

# FiniteCarbon

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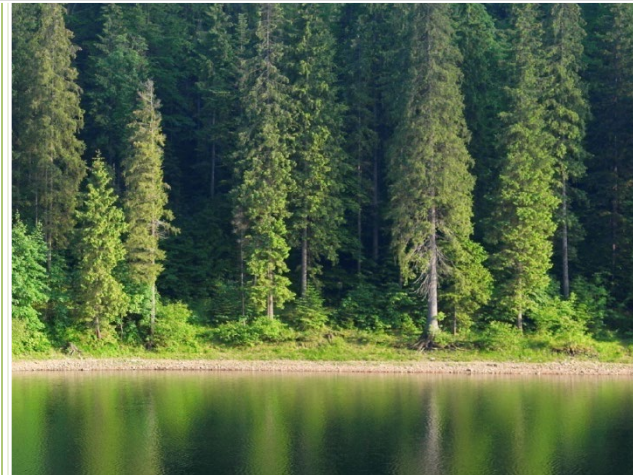
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## Appendix A. CAR1339 Inventory and Modeling Methodology “Humboldt Mixed Forest Improvement Project”

CA EPA Air Resources Board Compliance Offset Protocol  
U.S. Forests Projects: Improved Forest Management

Adopted: June 25, 2015

Initial Reporting Period: 05/01/2019 – 10/31/2019  
OPR Project ID#: CAR1339  
ARB Project ID#: CAFR6339



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## Introduction

California's Cap and Trade Regulation ("Regulation") took effect on January 1, 2012, with amendments to the Regulation effective September 1, 2012. The enforceable compliance obligation began on January 1, 2013. The Air Resources Board (ARB) has developed and implemented a compliance offset program as part of the State's Cap and Trade Program. Covered entities may use a limited number of ARB offset credits to fulfill up to 8% of their compliance obligation. Offset credits are tradable compliance instruments that represent verified greenhouse gas (GHG) emission reductions or removal enhancements made in sectors and sources not covered by the Cap and Trade Program.

The ARB U.S. Forest Projects Compliance Offset Protocol adopted on October 20, 2011 ("Forest Offset Protocol"; "Protocol"; COP; or FOP) provides requirements and methods for quantifying the net climate benefits of activities that sequester carbon on forestland. The protocol provides offset project eligibility rules; methods to calculate an offset project's net effects on GHG emissions and removals of CO<sub>2</sub> from the atmosphere (removals); procedures for assessing the risk that carbon sequestered by a project may be reversed (i.e. released back to the atmosphere); and approaches for long term project monitoring and reporting. The goal of this protocol is to ensure that the net GHG reductions and GHG removal enhancements caused by an offset project are accounted for in a complete, consistent, transparent, accurate, and conservative manner and may therefore be reported as the basis for issuing ARB or registry offset credits. The protocol is built from The Climate Action Reserve's Forest Project Protocol Version 3.2. This project was developed under the updated version of the FOP adopted on June 25, 2015, and also in compliance with the Regulation published April 1, 2019.

Finite Carbon is a forest carbon project developer specializing in the creation and monetization of forest carbon offsets. Combining unparalleled project development experience with extensive carbon market knowledge, Finite Carbon offers the most comprehensive forest carbon project development and commercialization service in the United States. With an in-house team of forest carbon experts, Finite Carbon provides all the expertise and resources for successful implementation of forest carbon inventories, project design, verification management and monetization of carbon offset.

This document is the primary appendix to the Offset Project Data Report (OPDR) for Humboldt Mixed Forest Improvement Project ("Humboldt"), assigned by the Climate Action Reserve, which is an ARB approved Offset Project Registry (OPR), as Project ID: CAR1339. The OPDR and all other project documentation and reports that reference carbon stocks have been prepared and submitted by Brandon Vickery, SAF Certified Forester (No. 51765) and Brian Sharer, SAF Certified Forester (No. 53906). Additional oversight of forestry documentation and modeling practices was provided by William Kleiner, who is a current California Registered Professional Forester (RPF) operating under license No. 2148 (see Figure 1) and satisfies the professional forester<sup>1</sup> requirements outlined in the FOP, section 7.2.

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<sup>1</sup> The project is located in a jurisdiction with a Professional Forester law; accordingly oversight by a registered or licensed professional forester has been employed to maintain professional standards and project quality.



Figure 1: Registered Forester Certification

## Inventory Overview

This section describes the inventory data collection specifications and is one part of the comprehensive forest carbon inventory methodology used for the project. The 'Sampling Methodology' section remains formatted as the instructive inventory specifications document provided to the contractor who performed the original project inventory. Additional footnotes have been inserted to provide clarifications and supplementary information as needed for this OPDR appendix.

The OPO, Green Diamond Resource Company, in collaboration with Finite Carbon has commissioned the following forest inventory for this project totaling approximately 33,217.53 forested acres in northern California. The project boundary is defined by the boundary and strata shape files provided with this specification document.

