,866,860    | 198,798      |
| 2037      | 3,185                 | 6,562     | 122         | 9,869         | 1034.89                      | 459.95         | 459.95           | 645.53              | 321.60            | 7.21                  | 4.37                 | 18.72             | 293.62            | 2,897,635    | 182,665      |
| 2038      | 3,185                 | 6,562     | 122         | 9,869         | 1040.06                      | 462.25         | 462.25           | 648.75              | 321.60            | 7.21                  | 4.37                 | 18.81             | 296.75            | 2,928,564    | 167,832      |
| 2039      | 5,199                 | 8,222     | 87          | 13,508        | 1040.06                      | 462.25         | 462.25           | 684.62              | 321.60            | 5.27                  | 3.19                 | 19.85             | 334.70            | 4,521,307    | 235,554      |
| 2040      | 5,199                 | 8,222     | 87          | 13,508        | 1045.26                      | 464.56         | 464.56           | 688.04              | 321.60            | 5.27                  | 3.19                 | 19.95             | 338.03            | 4,566,207    | 216,267      |
| 2041      | 5,199                 | 8,222     | 87          | 13,508        | 1050.49                      | 466.88         | 466.88           | 691.48              | 321.60            | 5.27                  | 3.19                 | 20.05             | 341.37            | 4,611,332    | 198,549      |
| 2042      | 5,199                 | 8,222     | 87          | 13,508        | 1055.74                      | 469.22         | 469.22           | 694.94              | 321.60            | 5.27                  | 3.19                 | 20.15             | 344.72            | 4,656,682    | 182,274      |
| 2043      | 5,199                 | 8,222     | 87          | 13,508        | 1061.02                      | 471.56         | 471.56           | 698.42              | 321.60            | 5.27                  | 3.19                 | 20.25             | 348.10            | 4,702,258    | 167,326      |
| 2044      | 5,199                 | 8,222     | 87          | 13,508        | 1066.32                      | 473.92         | 473.92           | 701.91              | 321.60            | 5.27                  | 3.19                 | 20.36             | 351.49            | 4,748,063    | 153,596      |
| 2045      | 5,199                 | 8,222     | 87          | 13,508        | 1071.65                      | 476.29         | 476.29           | 705.42              | 321.60            | 5.27                  | 3.19                 | 20.46             | 354.90            | 4,794,097    | 140,986      |
| 2046      | 5,199                 | 8,222     | 87          | 13,508        | 1077.01                      | 478.67         | 478.67           | 708.95              | 321.60            | 5.27                  | 3.19                 | 20.56             | 358.32            | 4,840,360    | 129,406      |
| 2047      | 5,199                 | 8,222     | 87          | 13,508        | 1082.40                      | 481.07         | 481.07           | 712.49              | 321.60            | 5.27                  | 3.19                 | 20.66             | 361.76            | 4,886,856    | 118,772      |
| 2048      | 5,199                 | 8,222     | 87          | 13,508        | 1087.81                      | 483.47         | 483.47           | 716.05              | 321.60            | 5.27                  | 3.19                 | 20.77             | 365.22            | 4,933,583    | 109,007      |
| 2049      | 4,981                 | 7,179     | 59          | 12,219        | 1093.25                      | 485.89         | 485.89           | 733.47              | 321.60            | 5.83                  | 3.53                 | 21.27             | 381.24            | 4,658,398    | 93,570       |
| 2050      | 4,981                 | 7,179     | 59          | 12,219        | 1098.71                      | 488.32         | 488.32           | 737.13              | 321.60            | 5.83                  | 3.53                 | 21.38             | 384.80            | 4,701,910    | 85,858       |
| 2051      | 4,981                 | 7,179     | 59          | 12,219        | 1104.21                      | 490.76         | 490.76           | 740.82              | 321.60            | 5.83                  | 3.53                 | 21.48             | 388.38            | 4,745,640    | 78,779       |
| 2052      | 4,981                 | 7,179     | 59          | 12,219        | 1109.73                      | 493.21         | 493.21           | 744.52              | 321.60            | 5.83                  | 3.53                 | 21.59             | 391.97            | 4,789,588    | 72,280       |
| 2053      | 4,981                 | 7,179     | 59          | 12,219        | 1115.28                      | 495.68         | 495.68           | 748.25              | 321.60            | 5.83                  | 3.53                 | 21.70             | 395.59            | 4,833,756    | 66,315       |
| 2054      | 4,981                 | 7,179     | 59          | 12,219        | 1120.85                      | 498.16         | 498.16           | 751.99              | 321.60            | 5.83                  | 3.53                 | 21.81             | 399.22            | 4,878,145    | 60,840       |
| 2055      | 4,981                 | 7,179     | 59          | 12,219        | 1126.46                      | 500.65         | 500.65           | 755.75              | 321.60            | 5.83                  | 3.53                 | 21.92             | 402.87            | 4,922,756    | 55,815       |
| 2056      | 4,981                 | 7,179     | 59          | 12,219        | 1132.09                      | 503.15         | 503.15           | 759.53              | 321.60            | 5.83                  | 3.53                 | 22.03             | 406.54            | 4,967,590    | 51,203       |
| 2057      | 4,981                 | 7,179     | 59          | 12,219        | 1137.75                      | 505.67         | 505.67           | 763.32              | 321.60            | 5.83                  | 3.53                 | 22.14             | 410.23            | 5,012,648    | 46,971       |
| 2058      | 4,981                 | 7,179     | 59          | 12,219        | 1143.44                      | 508.20         | 508.20           | 767.14              | 321.60            | 5.83                  | 3.53                 | 22.25             | 413.94            | 5,057,931    | 43,086       |
| 2059-2108 |                       |           |             |               |                              |                |                  |                     |                   |                       |                      |                   |                   |              | 529,641      |
|           |                       |           |             |               |                              |                |                  |                     |                   |                       |                      |                   |                   | Total        | 25,661,400   |

# ATTACHMENT K

# Coastal Ridges LLC. Willits Woods Modeling Plan

By James D. Clark, RPF #2528  
February 5, 2015

|                                                                                                  |    |
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## Introduction:

This Modeling Plan is intended to provide the information required by Appendix B of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014 with respect to the updating and forecasting of carbon stocks over the Project's initial crediting period. The baseline analysis described in this modeling plan is based on the analysis presented for the Early Action project CAR661 that was verified as a part of CAR661's initial reporting period.

\*\*\*\*Pertains to the Previous Baseline Analysis\*\*\*\*

## CRYPTOS Emulator:

Prior to the recent development of FORSEE, the procedure for modeling individual plots using CRYPTOS, and tracking the resulting inventory, harvest, and growth was problematic due to the fact that the original CRYPTOS user interface is antiquated. The previous CRYPTOS interface was extremely difficult to manage in extended runs with many plots, while implementing various silvicultural prescriptions, multiple ingrowth files, and calibrations. To resolve these problems, Coastal Forestlands contracted with Jan Derksen, Ph.D. for the development of a timber growth and harvest modeling tool, which allows for management of the required complexity in a user-friendly manner, and for the comparison of various 100 year modeling scenarios. This tool has evolved over the years, and is currently referred to by the author as the CRYPTOS Emulator, which is listed in CAR's Forest Project Protocol, Version 3.2 as an approved model

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

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

The Emulator allows users to load and maintain in a database:

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

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

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

## Growth and Yield Modeling:

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

### Plot Data Pertaining to Previous Baseline Analysis:

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

Prior to the 2008 cruise, Coastal Ridges relied on a cruise installed by Pioneer Resources, LLC ("Pioneer") in 1999 and 2000 under the guidance of Olympic Resource Management, Inc. The Pioneer cruise was designed to develop strata based volume estimates for the entire Pioneer property, including property not owned by Coastal (approximately 78,000 acres). The

inventory was completed in two phases, the first in the summer and fall of 1999 and the second in the summer and fall of 2000. Data collection procedures varied slightly between the phases.