The purpose of this forest inventory was to quantify the forest carbon stocks of the standing living and dead tree carbon pools in the project area for enrollment as an improved forest management carbon offset project. The procedures described herein shall also be the guiding basis for the collection of future inventory data annually and/or periodically throughout the project life. This inventory was conducted in a manner that is verifiable, facilitates modeling, and is replicable. All inventory data collected was audited for accuracy both by the primary contractor, Finite Carbon, and a third-party auditor.

## Project Area Background

The Project Area is comprised of natural forest in northern California providing critical habitat for native flora and fauna. The Project Area is managed for a wide variety of cultural, recreational, wildlife, and other multiple use objectives. The forest vegetation within the Project Area boundary is predominantly tanoak, Douglas-fir, redwood, and other Western tree species. Review of air photos and satellite imagery reveal a forest dominated landscape. The Project Area lies in the 8b, 9a, and 9b climate zones as shown of the USDA Plant Hardiness Zone mapping for the region.

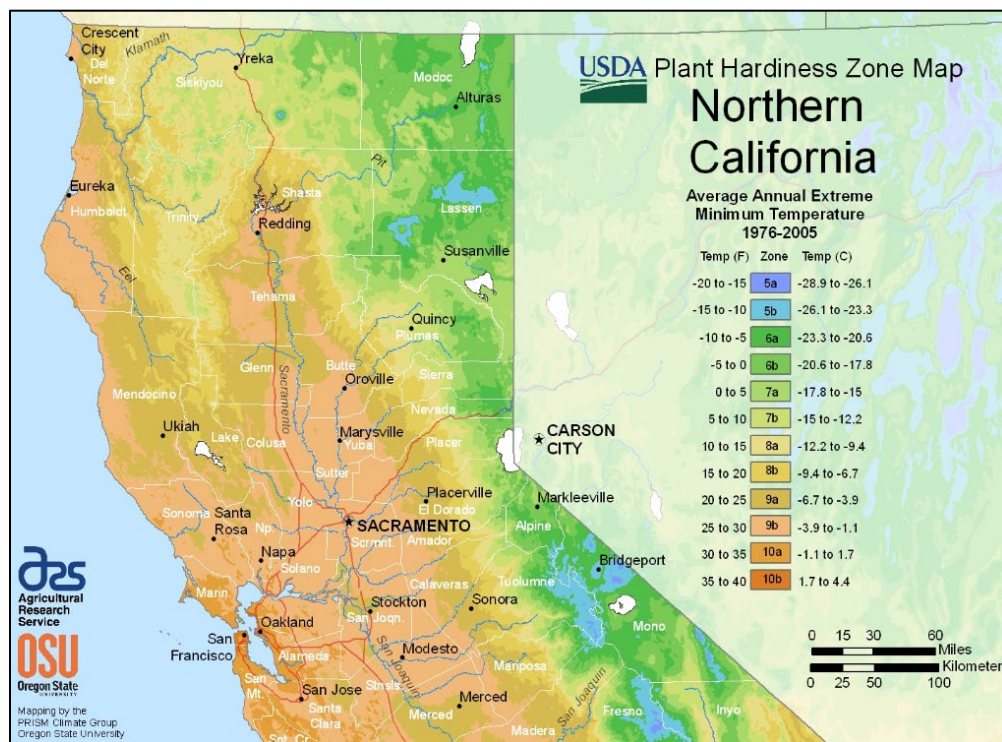


Figure 2. Plant Hardiness Zones (source: <https://planthardiness.ars.usda.gov/>)

Further review of a series of publicly available aerial imagery taken over time indicates that land use change pressure in this region is moderately low with limited residential development and little changes to other land uses from forest.

The primary purpose of the inventory is to accurately quantify the onsite forest stocks of the standing living and dead tree carbon pools in the project area for registration and approval as a forest carbon offset project with the California Air Resources Board compliance offset program. This inventory shall be conducted in a manner that can be verified, facilitates growth and yield modeling, and is replicable. The following inventory procedures will be the guiding requirements for future inventory work done on this site to comply with the offset program, including updates of sample data done as forests are affected by management annually and periodically.

Inventory data collected will be independently and/or jointly audited by the contractor and Finite Carbon for accuracy. As all carbon claims for this project site will also be independently verified at a later date by an ARB accredited verifier, the accuracy and precision of the data collection for this project is paramount to project success for the landowner.

## Description of the Offset Project's GHG Assessment Boundary

**Table 1. GHG Sources, Sinks, and Reservoirs**

| SSR                                                  | Description                                                           | Type             | Gas | Quantification Method                                                                                                                                         | Justification/Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------|-----------------------------------------------------------------------|------------------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Primary Effect Sources, Sinks, and Reservoirs</b> |                                                                       |                  |     |                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| IFM-1                                                | Standing live carbon (carbon in all portions of living trees)         | Reservoir / Pool | CO2 | <b>Baseline:</b> Modeled based on initial field inventory measurements<br><b>Project:</b> Measured by field measurements and updating forest carbon inventory | Increases in standing live carbon stocks are likely to be the largest primary effect of Improved Forest Management Projects.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| IFM-3                                                | Standing dead carbon (carbon in all portions of dead, standing trees) | Reservoir / Pool | CO2 | <b>Baseline:</b> Modeled based on initial field inventory measurements<br><b>Project:</b> Measured by updating forest carbon inventory                        | Improved Forest Management Projects may significantly increase standing dead carbon stocks over time.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| IFM-7                                                | Carbon in in-use forest products                                      | Reservoir / Pool | CO2 | <b>Baseline:</b> Estimated from modeled harvesting volumes<br><b>Project:</b> Estimated from measured harvesting volumes                                      | Included because many Improved Forest Management Projects may significantly change carbon storage in in-use forest products relative to baseline levels. Treated as a "source/sink" because forest product carbon is quantified according to the change in harvesting volumes, relative to baseline levels, in each year. Of this change (increase or decrease), only the average amount of carbon expected to remain stored for 100 years is included in the final quantification of annual net GHG removals/emissions. This approach accounts for CO2 emissions from decomposition or disposal of wood products (see SSR #IFM-17). |
| IFM-8                                                | Forest product carbon in landfills                                    | Reservoir / Pool | CO2 | <b>Baseline:</b> Estimated from modeled harvesting volumes<br><b>Project:</b> Estimated from measured harvesting volumes                                      | Because of significant uncertainties associated with forecasting the quantity of forest product carbon that will remain stored in landfills, landfill carbon is excluded from quantification in years when project harvesting volumes exceed baseline volumes. Landfill carbon is included, however, in years when project harvesting volumes are below baseline levels. This case-dependent exclusion or inclusion is necessary to                                                                                                                                                                                                  |

|                                                        |                                                                                                  |               |     |                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                        |                                                                                                  |               |     |                                                                                                                                                                                                                                                                                                 | ensure that total GHG reductions and removals caused by the Forest Project are not overestimated.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Secondary Effect Sources, Sinks, and Reservoirs</b> |                                                                                                  |               |     |                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| IFM-9                                                  | Biological emissions from site preparation activities                                            | Source        | CO2 | <b>Baseline:</b> N/A<br><b>Project:</b> Quantified based on measured carbon stock changes in included reservoirs (SSR #IFM-6, where applicable)                                                                                                                                                 | Biological emissions from site preparation are not quantified separately, but rather are captured by measuring changes in included carbon reservoirs (soil carbon, where applicable). For other carbon reservoirs, changes are unlikely to have a significant effect on total quantified GHG reductions/removals.                                                                                                                                                                                                                                                                                                                                                              |
| IFM-14                                                 | Biological emissions/ removals from changes in harvesting on forestland outside the Project Area | Source / Sink | CO2 | <b>Baseline:</b> N/A<br><b>Project:</b> Estimated using a default 20% "leakage" factor applied to the difference in harvest volume relative to baseline                                                                                                                                         | Improved Forest Management Projects may either increase or decrease harvesting relative to baseline levels. If harvesting is reduced in the Project Area, harvesting on other lands may increase to compensate for the lost production. This "leakage" effect is included in the GHG Assessment Boundary. If harvesting is increased in the Project Area, harvesting on other lands may decrease in response to the increased production. The reduction in harvesting may lead to increased carbon stocks on other lands. Carbon stock increases on other lands are excluded from the GHG Assessment Boundary, however, because it is not possible to ensure their permanence. |
| IFM-17                                                 | Biological emissions from decomposition of forest products                                       | Source        | CO2 | <b>Baseline:</b> Quantified as a component of calculating carbon stored for 100 years in wood products (SSR #IFM-7) and landfills (SSR #IFM-8)<br><b>Project:</b> Quantified as a component of calculating carbon stored for 100 years in wood products (SSR #IFM-7) and landfills (SSR #IFM-8) | CO2 emissions from the decomposition of forest products are built into calculations of how much forest product carbon will remain in in-use wood products and in landfills, averaged over 100 years.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

## Sampling Methodology

The project inventory design is based on the requirements for volume and biomass calculation as listed in the volume and biomass equations approved for use by the California ARB U.S. Forests Compliance Offset Protocol. Finite Carbon developed the following sampling design to be implemented by the inventory to reduce overall sampling error and optimize the carbon results for the forest owner. In all cases the inventory protocol was implemented as written.