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

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

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

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

\*\*\*\*Pertains to the New Crediting Period\*\*\*\*

In 2015, an additional inventory will be conducted as the project transitions from a voluntary project under CAR to a compliance project under ARB. The cruise will use 284 of the original locations of plots installed in 2008. The sample design includes the installation of fixed area plots to measure both standing live and standing dead conifers and hardwoods. A 1/250th acre fixed area plot was installed at each sample point to sample conifer and hardwood trees 1" DBH to 3.5" DBH; a 1/50th acre fixed area plot was installed at each sample point to sample conifer trees 3.5" DBH to 10.4" DBH, and hardwood trees 3.5" DBH and larger; and, a 1/5th acre fixed area plot was installed at each sample point to sample conifer trees 10.5" DBH and larger.

### Updating the Inventory:

As timber management activities take place on the Willits Woods Project Area or disturbance such as fire or mortality resulting from pathogens or other factors occurs, cruise plots installed in 2015 will be relocated and remeasured within areas that have been harvested, treated for hardwood reduction, or subject to other 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 other disturbance. On this basis, Coastal Ridges will maintain a forest inventory system that will meet the inventory specifications and requirements contained in Appendix E of the Forest Project Design Document, with plots which are no more than 12 years old.

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

1. Any newly installed inventory plots will be incorporated into the inventory estimate.
2. Existing inventory plots will be updated using the CRYPTOS Emulator and the calibration factors described below. Plot data will then be exported to FORSEE for the calculation of the final carbon stock values.
3. Updating the forest inventory for harvests, hardwood reduction, or disturbances that have occurred during the previous year through the installation of new plots, or adjustments to previous plot data.
4. Where necessary, the inventory update process may result in re-stratification of portions of the timber strata.
5. Inventory updates following harvest, hardwood reduction, or disturbance will be re-measured within 12 months of the harvest or disturbance.

## Volume Calculations:

Reported volumes for the current crediting period are in board feet Scribner Scale for all conifers 8.5 inches DBH and larger. The FIA volume and biomass equations described in the listing application are used for the calculation of all carbon stock values.

## Biomass Calculations:

Biomass calculations utilized in the modeling and reporting of current and future carbon stocks are described in detail in the listing application. The listing application lists all of the species' specific volume and biomass equations utilized which are in compliance with the Compliance Offset Protocol U.S. Forest Projects.

\*\*\*\*Pertains to the Previous Baseline Analysis\*\*\*\*

## Volume Calculations:

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

## Biomass Calculations:

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

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

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

In order to adjust the 2008 plot data to 1/1/2004, diameter increment regression formulas were created from Coastal Ridges' permanent plot remeasurements between the second measurement in 2000 to 2003 and the third measurement in 2007 to 2008. This data was taken from 67 of the 90 remeasured permanent plots. As plot measurements were not necessarily made at the same time of the year, each plot is considered to have its own growth period. The growth period of a plot is the difference between the current measurement and the last measurement rounded to the nearest tenth of a year. The permanent plots utilized to create the diameter increment regressions have growth periods ranging from 3.2 to 7.8 years.

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

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

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

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

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

In addition to the treatment of hardwoods, a small portion of the Willits Woods Tract burned during the 2008 Mendocino Lightning Complex. Two

fires were started by the lightning storm. The first fire burned approximately 2 acres in the northern portion of the ownership adjacent to the Two Rock Lookout. A second fire approximately 423 acres in size burned in the southern portion of the tract adjacent to the headwaters of Big River. Both of these fires were characterized primarily as slow burning ground fires that crept through the understory. These fires did not consume a significant portion of vegetation in the 3.5" DBH and larger diameter classes. The burned areas were cruised after the fires had been suppressed. The cruise plots indicate that very little of the measured trees were burned. Accordingly, no adjustment to the 2008 plot data has been made to account for the 2008 fires.

## Standing Dead Adjustments

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

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

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

above-ground standing dead carbon in trees  $\geq 10.5$ " DBH and 15'-19' in height. Total above-ground standing dead carbon  $\geq 10.5$ " DBH and  $\geq 15'$  in height is then 0.169 Mg C per acre on average for the Willits Woods Project.

Above-ground standing dead carbon for trees  $\geq 5$ " DBH and  $< 10.5$ " DBH will be estimated by calculating the relative proportion of above-ground live carbon per acre in the 5"-10" DBH class to above-ground live carbon per acre 10.5" DBH and larger (11" class and larger), and applying the same relative proportion to the estimate of standing dead 10.5" DBH and larger calculated above.

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

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

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

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

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

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

### Calibration:

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

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

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

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

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

**Table 1: Basal Area Calibration Factors**

| DBH Class | Basal Area Calibration Factor |             |         |        | DBH Class | Sample Size |             |            |        |
|-----------|-------------------------------|-------------|---------|--------|-----------|-------------|-------------|------------|--------|
|           | Redwood                       | Douglas-fir | Sugar P | Tanoak |           | Redwood     | Douglas-fir | Sugar Pine | Tanoak |
| 0-5       | 0.27                          | 0.76        | 0.49    | 1.50   | 0-5       | 13          | 28          | 2          | 50     |
| 6-10      | 0.68                          | 0.91        | 1.22    | 1.61   | 6-10      | 31          | 54          | 4          | 70     |
| 11-15     | 0.78                          | 1.05        | 1.77    | 2.11   | 11-15     | 128         | 111         | 26         | 18     |
| 16-20     | 1.07                          | 1.56        | 2.13    | 2.24   | 16-20     | 62          | 33          | 18         | 3      |
| 21+       | 1.86                          | 1.88        | 2.85    | 1.50   | 21+       | 14          | 10          | 5          | 2      |
| Average   | 0.88                          | 1.09        | 1.90    | 1.65   | Total     | 248         | 236         | 55         | 143    |

These calibration factors will be utilized for the first two periods of the 100-year planning period, and during future inventory updates utilizing the CRYPTOS Emulator model to estimate stand growth. Coastal Ridges will continue to develop appropriate calibration factors based upon remeasurement of its permanent plots over time. The use of updated calibration factors will be fully described in future option A updates.

Utilizing these calibration factors within the CRYPTOS Emulator model, the Pioneer 1999/2000 cruise data was grown forward to and compared with

Coastal Ridges' 2008 cruise results. The projected volume based on the 1999/2000 cruise is within a few percentage points of the volume reported by the 2008 cruise.

### Ingrowth:

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

**Table 2: Regeneration (Ingrowth) Assumptions**

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

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

## Site Index:

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

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

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

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

**Table 3: Site Index by Ownership Block**

| Willits Woods |            |
|---------------|------------|
| Species       | Site Index |
| Douglas-fir   | 120        |
| Redwood       | 119        |

## Project Acreage:

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

## Baseline Modeling:

The baseline modeling utilizes the above-described 2004 plot dataset, and an unevenaged management harvesting strategy employing selection and transition combined with small group openings not exceeding 2.5 acres in size. Portions of Coastal Ridges' timber stands are dominated by hardwoods species, or are in an understocked condition. The baseline modeling assumes an aggressive treatment of hardwood species in order to release existing conifer regeneration, and convert areas dominated by hardwoods to conifer occupation. Since 2003, Coastal Ridges has treated approximately 991 acres on the Project Area for the purpose of reducing hardwood stocking (primarily tanoak), and releasing existing conifer regeneration. The baseline harvest scenario assumes a continuation of this intensive hardwood reduction program.