### Inventory Design

- **Sampling method** for all sample plots in the inventory consisted of a nested sample approach that included a 1/2 acre (83.26 foot radius) fixed radius sample plot for supercanopy trees<sup>2</sup> (live trees greater or equal to 30 inches DBH AND greater or equal to 120 feet total height), a 1/20 acre (26.3 foot radius) fixed radius sample plot for all stems 5.0 inches DBH and larger, a 1/150 acre (9.61 foot radius) fixed radius sample plot for all stems equal to or greater than 1.0 inch DBH and less than 5.0 DBH. All eligible standing living and standing dead trees shall be tallied. Eligibility is defined for living trees as either standing or downed provided they still have foliage/buds/or living cambium. Dead trees are eligible provided they are attached to the stump and not supported by other downed dead material that is on the ground. Should additional samples be required to meet statistical targets, they shall be placed randomly within the project area in an unbiased manner consistent with the underlying sampling design. All borderline trees will be measured to the geometric center of the base of the tree using approved devices, including slope adjustments for slopes of 10% and greater in accordance with the guidance provided later in this document.
- **Sampling Intensity** has been determined as 218 total nested samples across the project area systematically located in a grid across the Project Area<sup>3</sup>. All sample locations have been pre-determined on the provided field maps and have been assigned GPS coordinates. If a plot location falls in an open area with no eligible trees to be tallied, the plot will be taken as is and considered a no-tally plot. If the plot location is determined to be too dangerous for safe access, that plot will be considered a zero-tally plot.
- **Statistical Standards** of Inventory will be a minimum of +/- 5% of total carbon (tCO<sub>2</sub>e) expressed at the 90% confidence interval for forest stratum on the project. If, after processing, the original sample does not yield the target statistical targets, additional samples may be commissioned on a per plot basis until the target statistical results are realized. All additional samples will be located randomly within target strata using GIS forestry tools and consistent with the underlying sampling design.
- **Edge plots** shall be collected using the “walk through” procedure described later in this document on “hard edges” such as mapped non-forest areas, project to non-project areas, stand boundaries where the timber type (or other condition) is abrupt, marked property lines, etc. Plots that extend beyond the hard edge when buffering the plot two times the plot radii have been attributed in the GIS as potential walk-through plots along with a bearing and distance of each plot to the nearest polygon edge(s). Other hard

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<sup>2</sup> A supercanopy persists throughout the project area consisting of scattered overstory trees that clearly rise above the main canopy.

<sup>3</sup> Systematic sampling grid with random starting point generated with a spacing of 1,782 feet (Master Grid). To reach target number of sample points, every other plot along both X and Y axis of master grid were removed resulting in 218 sample points for the project.

edges will have to be determined on a case by case basis in the field. If a plot falls wholly within the sample frame but within 2 plot radii, use the walk-through method and denote the plot as being within the sample frame in the notes.

Monumentation of walk-through plots shall include a marked flagged and painted line where the edge is declared (cut stakes if needed to represent your measurement location). Cruisers will record the actual bearing and distance(s) observed at the plot site. When declaring an edge location, cruisers should look for obvious physical features like the top of the ditch line on a road, edge of a river bank or lake shore, or the drip line or edge of the canopy for the polygon the plot center falls in. It is impossible to escape the use of good judgement on the part of the cruiser in this task as edges take many configurations. In some instances, the edge location may be an estimate based on these principles. Any trees double tallied using the attached procedures shall receive two different and consecutive tree numbers painted above DBH. The tree will be entered twice in the tally in accordance with the assigned tree numbers.

Cruisers may also run into plot locations where non forest area (5 acres or greater) or other hard edges are incurred unexpectedly (not previously designated on mapping). If a cruiser questions whether or not to install a walk-through plot at any location they are to cruise, monument, and tally the plot normally (no walk-through trees), flag the potential edge, and designate any potential double count trees in the notes section of the tally only. All plots executed in this manner must be brought to the attention of Finite Carbon at the completion of the inventory. On any plot where a walk-through procedure is used, the cruiser is asked to provide a bearing and distance to the shortest point to the declared edge as a note for the plot.

Some edge plots may be located next to marked property lines. In this instance, trees bisected by the line as evidenced by fence, blazes, or signage are considered out of the sample frame. Trees bisected by the line are considered the property of both landowners and are not in the direct control of the project owner, therefore they are not cruised.