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

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

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

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

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

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

### Baseline Harvest Strategy:

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

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

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

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

Silvicultural prescriptions on individual THPs are designed to best accommodate local timber stand conditions, while complying with the Forest Practice Rules. To accomplish this, a harvest strategy has been developed that evaluates each plot's stocking status in square feet of basal area per acre and point count stocking. Tables 3a-3c below illustrate the silviculture decision matrix upon which the growth and yield modeling is based. Harvesting under selection-transition, utilizes a BDq harvest strategy.

The "Bdq" formula is commonly used to describe the stand structure of uneven-aged forest stands and has been described extensively in the scientific literature (Guldin 1991). BDq refers to the stand structure with, in order of relative importance: B, the residual basal area; D, the maximum retained diameter class; and q, the ratio of the number of trees in adjacent (one inch) diameter classes.

## General Harvest Constraints:

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

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

The rules that specifically effect the determination of baseline are those that include limits to silviculture activities. This includes the requirements for minimum basal area retention, rotation ages, harvest adjacency restrictions, watercourse buffer widths and sustained yield requirements. Based on the size of the timber found on the Willits Woods, the sustained yield rules referred to as 'Option A' rules are used to meet sustained yield requirements. The pertinent rules include the following:

- 14 CCR 913.11(a): Maximum Sustained Production of High Quality Timber Products;

- 913.2: minimum basal area retention standards for Unevenaged Regeneration Methods;
- 913.2 (a)(2)(B): Group selection harvest limitations;
- 913.2 (b)(6): Minimum post-harvest residual basal area retention standards;
- 913.3; minimum basal area retention standards for Intermediate Treatments;
- 913.4 (b): standards for rehabilitation of Understocked Areas;
- 913.1 (c ): standards for Seed Tree Seed Step;
- 916.9: details harvest limitations for Watercourse and Lake Protection Zones around Class 1, 2 and 3 streams;

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

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

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

#### **Class I no Harvest Zone:**

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

#### **Harvesting WLPZ Plots:**

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

to meet FPR standards for shade canopy retention. FPR requirements for the retention of the largest trees, and restrictions on harvests within the channel zone are addressed given the basal area retention standards applied in the model.

#### **Northern Spotted Owl:**

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

#### **Hardwood Harvest:**

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

#### **Non-Commercial Treatments:**

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

#### **No Harvest Area:**

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

#### **Small Tree Mortality Adjustment:**

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

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

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

## Silvicultural Prescriptions

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

**Table 4a: Silvicultural Prescriptions used by Coastal**

| Prescription                  |                              | Description                                                                                                                                                                                                                                    |
|-------------------------------|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Uneven-Aged Management</b> |                              |                                                                                                                                                                                                                                                |
|                               | Single Tree Selection        | The goal of this prescription is to create and maintain, multistoried, uneven-aged stands with varied diameter classes.                                                                                                                        |
|                               | Single Tree Selection (WLPZ) | The goal of this prescription is to create and maintain dense, multistoried, uneven-aged stands with varied diameter classes.                                                                                                                  |
|                               | Group Selection              | The goal of this prescription is to create and maintain, multistoried, uneven-aged stands with varied diameter classes. Groups are up to 2.5 acres in size.                                                                                    |
|                               | Transition                   | The goal of this prescription is to develop uneven-aged stands from stands that have an even-aged or irregular stand structure. Trees are harvested individually, or in small groups up to 2.5 acres in size.                                  |
|                               | Commercial Thinning          | To promote timber growth and improve forest health through the harvest of trees in a manner that results in a stand capable of being managed using single tree or group selection.                                                             |
| <b>Even-Aged Management</b>   |                              |                                                                                                                                                                                                                                                |
|                               | Even-aged                    | The goal of this prescription is to perform the final step in rotating the stand that proceeded the current stand. Successive harvests will utilize uneven-aged silviculture.                                                                  |
|                               | Rehabilitation               | The goal of this prescription is to regenerate stands that are primarily experiencing excessive hardwood competition, and that also do not meet minimum stocking standards. Successive harvests will utilize uneven-aged silviculture.         |
|                               | Hardwood Release             | The goal of this prescription is to improve growth in stands that are primarily experiencing excessive hardwood competition, and that are also well stocked with conifer seedlings. Successive harvests will utilize uneven-aged silviculture. |

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

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

**Table 4c: Post-harvest Stocking by Silvicultural Prescription**

| Prescription                  |                                              | Stocking Considerations                                                | Conifer Basal Area Retention (sq. ft. per acre) | Hardwood Basal Area Retention (sq. ft. per acre) | Time to Next Treatment       |
|-------------------------------|----------------------------------------------|------------------------------------------------------------------------|-------------------------------------------------|--------------------------------------------------|------------------------------|
| <b>Uneven-Aged Management</b> |                                              |                                                                        |                                                 |                                                  |                              |
|                               | Single Tree Selection                        | All age, evenly distributed                                            | >75                                             | 8                                                | At Least 10 Years            |
|                               | Single Tree Selection Low Stocking (WLPZ)    | All age, evenly distributed                                            | >140                                            | 30                                               | At Least 10 Years            |
|                               | Single Tree Selection Medium Stocking (WLPZ) | All age, evenly distributed                                            | >175                                            | 25                                               | At Least 10 Years            |
|                               | Single Tree Selection High Stocking (WLPZ)   | All age, evenly distributed                                            | >225                                            | 20                                               | At Least 10 Years            |
|                               | Group Selection                              | Less than 20% of stand in group openings                               | >75                                             | 5                                                | At Least 10 Years            |
|                               | Transition                                   | Less than 20% of stand in group openings, at least 15 sq. ft. >12" DBH | >50                                             | 8                                                | Selection within 10-20 Years |
|                               | Commercial Thinning                          | Equal to or Greater average stand diameter than pre-harvest stand      | >100 if QMD >14" and 100 4"+ trees if QMD <14"  | 8                                                | Selection within 10-20 Years |
| <b>Even-Aged Management</b>   |                                              |                                                                        |                                                 |                                                  |                              |
|                               | Even-aged                                    | Retain/recruit 2-3 snags per acre                                      | >8                                              | 8                                                | Selection within 20-40 Years |
|                               | Rehabilitation                               | Retain/recruit 2-3 snags per acre                                      | >8 where conifer >8 pre-harvest                 | 8                                                | Selection within 30-40 Years |
|                               | Hardwood Release                             | No Commercial Conifer Harvest                                          | No Commercial Conifer Harvest                   | 8                                                | Selection within 20-40 Years |

## Growth and Yield Analysis:

The baseline growth and yield analysis was modeled using the CRYPTOS Emulator model utilizing the above described harvest strategy. The calibration factors shown in Table 1 were applied during the first two decades of the 100-year planning period. The maximum retention diameter was set at 18.5” for the first decade, and was increased by two inches per decade until the 4<sup>th</sup> decade and was thereafter held at 24.5 inches for the remainder of the planning period. Table 5a shows the results of the growth and yield analysis in terms of conifer yields, while table 5b shows the results in terms of tonnes of live carbon for all species. Table 6 shows the results in terms of average basal area per acre over the 100 year planning horizon.