## Field Procedures

- Tools/materials required include: a WAAS enabled GPS unit, laser hypsometer, and/or relaskop, diameter tape, calipers, increment borer, calculator, hammer, paint, surveyors' ribbon, grease pencils or permanent markers, "fat max" 20-foot tape, and metal tree tags. Tools selected for height and diameter measurements can be determined prior to field data collection but must be consistent for all trees and plots unless a device failure is experienced (note, relaskops and steel logger's tapes are preferred).<sup>4</sup>
- All tally files shall be labeled with the following information; cruise line and/or plot ID, date, tract (if applicable), stand and/or strata ID, cruiser name or initials. Each plot shall have a stand identifier, reflecting the stand or strata the sample was taken in (please include this in all tally files submitted).
- Cruisers should navigate to all sample plots using 3 to 5-meter accuracy GPS (WAAS enabled) units. Cruisers not able to use their GPS due to reception or other reasons may locate and collect data using compass and pacing. When plots are located in this manner, the declination, bearing, and distance from a key starting point (i.e. road intersection, other data samples located with GPS, etc.) should be noted in the notes section of the tally file. Appropriate declination for the subject tract shall be pre-determined by the

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<sup>4</sup> All tree heights were measured with a laser hypsometer and/or relaskop and diameters were measured with steel logger's tape.

contractor and provided to all parties collecting data, including Finite Carbon foresters at the beginning of the project. When using GPS for plot location, the cruiser is instructed to establish the plot at the first indication from the GPS receiver that they have reached the target location coordinates using a 5-foot perimeter alarm. Cruisers are also asked to collect a GPS point at the location of the pin and provide that to Finite Carbon as a shapefile at the end of the inventory. This requirement is meant to ensure non-bias in sample location. Should a cruiser navigate to assigned coordinates for a sample plot and find that it is across a marked property boundary line the cruiser should drop the plot and make notes to indicate the nature of the line. The cruiser should also collect at least two GPS points on the marked boundary or preferably nearby corners so that the GIS representation of the project area can be addressed post cruise. **UNDER NO CIRCUMSTANCES SHOULD ANY PLOT BE OFFSET OR MOVED FROM ITS MAPPED LOCATION; MEASURE THE PLOT AS IS WHERE THE PLOT COORDINATES ARE POSITIONED ON THE GROUND.**

- **Monumentation** of sample locations is critical to project success.
  - **Plot center** shall be monumented with a 2 to 3-foot-long highly visible survey ribbon (hung at or above eye level as close to point center as possible and a painted metal stake placed at plot center leaving 4 to 6 inches of the stake visible above ground level. Highly visible ribbon can also be tied around the head of the metal stake prior to being driven into the ground to help locate plot center. The survey ribbon shall be labeled with the following information: Plot #, Cruiser's initials, and Date. Some samples will fall on or near rocky outcrops, talus slopes, or other rocky areas. Cruisers shall do their best to place the steel pin in the ground at each sample. Should the site preclude the placement of the pin, a heavily painted X shall be painted on the sample center (a small pile of rocks is useful for this purpose as well) with the pin placed in an area nearby that facilitates placement. Cruisers shall record the offset of the pin in feet along with the bearing and distance to the sample center along with witness tree data as specified below (witness tree data should always be referenced to the plot center location, not the offset pin).  
Note: Should a cruiser navigate to a location that is deemed unsafe, they should not measure any trees and the plot will be considered a zero-tally plot and this zero value will be conservatively included within the inventory totals.
  - **Witness trees.** At each sample two witness trees shall be selected. The witness trees should (preferably) be a living and large diameter tree for the area that is easily seen from plot center. All witness trees will have a prominent W and the plot number scribed into or painted on the tree at eye level facing plot center or a metal tree tag at eye level and stump level with the plot number etched on it. Witness trees shall also have a highly visible painted ring around the stem at eye level and a painted plot number. The species and size of the witness trees will be recorded in the notes section of the tally, as will the azimuth (from plot center to middle face of tree) and distance (in feet and tenths of feet) to plot center from the middle of the witness tree face. Ideal witness tree selection should consider the angle created from each witness tree to the plot center. Ideally an angle near 90 degrees will be created facilitating accurate plot center replacement should the center pin be disturbed in the future.
  - **Measured trees** shall have a horizontal paint mark at the DBH measurement location and for trees in the larger overstory plot, a painted tree number facing plot center.
  - **Walk through plots** shall also consist of a flagged line where the edge is declared. Any trees double tallied using the attached procedures shall receive two tree numbers. The tree will be entered twice in the tally in accordance with the assigned tree numbers.

- Borderline trees.** The most sensitive part of the plot measurements are borderline trees. Cruisers should be very diligent in their measurement and assessment of these trees to avoid failed plots. Any tree that cannot be definitively determined to be in or out shall be measured for horizontal Limiting Distance based on the critical distance and slope correction in compliance with USDA FS procedure (see the end of this appendix for limiting distance calculations and tables). DBH shall be measured to the nearest 0.1" for the calculation and distance shall be measured with a steel tape. If a borderline tree is found to be out, the tree shall receive an "X" marked through the DBH line. It is important the cruiser take their time to ensure the tree is truly in or out. The critical measurement point on borderline trees is the point of origin or stump of the tree. It is possible that a leaning tree could have a point of origin inside the plot while outside the plot at DBH. Best practices would include a paint mark at the geometric center of the tree where the measurement was taken, use the DBH staff and DBH mark on the tree to measure slope, and trim out the line of sight for accurate results. Cruisers measuring an edge tree that is close to the plot radius should measure the distance on two sides of the stump and average them before concluding that a tree is in or out. Make paint marks at the two measurement locations to indicate that this was the process used.