**Table 5a: Average per Acre Conifer Growth and Yield through the Planning Horizon**

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

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

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

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

| Elapsed Time (years) | 0   | 10  | 20 | 30  | 40  | 50  | 60  | 70  | 80  | 90  | 100 |
|----------------------|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|
| Conifer              | 71  | 81  | 80 | 88  | 87  | 90  | 91  | 97  | 95  | 99  | 99  |
| Hardwood             | 77  | 23  | 19 | 17  | 14  | 15  | 16  | 18  | 19  | 20  | 20  |
| Total                | 149 | 104 | 99 | 106 | 101 | 104 | 107 | 116 | 114 | 119 | 120 |

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

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

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

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

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

## Baseline Carbon Stocks

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

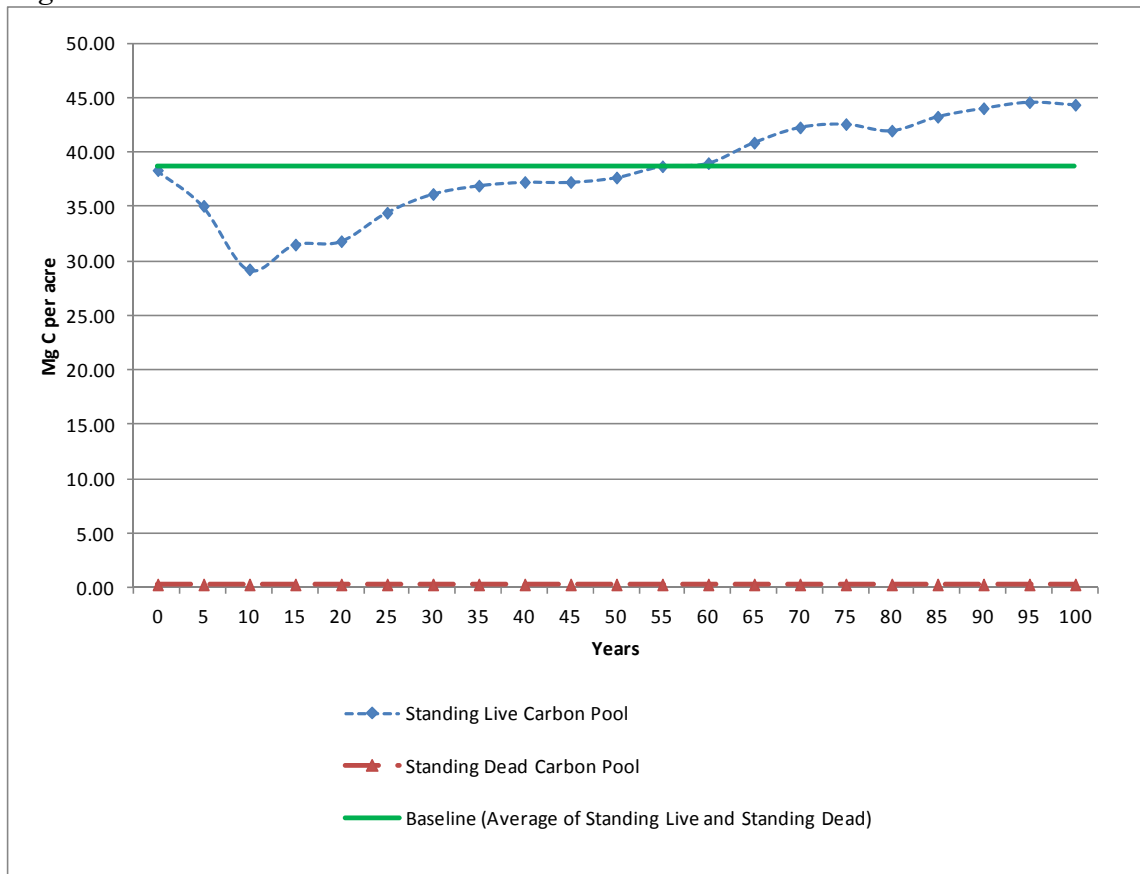
Key components of the calculated baseline are as follows:

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

**Table 8: Average Baseline Carbon Stocks per acre Generated by the Baseline Harvest Scenario.**

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

Figure 1: Baseline Carbon Stocks



## Wood Products

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

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

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

## Literature Cited

- Guldin, James M., 1991. Uneven-Aged BDq Regulation of Sierra Nevada Mixed Conifers. *Journal of Forestry*, Vol. 6, No. 2, p. 27-32.
- Oliver, W.W., J.L. Lindquist, and R.O. Strothman. 1994.  
Young-growth redwood stands respond well to various thinning intensities. *West. J. Appl. For.* 9(4): 106-112.
- Wensel, Lee C., and Krumland, Bruce. Volume and Taper Relationships for Redwood, Douglas Fir, and Other Conifers in California's North Coast, University of California, Division of Agricultural Sciences Bulletin 1907, 1983.

**ATTACHMENT L**

## **WILLITS WOODS CARBON PROJECT INVENTORY METHODOLOGY**

This document contains specifications for the collection of data in the field for the Willits Woods Inventory, as well as the data to be collected and the standards for data collection and processing. The Willits Woods Carbon Project includes approximately 18,008 acres of timberland characterized by redwood, Douglas-fir, Black Oak, Interior live oak, Ponderosa Pine, Pacific Madrone, 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 Willits Woods Project. Sampling will be conducted through the installation of sampling points on a square systematic plot grid 25.4 chains on a side utilizing a random starting location. A map of the sampling grid is attached. 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 Application 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 Willits Woods 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 Application 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 Willits Woods 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 resulted in a final data set for cruise processing. The Access database serves as the repository for inventory data and is accessed by the growth and yield model during growth and yield simulations.

The inventory database is utilized to process the inventory data through the growth and yield model FORSEE. 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 Application as referenced above.

## **Stratification Methodology**

The Willits Woods Project Area will be stratified based on species composition and relative stocking.

## **Quality Assurance/Quality Control (QA/QC)**

Procedures for ensuring quality control are explained in the attached Willits Woods Carbon Project Inventory Specifications document under the “Check Cruising” heading. Procedures in verifying the integrity of inventory data are described above.

## **Updating the Inventory**

As timber management activities take place on the Willits Woods Project Area or disturbance such as fire or mortality resulting from pathogens or other factors occurs, cruise plots installed in 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, Willits Woods 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 year to year will involve the following steps:

1. Any newly installed inventory plots will be incorporated into the inventory estimate.
2. Existing inventory plots will be updated using the CRYPTOS Emulator. Plot data will then be exported to FORSEE for the calculation of the final carbon stock values as described in the modeling plan.
3. Updating the forest inventory for harvests or disturbances that have occurred during the previous year through the installation of new plots, relocation and re-measurement of

- existing plots, or adjustments to previous plot data.
4. Where necessary, the inventory update process may result in restratification of portions of the timber strata.
  5. Inventory updates following harvest or disturbance will be re-measured within 12 months of the harvest or disturbance.