## Tally Measurements

**Species** must be recorded for all eligible living and dead stems in accordance with the USDA FS FIA numerical three-digit species codes. Trees smaller than 1" DBH, whether alive or dead are not eligible for this inventory. All species shall be measured, commercial and non-commercial species. If the tree has no bark or other identifiable features, the cruiser must make a best guess as to the species based on surrounding trees and site evidence. No miscellaneous species or species group codes should be used. Cruisers should make their best assessment of species possible, even for dead stems. If a tree species does not have the natural ability to grow to a minimum of 5" DBH and 15' in height do not tally it.

**Tree Status** shall be recorded for every tallied tree. All standing live trees greater or equal to 1" DBH shall have their tree status recorded as zero (0). Standing dead trees greater than or equal to 1.0" DBH shall only be tallied if they are a minimum 15 feet in total height and recorded as one (1). Standing dead trees that are leaning at more than a 45-degree angle from vertical shall not be tallied. All tallied standing dead trees shall be visually evaluated and categorized in one of the following decay classes status categories listed below in the tree status field:

### Standing Dead Tree Decay 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. 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. 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. 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. No evidence of branches remains; the top is broken; <20 percent of the bark remains; sapwood is gone; heartwood is sloughing throughout.

Note: Cruisers should start with Class 5 with every standing dead tree. If the tree does not meet all qualities of that class, move upward in the scale until the most accurate designation is reached.

**Diameter** at breast height (4.5') on the high side of the stump, measured with a diameter tape **to the 0.1 inch.** Cruisers are encouraged to use guide sticks 4.5 feet long or a measuring tape to ensure that DBH is measured at the correct height consistently. DBH locations shall be measured to the 4.5-foot height or alternative as noted below and in the USDA FIA Field Guide provided at the end of this document.

Trees with large butt swells such as some cedars and redwoods shall be measured at a point 1.5 feet above the end of the swell. While the alternative diameter point may not be marked at that height, a paint mark is still required on the tree facing point center, indicating the tree as an "in" or count tree. Also, some trees have heavy moss coating the tree at diameter measurement points. Cruisers are to remove the moss prior to taking their measurements and marking trees.

Independent trees that grow together (primarily clumpy redwood stems): If two or more independent stems have grown together at or above the point of DBH (pith intersection is below DBH), continue to treat them as separate trees and use the following "double-nail" method for measuring and calculating DBH for each separate tree (as described in the FIA PNW Field Instructions for Annual Inventory, Page 178 and shown in Figure 8.16):

1. Set two diameter nails at DBH halfway around the tree's circumference and perpendicular to the axis of the joined trees centers from each other (after placing 1<sup>st</sup> nail, stand back from the bole; take azimuth to nail; on opposite side of bole, place nail where the back azimuth of the first nail lines up).
2. Measure the distance as a DBH (not a circumference) between the nails with a diameter tape making sure zero is aligned and not the hook at the end of the diameter tape with one diameter nail.
3. Multiply the measurement by 2 and record the result as the current diameter. Example: Distance measured = 12.8 inches ( $12.8 \times 2$ ) = 25.6 inches.

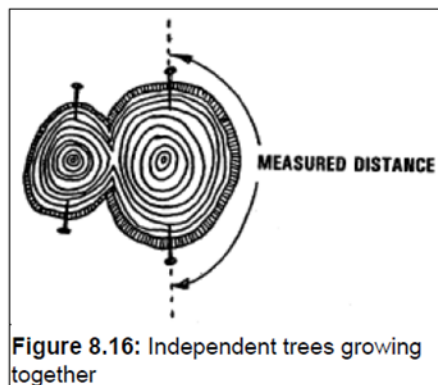


**Figure 3: Illustration of the "double-nail" method**

*If the "double-nail" method is physically impossible to implement (i.e., more than two trees have grown together, large trees on steep ground, etc.), estimating DBH for each individual stem is acceptable. Best practices for DBH estimation shall include, implement double-nail method on accessible stems and then make ocular estimate of the non-accessible stems, using a relaskop if tree seams are visible, or using other standard forest mensuration tools. If ocular estimate is the only option, err on the conservative side with estimated DBH measurement. In all cases, cruisers are instructed to provide a tree comment indicating tree DBH was estimated and describe method of estimation.*

Trees will be measured to the nearest 0.1 inch diameter class using standard rounding rules ( $\leq 0.04$  rounds down,  $\geq 0.05$  rounds up).

**Table 2. DBH Rounding Examples**

| Cruiser DBH Measurement | Recorded Diameter Class             | Plot Eligibility                      |
|-------------------------|-------------------------------------|---------------------------------------|
| 0.97 inches             | None, as it is less than 1.00 inch. | Not eligible                          |
| 1.04 inches             | 1.0 inch                            | 1/150 <sup>th</sup> fixed radius plot |
| 1.05 inches             | 1.1 inches                          | 1/150 <sup>th</sup> fixed radius plot |
| 4.95 inches             | 5.0 inches                          | 1/20 <sup>th</sup> fixed radius plot  |

**Alternative DBH locations:**

All trees should be measured with a steel diameter tape at DBH (4.5 feet above the ground on the high side of the stump), unless as noted below:

- There are swells, branches or other abnormalities at the required location. In this case, measure the tree just above the abnormality.
- The tree forks below 4.5 feet. In this case measure each fork 3.5 feet above the estimated junction of the piths. In this case each fork is recorded as a separate tree. Trees that join within a foot of the ground level can be measured at 4.5 feet.
- The tree has a distinct butt swell. In this case, measure the tree 1.5 feet above the swell. Measurement tools can include a relaskop, laser calipers, or equivalent.
- For leaning trees measure the DBH location (4.5 feet) from the underside of the lean or the face of the tree closest to the ground to identify the location that pushes DBH the farthest up the stem. A tree is designated as leaning when the angle of the tree to the ground in the direction of the lean is less than 90 degrees.
- For oddly shaped trees please reference the USFS FIA diameter location document and tree diagrams included with this specification. Interference at DBH by other plants or features must be considered by the cruiser. Moss, vines or abnormal large bark ridges must be removed or otherwise accounted for in the measurement of diameter. Make a note if necessary. Cruisers should keep in mind that the spirit of the DBH location is to measure the stem 4.5 feet above highest side of the root collar location. Odd tree configurations at the root collar can sometimes give the cruisers more than one possible location. Use the location that pushes the DBH location the farthest up the stem.

**Height of each stem** shall be measured with a laser hypsometer, relaskop, or clinometer in one-foot increments for all height measurements. Small trees may be directly measured with a tape.

Note: for leaning trees, the total tree length shall be the measurement objective, not height off the ground. Leaning tree height can be calculated using the  $A^2 + B^2 = C^2$  formula. See diagram below. When this method is used, please note such in the comments section of the tally. Cruisers are cautioned to be sure they get back an enough distance (one tree height or more) from the stem to get an accurate height measurement.

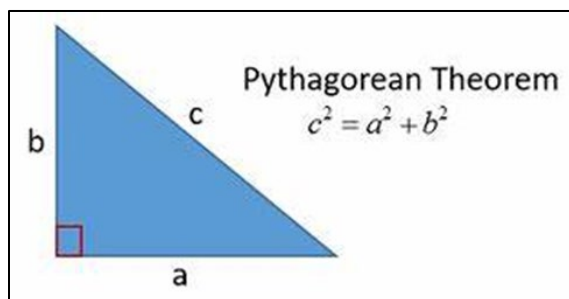


**Figure 4: Illustration of the Pythagorean Theorem**

Record total height in one-foot increments for all standing live trees  $\geq 1"$  DBH and for all standing dead trees  $\geq 1"$  DBH and  $\geq 15'$  in total height.

- Total height is recorded to the most vertical tip of the living stem or crown. Note, on some trees with large broad crowns, this will entail shooting through the crown to measure, as best you can, to the top of the middle of the crown. Total heights are recorded for every tallied tree regardless of species or size.
- If the top of the tree is dead or missing, total height should be measured at the point it is broken or becomes dead unless a new leader has developed, in which case the height of the new leader should be measured. Cruisers should not deduct dead tree top volume, instead they should measure the total height of the living crown. The highest top of any lateral branch that has assumed the highest portion of the living crown would be the correct height for a "top of the living crown" measurement. This will be common on trees with dead tops.
- For dead trees that are close to 15 feet total height, a guide stick or measuring tape is encouraged to ensure the snag is in fact at least 15 feet total height.

**Best Practices:** Tie a flag at the location you take large tree heights so that it can be replicated. Always strive to be up hill or on the same elevation as the tree to be measured and about 1 tree length away at 90 degrees to the lean of the tree. Also, due to the difficulty seeing the base of the tree in this forest, shoot to the DBH mark and add 4.5 feet to your measurement.

**Soundness** deductions for any missing biomass and visible possibilities of rot or cavities in the bole (including bark) shall be recorded. When estimating loss, only consider missing portions on the merchantable bole/portion of the tree, from a 1-foot stump to a 4-inch top. It should not consider missing branches or estimated missing/broken tops. Deductions for blemishes such as "cat faces" should not be made unless the blemish has caused visible rot or cavities. Deductions should be made using the USDA Forest Service Table provided with this document. For example, a tree that is 90% sound should be recorded as a 10 in the deduction column.