**Appendices:**

- A. Inventory Change Log
- B. Willits Woods Carbon Project Inventory Specification
- C. Willits Woods Ranch Inventory Plot Data Entry Procedures
- D. Plot Map

## Appendix A

## Willits Woods Carbon Project Inventory Change Log

[illegible]

## **Appendix B**

### Willits Woods Carbon Project Inventory Specification

## Willits Woods Carbon Project Inventory Specification

The cruise shall include the Willits Woods for a total of approximately 18,008 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 post-cruising stratification. The cruise design will measure approximately 284 plots on a square systematic plot grid 25.4 chains on a side established in 2008 as a part of the initial inventory of the Willits Woods Project's timber stands. This revised inventory specification will utilize the same plot center locations as the 2008 inventory, as well as the same set of nested fixed-area plots. In addition to the inclusion of timber stand stratification, this revised inventory specification will collect tree heights on all trees, include update plot monumentation procedures, as well as gather data on missing tree volume. DBH will be recorded to the nearest 1/10<sup>th</sup> inch as opposed to the nearest 1" class as with the previous inventory design. Following remeasurement of the 2008 plot locations, it may be necessary to install additional plots within some or all of the timber strata either randomly or systematically in order to achieve the desired inventory confidence of plus or minus 5% at the 90% confidence level.

**Plot Documentation and Location:** Cruiser 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 the existing 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 list of GPS coordinates as supplied by Coastal Ridges and if necessary, due to lack of adequate GPS satellite reception, road take-off points established by Coastal Ridges, and field measurement (hip chain, or electronic device). Handheld GPS equipment will be used to locate 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. In the event that the cruiser cannot locate the previously installed inventory plot, a new plot center will be established.

Plots were previously measured where they fell on the systematic grid 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.

Plot centers will be documented with a 3/8" rebar stake at least 16 inches in length (provided by Coastal Ridges) and flagging (tied to the stake) with the plot number written in rain proof ink. The plot center stake shall be inserted at least 12 inches into the ground, with the protruding portion being painted with glo-orange paint. 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 with orange spray paint. Flagging to establish plot center shall be glow lime green and provided by Coastal Ridges. A GPS coordinate of the actual plot center shall be recorded.

At each plot center, two plot reference trees will be established for the purpose of relocating the plot center. 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 from the reference tree to the plot center shall be recorded with the plot data. Reference trees shall be at least 3.5" in diameter and should be located as close as possible at right angles to plot center. A ring shall be painted around the circumference of the reference trees at DBH to identify these trees and the plot in the future. Paint color shall be glo-orange.

**Plot Card Format:** Paper field data forms will follow the format of the attached sample cruise card (to be provided by Coastal Ridges on Rite-In-The-Rain paper). 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. Cruiser will be responsible for providing copies of the field data cards to Coastal Ridges within 1 day of cruising, and providing the cruise data in a digital format within 30 days of cruise completion.

**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. 1/5<sup>th</sup> acre (52.67') – Conifers 10.5" DBH and larger.
2. 1/50<sup>th</sup> acre (16.65') – Conifers 3.5" DBH to 10.4" DBH, and hardwoods 3.5" DBH and larger.
3. 1/250<sup>th</sup> acre (7.45') – Conifers and hardwoods 1.0" DBH to 3.4" 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 3.5" 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<sup>th</sup> 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. Visible defect will be recorded by log position for all conifers which contain at least one 16.5' x 6" dib log.
6. Total height to the nearest foot.
7. Merchantable Height – Number of Logs (measured to a 6" DIB top). (WTS Note: Log heights start at the top of the stump height. [Merch. Ht. data can be noted for each tree on the cruise card.] To be consistent and help check cruisers, logs should be identified within a range per log height, please see table below):

| Log Ht. | Height (ft.) | Min (ft.) | Max (ft.) |
|---------|--------------|-----------|-----------|
| Log 1   | 16.5         | 16        | 24        |
| Log 2   | 33.0         | 25        | 41        |
| Log 3   | 49.5         | 42        | 57        |
| Log 4   | 66.0         | 58        | 74        |
| Log 5   | 82.5         | 75        | 90        |
| Log 6   | 99.0         | 91        | 107       |
| Log 7   | 115.5        | 108       | 123       |
| Log 8   | 132.0        | 124       | 140       |
| Log 9   | 148.5        | 141       | 156       |
| Log 10  | 165.0        | 157       | 173       |
| Log 11  | 181.5        | 174       | 189       |
| Log 12  | 198.0        | 190       | 206       |

8. Status Code
9. 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.
10. Missing volume by 1/3<sup>rd</sup> 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:**

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

\*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. 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.

**Live Crown Ratio:**

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

**Visible Defect:**

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

**Missing Volume:**

Record missing gross volume for each 1/3<sup>rd</sup> portion of the tree, bottom, middle, and top. For trees with broken tops, estimate the total height including the missing top section before estimating the height of each 1/3<sup>rd</sup> segment of the tree. If the broken top is the only missing portion of the tree, record nothing for missing volume 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 1/3<sup>rd</sup> segment of the tree. For example if 20% of the bottom 1/3<sup>rd</sup>, and 100% of the middle 1/3<sup>rd</sup> is missing, record 20-100-0 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 break in the stem, unless a new leader has developed then measure to the height of the new leader). The dominant stem is measured for trees having a fork. Trees with previously broken tops are considered recovered when a new leader (dead or alive) is 1/3 the diameter of the broken top at the point where the top was broken (not where the new leader originates from the trunk). Forked trees should be treated the same as unforked trees.

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]). Height to the nearest foot will be recorded for each tree that has a broken top.

**Status Codes:**

|    |                  |
|----|------------------|
| BT | Broken top       |
| FT | Forked top       |
| 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:

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

**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 Coastal Ridges for check cruising within 3 days of cruising. Coastal Ridges 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 1/5 <sup>th</sup> , and 1/50 <sup>th</sup> acre plot only including snags | None.                                                                                                      |
| Species                                                                                 | None.                                                                                                      |
| Total height                                                                            | ±10% or 10' whichever is less, on each tree.                                                               |
| DBH 1/5 <sup>th</sup> acre plot                                                         | ±0.3" for trees less than 24" DBH<br>±0.5" for conifer trees and ±1" for hardwood trees 24" DBH or greater |
| DBH 1/50 <sup>th</sup> and 1/100 <sup>th</sup> acre plots                               | ±0.3" for all trees                                                                                        |
| Live crown ratio                                                                        | 20%.                                                                                                       |
| Plot location                                                                           | Within one chain of mapped location                                                                        |
| Tree count on 1/250 <sup>th</sup> – 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 remeasured in their entirety.

### Remarks:

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

### Special Circumstances:

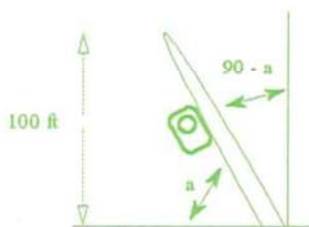
DBH: Trees with irregularities at DBH shall be measured just above the irregularity. For trees with a fork near DBH, the tree shall be treated as two trees if the fork occurs below DBH, and as a single tree if the fork occurs above DBH. As the plots are fixed area plots, trees are considered on the plot 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.

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

Leaning Trees: Total height on slightly leaning trees (less than 15 degrees) shall be measured perpendicular to the lean of the tree. Severely leaning trees (15 degrees or more) shall be measured perpendicular to the lean with the vertical distance from the ground to the tip of the tree, and the angle of the tree lean to the nearest 5 degrees recorded in the "Remarks" column. The cruiser may additionally estimate the trees height using the heights of similar diameter trees that are standing upright. Severely leaning tree 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  $90^\circ$
4. Find slope correction factor for step 3 angle.
5. Multiply vertical height by slope correction factor.



#### EXAMPLE:

Vertical height = 100 ft. Clinometer reading =  $61^\circ$  ( $a = 61$ )  
 $90^\circ - 61^\circ = 29^\circ$  Slope Correction Factor for  $29^\circ = 1.14$   
Corrected height =  $100 * 1.14 = \underline{114 \text{ ft}}$

### 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.

## **Appendix C**

Willits Woods Inventory  
Plot Data Entry Procedures

# Willits Woods Inventory

## Plot Data Entry Procedures

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 "Willits\_Woods\_2015.mdb" Access database found at L:\CFL\Coastal Ridges\ARB\Inventory2015.
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.

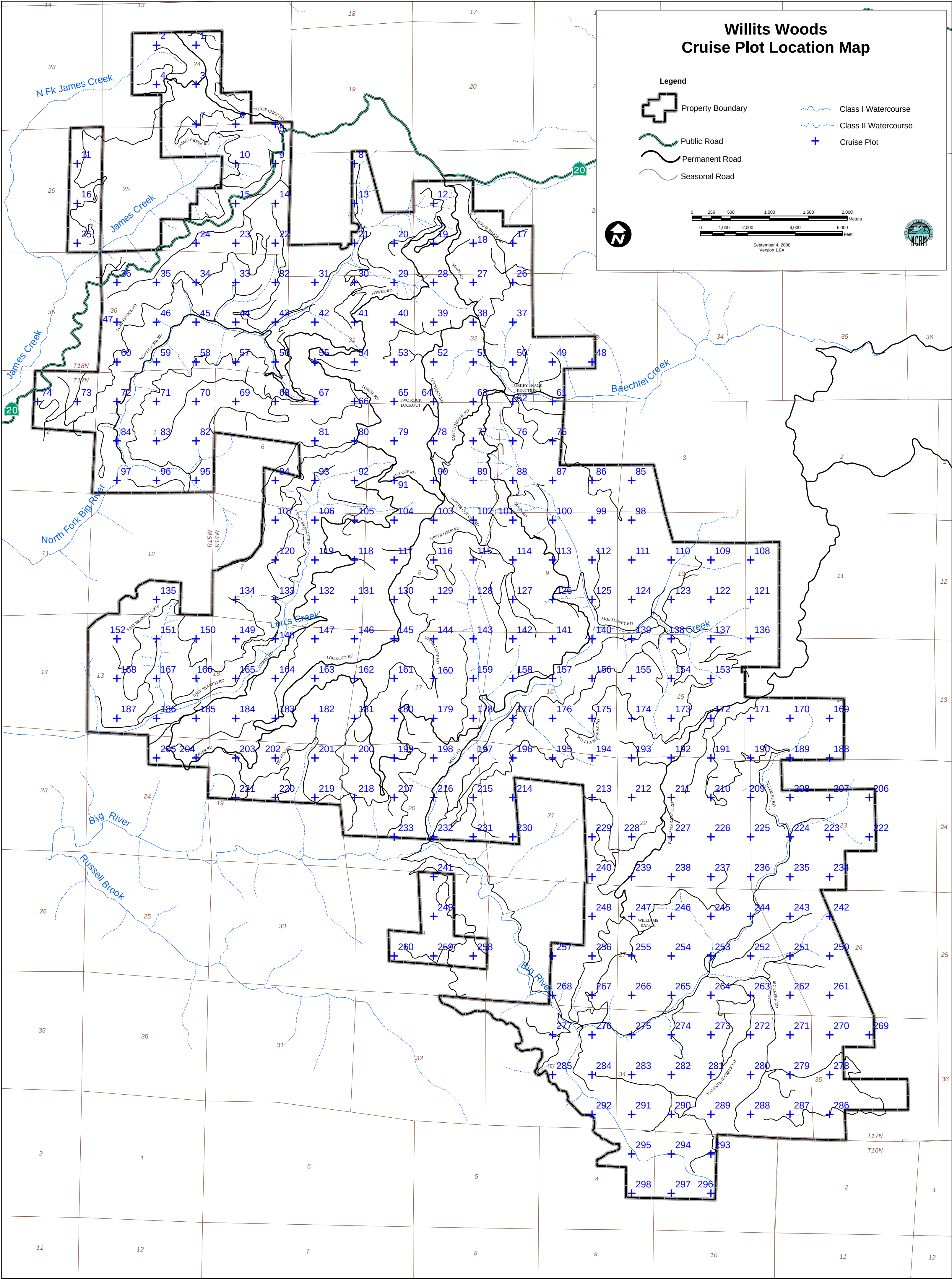
11. If there is a problem reading the data for a tree, or if the data entered differs from the data on the cruise card, describe the issue in the Entry Note column for the tree in question.
12. When data entry is complete, the person entering the card shall write the word "Entered", the date entered, 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:\CFL\Coastal Ridges\ARB\Inventory2015\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.

## **Appendix D**

### Plot Map



**ATTACHMENT M**

# 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  $\geq 1$ " DIA, and on dead trees that are  $\geq 5$ " 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  $\geq 5$ " 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  $\geq 9$ " DIA; and for hardwoods, it is the volume of a tree from a 1-foot stump to an 8" top, calculated for hardwood species  $\geq 11$ " 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)

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

BOARD FOOT VOLUME (square feet)

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

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

# SOFTWOOD CUBIC VOLUME EQUATIONS

## Volume equation numbers

| Species Code | Species                | Halfstate |     |      |     |      |
|--------------|------------------------|-----------|-----|------|-----|------|
|              |                        | 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

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

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

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

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

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

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

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<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

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<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

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<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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<sup>1/3</sup>) ) + ( .036329 x S ) )<sup>3</sup>

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<sup>1/3</sup>) ) - ( .016712 x S ) )<sup>3</sup>

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;

$$\text{VOLUME} = (0.02434 + (0.119106 \times (\text{Factor}^{1/3}))^3$$

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

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

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

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

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

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

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<sup>2</sup>

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

$$CVTS = 0.005454154 \times \left[ 0.30708901 + 0.0008615762 \times HT - 0.0037255243 \times DBH \times \frac{HT}{HT - 4.5} \right] \times DBH^2 \times HT \times \left( \frac{HT}{HT - 4.5} \right)^2 \quad (1)$$

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

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

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

If 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<sup>2</sup>

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

$$CV6 = RC6 \times CV4$$

IF CV6 > CV4 THEN CV6 = CV4

$$CUBUS = CV4 - CV6$$

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

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

$$RS616 = 10.0^{RS616L}$$

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

$$SV616 = RS616 \times CV6$$

$$SV632 = RS632 \times SV616$$

$$SCRIB = SV632$$

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

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

$$XINT6 = RI6 \times CV6$$

Where:

B4 = BINGO FACTOR

CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION

RC6 = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP

CV6 = CUBIC FOOT VOLUME, 6-INCH TOP (SAWLOG)

RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS

RS632 = RATIO TO CONVERT SCRIB 6-INCH TOP IN 16-FT LOGS TO SCRIB 6-INCH TOP IN 32-FT LOGS (WEST-SIDE ONLY)

SV632 = SCRIBNER VOLUME--6-INCH TOP (IN 32-FT LOGS) (WEST-SIDE ONLY)

SV616 = SCRIBNER VOLUME--6-INCH TOP (IN 16-FT LOGS)

RI6 = RATIO TO CONVERT CUBIC 6-INCH TOP TO INTERNATIONAL ¼ INCH 6-INCH TOP

XINT6 = INTERNATIONAL ¼ INCH VOLUME--6-INCH TOP (IN 16-FT LOGS)

# HARDWOOD CUBIC VOLUME EQUATIONS

## Volume equation numbers

| Species Code | Species                          | Halfstate |     |     |     |    |
|--------------|----------------------------------|-----------|-----|-----|-----|----|
|              |                                  | 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)

| Species Code | Species              | Halfstate |     |     |     |    |
|--------------|----------------------|-----------|-----|-----|-----|----|
|              |                      | 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

|                             |                                 |                                                   |
|-----------------------------|---------------------------------|---------------------------------------------------|
| <a href="#">EQUATION 25</a> | <a href="#">ALDER</a>           | (CURTIS/BRUCE, PNW-56 and DNR 24)                 |
| <a href="#">EQUATION 26</a> | <a href="#">ALDER</a>           | (BC-ALDER--DNR RPT#24,1977)                       |
| <a href="#">EQUATION 27</a> | <a href="#">COTTONWOOD</a>      | (BC-COTTONWOOD--DNR RPT#24,1977)                  |
| <a href="#">EQUATION 28</a> | <a href="#">ASPEN</a>           | (BC-ASPEN--DNR RPT#24,1977)                       |
| <a href="#">EQUATION 29</a> | <a href="#">BIRCH</a>           | (BC-BIRCH--DNR RPT#24,1977)                       |
| <a href="#">EQUATION 30</a> | <a href="#">BIGLEAF MAPLE</a>   | (BC-MAPLE--DNR RPT#24,1977)                       |
| <a href="#">EQUATION 31</a> | <a href="#">EUCALYPTUS</a>      | (MEMO,COLIN D. MacLEAN 1/27/83,(REVISED 2/7/83) ) |
| <a href="#">EQUATION 32</a> | <a href="#">G.CHINQUAPIN</a>    | (PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)       |
| <a href="#">EQUATION 33</a> | <a href="#">C.LAUREL</a>        | (PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)       |
| <a href="#">EQUATION 34</a> | <a href="#">TANOAK</a>          | (PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)       |
| <a href="#">EQUATION 35</a> | <a href="#">CALIF WHITE OAK</a> | (PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)       |
| <a href="#">EQUATION 36</a> | <a href="#">ENGELMANN OAK</a>   | (PILLSBURY (H,D), CHARLES BOLSINGER 1/3/83)       |
| <a href="#">EQUATION 37</a> | <a href="#">BIGLEAF MAPLE</a>   | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 38</a> | <a href="#">CALIF BLACK OAK</a> | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 39</a> | <a href="#">BLUE OAK</a>        | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 40</a> | <a href="#">PACIFIC MADRONE</a> | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 41</a> | <a href="#">ORE WHITE OAK</a>   | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 42</a> | <a href="#">CANYON LIVE OAK</a> | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 43</a> | <a href="#">COAST LIVE OAK</a>  | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 44</a> | <a href="#">INT LIVE OAK</a>    | (PILLSBURY (H,D,FC), CHARLES BOLSINGER 1/3/83)    |
| <a href="#">EQUATION 45</a> | <a href="#">MTN. MAHOGANY</a>   | (Chojnacky, 1985)                                 |
| <a href="#">EQUATION 46</a> | <a href="#">MESQUITE</a>        | (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

Brckett, 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

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

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

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

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

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

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

$$RC8 = 0.983 - \left( 0.983 \times 0.65^{(DBH-8.6)} \right) \tag{6}$$

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

$$CV4X = CV4$$

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES) BA = .005454154 x DBH<sup>2</sup>

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 26

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

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

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

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

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

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

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

$$CV4X = CV4$$

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH<sup>2</sup>

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

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 27

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

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

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

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

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

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

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

$$CV4X = CV4$$

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

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

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 28

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

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

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

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

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

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

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

$$CV4X = CV4$$

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

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

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 29

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

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

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

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

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

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

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

$$CV4X = CV4$$

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

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

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 30

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

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

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

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

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

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

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

$$CV4X = CV4$$

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

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

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 31

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

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

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

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

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

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

$$CV4X = CV4$$

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 32

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 33

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 35

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 36

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA = .005454154 x DBH<sup>2</sup>

CVTS = CUBIC FOOT VOLUME, TOTAL STEM, WITH TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 37

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

FC= HARDWOOD FORM CLASS

CVTS= CUBIC FOOT VOLUME, TOP AND STUMP

TARIF= TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 38

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 39

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

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

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

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

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

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

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

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

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

WHERE:

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

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

BA= BASAL AREA (DBH IN INCHES) BA= .005454154 x DBH<sup>2</sup>

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 41

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 42

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 43

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

FC=HARDWOOD FORM CLASS

CVTS = CUBIC FOOT VOLUME, TOP AND STUMP

TARIF = TARIF NUMBER EQUATION

CVT = CUBIC FOOT VOLUME ABOVE STUMP

CV4 = CUBIC FOOT VOLUME, 4-IN TOP

CV8 = CUBIC FOOT VOLUME, SAWLOG (8-IN TOP)

## EQUATION 44

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

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

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

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

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

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

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

WHERE:

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

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

BA = BASAL AREA (DBH IN INCHES)      BA= .005454154 x DBH<sup>2</sup>

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<sup>1/3</sup>) ) + 0 .080208 )<sup>3</sup>

ELSE IF STEMS > 1 THEN

VOLUME = (-0.13363 + ( 0.128222 x (Factor<sup>1/3</sup>) ))<sup>3</sup>

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

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

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

-----  
IF Hardwood Equation Number is 25 to 31 THEN set

CV4X = CVT

TARIFX = TARIF (note that TARIF was calculated in the cubic volume equation)

Otherwise, for all other hardwood equation numbers, calculate CV4X and TARIFX as follows:

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

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

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

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

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

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

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

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

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

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

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

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

Calculated on hardwood species only:

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

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

WHERE:

B4 = BINGO FACTOR

CUBUS = CUBIC FOOT VOLUME, UPPER-STEM PORTION

RC6 = RATIO TO CONVERT CUBIC 4-INCH TOP TO CUBIC 6-INCH TOP

CV6 = CUBIC FOOT VOLUME, 6-INCH TOP (SAWLOG)

RS616 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 6-INCH TOP IN 16-FT LOGS

SV616 = SCRIBNER VOLUME--6-INCH TOP (IN 16-FT LOGS)

RS816 = RATIO TO CONVERT CUBIC 6-INCH TOP TO SCRIB 8-INCH TOP IN 16-FT LOGS

SV816 = SCRIBNER VOLUME--8-INCH TOP (IN 16-FT LOGS)

XINT6 = INTERNATIONAL ¼ INCH VOLUME--6-INCH TOP (IN 16-FT LOGS)

RI8 = RATIO TO CONVERT INTERNATIONAL ¼ INCH 6-INCH TOP TO INTERNATIONAL ¼ INCH 8-INCH TOP

XINT8 = INTERNATIONAL ¼ INCH VOLUME--8-INCH TOP (IN 8-FT LOGS)

# 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 (ft<sup>3</sup>)

Wood density = (Specific gravity of a tree species) \* (62.4 lbs/ft<sup>3</sup>)

Weight of water = 62.4 pounds/cubic foot

**Biomass of the tree stem** (in tons) = (cubic foot volume \* wood density) / 2000

The tables below contain specific gravity and wood density values for many species.

# BIOMASS EQUATIONS AND PROCEDURES

## Softwoods – 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)

| <b>Code</b> | <b>Species</b>               | <b>Specific gravity</b> | <b>Wood density</b> |
|-------------|------------------------------|-------------------------|---------------------|
| 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 torreyia          | 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)

| <b>Code</b> | <b>Species</b>             | <b>Specific gravity</b> | <b>Wood density</b> |
|-------------|----------------------------|-------------------------|---------------------|
| 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   | Subalpine 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 |

SOFTWOOD BIOMASS EQUATION ASSIGNMENTS  
--continued--

**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 EQUATIONS

### BIOMASS OF BARK

**All equations produce Biomass of Bark in Kilograms ---  
to convert to tons multiply by 0.0011023**

\*Log\* in the equations is = NATURAL LOG

#### EQUATION 1

BIOPAK EQUATION 379

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

#### EQUATION 2

BIOPAK EQUATION 887

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

#### EQUATION 3

BIOPAK EQUATION 917

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

#### EQUATION 4

BIOPAK EQUATION 382

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

#### EQUATION 5

BIOPAK EQUATION 251

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

#### EQUATION 6

BIOPAK EQUATION 845

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

#### EQUATION 7

BIOPAK EQUATION 875

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

#### EQUATION 8

BIOPAK EQUATION 5

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

#### EQUATION 9

BIOPAK EQUATION 705

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

**EQUATION 10**

BIOPAK EQUATION 391

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

**EQUATION 11**

BIOPAK EQUATION 899

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

**EQUATION 12** (updated)

BIOPAK EQUATION 385

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

**EQUATION 13**

BIOPAK EQUATION 461

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

**EQUATION 14**

BIOPAK EQUATION 904

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

**EQUATION 15**

BIOPAK EQUATION 174

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

**EQUATION 16**

BIOPAK EQUATION 54

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

**EQUATION 17**

BIOPAK EQUATION 394

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

**EQUATION 18**

BIOPAK EQUATION 942

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

**EQUATION 19**

$$BB = 0.0$$

**EQUATION 20**

BIOPAK EQUATION 275

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

**EQUATION 21**

BIOPAK EQUATION 911

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

**EQUATION 22**

BIOPAK EQUATION 881

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

**EQUATION 23**

BIOPAK EQUATION 923

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

**EQUATION 24**

BIOPAK EQUATION 893

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

**EQUATION 25**

BIOPAK EQUATION 857

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

**EQUATION 26**

BIOPAK EQUATION 455

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

**EQUATION 27**

BIOPAK EQUATION 948

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

**EQUATION 28**

BIOPAK EQUATION 930

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

**EQUATION 29 (Bigleaf maple)**

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

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

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

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

**EQUATION 30 (California Black Oak)**

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

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

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

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

**EQUATION 31 (Canyon Live Oak)**

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

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

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

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

**EQUATION 32 (Golden Chinkapin)**

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

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

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

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

**EQUATION 33 (California Laurel)**

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

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

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

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

**EQUATION 34 (Pacific Madrone)**

$$ADBH = \frac{(DBH + 0.03425)}{0.98155} \quad 1$$

$$OUTERVOL = 0.0000378129 \times (ADBH^{1.99295} (HT^{1.01532})) \quad 2$$

$$INNERVOL = 0.0000378129 \times (DBH^{1.99295} (HT^{1.01532})) \quad 3$$

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

**EQUATION 35 (Oregon White Oak)**

$$ADBH = \frac{(DBH + 0.78034)}{0.95956} \quad 1$$

$$OUTERVOL = 0.0000236325 \times (ADBH^{2.25575} (HT^{0.87108})) \quad 2$$

$$INNERVOL = 0.0000236325 \times (DBH^{2.25575} (HT^{0.87108})) \quad 3$$

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

**EQUATION 36 (Tanoak)**

$$ADBH = \frac{(DBH + 4.1177)}{0.95354} \quad 1$$

$$OUTERVOL = 0.0000081905 \times (ADBH^{2.19576} (HT^{1.14078})) \quad 2$$

$$INNERVOL = 0.0000081905 \times (DBH^{2.19576} (HT^{1.14078})) \quad 3$$

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

**EQUATION 37 (Blue oak)**

$$ADBH = \frac{(DBH + 0.44003)}{0.95354} \quad 1$$

$$OUTERVOL = 0.0000204864 \times (ADBH^{2.53987} (HT^{0.50591})) \quad 2$$

$$INNERVOL = 0.0000204861 \times (DBH^{2.53987} (HT^{0.50591})) \quad 3$$

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

**EQUATION 38****BIOPAK EQUATION**

$$BB = 3.3 + 9.0 \times \left( \frac{DBH}{100} \right)^2 \times HT$$

**EQUATION 39****BIOPAK EQUATION 936**

$$BB = -1.2 + 24.0 \times \left( \frac{DBH}{100} \right)^2 \times HT$$

**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 |
| $\pi$   | = 3.141593                                                           |

## BIOMASS EQUATIONS

### BIOMASS OF LIVE BRANCHES

**All equations produce Biomass of Live Branches in Kilograms ---  
to convert to tons multiply by 0.0011023**

\*Log\* in the equations is = NATURAL LOG

*Log = natural log*

#### EQUATION 1

BIOPAK EQUATION 889

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

#### EQUATION 2

BIOPAK EQUATION 919

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

#### EQUATION 3

BIOPAK EQUATION 28

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

#### EQUATION 4

BIOPAK EQUATION 877

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

#### EQUATION 5

BIOPAK EQUATION 847

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

#### EQUATION 6

BIOPAK EQUATION 2

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

#### EQUATION 7

BIOPAK EQUATION 702

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

#### EQUATION 8

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

#### EQUATION 9

BIOPAK EQUATION 901

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

**EQUATION 10**

BIOPAK EQUATION 459

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

**EQUATION 11**

BIOPAK EQUATION 907

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

**EQUATION 12**

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

**EQUATION 13**

BIOPAK EQUATION 51

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

**EQUATION 14**

BIOPAK EQUATION 944

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

**EQUATION 15**

BIOPAK EQUATION 932

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

**EQUATION 16**

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

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

**EQUATION 17**

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

**EQUATION 18**

BIOPAK EQUATION 883

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

**EQUATION 19**

BIOPAK EQUATION 925

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

**EQUATION 20**

BIOPAK EQUATION 895

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

**EQUATION 21**

BIOPAK EQUATION 446

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

**EQUATION 22**

BIOPAK EQUATION 859

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

**EQUATION 23**

Weyerhaeuser Co Equation

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

**EQUATION 24**

BIOPAK EQUATION 913

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

**EQUATION 25**

BIOPAK EQUATION 950

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

**EQUATION 26**

BIOPAK EQUATION 938

$$BLB = 8.1 + 21.5 \times \left( \frac{DBH}{100} \right)^2 \times HT$$

**EQUATION 27**

Snell et.al 1983, bigleaf maple

$$BLB = \exp(4.0543553 + 2.1505 \times \log(DBH)) \left( 1 - \frac{1}{(4.6762 + 0.0163 \times DBH^{2.039})} \right) / 1000$$

**EQUATION 28**

Snell et.al 1983, pacific madrone

$$BLB = \exp(3.0136553 + 2.4839 \times \log(DBH)) \left( 1 - \frac{1}{(1.6013 + 0.1060 \times DBH^{1.309})} \right) / 1000$$

**EQUATION 29**

Snell et.al 1983, giant chinkapin

$$BLB = \exp(3.1980553 + 2.2699 \times \log(DBH)) \left( 1 - \frac{1}{(1.6048 + 0.2979 \times DBH^{0.6828})} \right) / 1000$$

**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 $\pi$  = 3.141593

**ATTACHMENT N**

## 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.