**General observations** are to be made during the cruise that may impact project development. As field data collection takes place, cruisers are asked to note any clear and obvious examples of significant disturbance (>20 acres), incorrect non-forest designation and errors in forest strata or vegetation typing. Examples of natural disturbance include (but are not limited to) ice damage, wind throw, insect infestation, disease, and timber theft.

## Inventory Audit (QA/QC)

Finite Carbon shall jointly and independently audit the project cooperatively to ensure that the data quality meets the standards of the CA ARB program and Finite Carbon expectations. (Note, if a contractor enlists the services of additional sub-contractors, the quality of data collection should not be left to this audit procedure alone. It is the contractor's responsibility to ensure the quality of work done by sub-contractors they employ).

The joint audit will consist of a minimum of 7% of the samples collected. Initially, audits will address all cruisers equally. If, however, individual cruisers are found to be consistently out of compliance, the auditor or audit team may focus on individuals in order to verify compliance with the specifications. Additional audits may be conducted by Finite Carbon or their assigns at any time and at any intensity.

Audit report summaries will be generated for Finite Carbon by the contracted auditor periodically throughout the inventory project and will be submitted with per cruiser audit totals and results. A final audit results summary shall be provided to Finite Carbon at the completion of the project which shall include audit dates, number of audited samples per cruiser including sample location identifiers, total audited samples vs. total samples as a percent, corrective actions per cruiser, any plots re-done due to noncompliance, and overall auditor's comments.

Audit results will be based on a per cruiser assessment of plot tally on a percent error basis. Error will be expressed as the number of errors (as noted below) divided by the number of trees sampled on a minimum of 6 randomly selected sample plots. The maximum acceptable error threshold for accuracy is 1 error in 10 trees or 10%.

**Table 3. Check Cruise Error Calculations**

|                                                                                                                             |           |
|-----------------------------------------------------------------------------------------------------------------------------|-----------|
| Incorrect Species                                                                                                           | 1 error   |
| Incorrect Diameter (tolerance +/- 0.2")                                                                                     | 1 error   |
| Incorrect Height (tolerance of +/-8 feet on trees 139 feet and lower, +/- 10 feet on trees 140 feet and higher) on THT only | 1 error   |
| Incorrect tree status designation                                                                                           | 1 error   |
| "In" tree marked "Out" (tolerance 0.2 foot)                                                                                 | 2 errors  |
| "Out" tree marked "In" (tolerance 0.2 foot)                                                                                 | 2 errors  |
| Plot location (greater than 1.5 chains from map location/coordinates)                                                       | 1 error   |
| Incomplete tally file label                                                                                                 | 0.5 error |
| Incorrect or poor monumentation                                                                                             | 1 error   |

When an audit of a cruiser is completed, the total number of errors will be divided by the total number of trees included in the audit plots and expressed as a percent. Error ratings at or below 10 percent require no further action. Error ratings above 10% should result in further investigation and corrective actions. If the error rate is close to 10% and no trend in errors is evident (i.e. consistent height problems) the auditor may choose to select another 2 to 4 samples for the non-compliant cruiser to fully assess the errors before determining corrective action.

Corrective actions: Re-training non-compliant cruisers and correcting erroneous samples are the minimum corrective actions to be implemented. Based on the results of audits, if a cruiser repeatedly cannot or did not meet the quality standards (fails two consecutive audits) for allowable error, all plots for that cruiser must be re-done at the expense of the contractor by a cruiser that can consistently meet quality thresholds.

**Inventory Deliverables:**

- Electronic data files for both the raw field tally and screened tally with an edit log summarizing changes to the data set in the screening process. These files will be submitted in Excel, or Access formats providing the full tally and notes. All electronic files shall be screened for obvious errors such as missing data, and data outside of normal parameters for forests of the region. If paper tally is done, scanned copies of the tally cards must be submitted.
- Any joint audit field files, notes, and summary report.
- Summary report of all cruiser comments, including field maps with noted plot relocations and natural disturbances noted.
- A description of the methods used to screen completed data files and otherwise ensure data quality and integrity.

**Review and Approval:**

Once received, Finite Carbon representatives will also screen and edit the data files for approval to the written requirements. Following the screening process, the work will be deemed acceptable or unacceptable. Contractors will be provided with feedback on any omissions, missing data or deficiencies in the product and will be granted the opportunity to correct any issues in a timely fashion. Pending final approval of the data, all outstanding fees will be paid to the contractor as per the terms of the Services Agreement.

## Overview and Project Parameters

Prior to sampling the project area, Finite Carbon assesses the overall quality and integrity of the mapped boundaries and underlying spatial data. Ancillary spatial data is taken from a variety of sources including publicly available data, landowner shapefiles, and files created from site visit field work. In all cases, GIS shapefiles are projected to the proper coordinate system, checked against publicly available shapefiles for ownership and boundary issues, ground-truthed using GPS and other field equipment, and then stored in geodatabases to ensure compatibility with outside data and data integrity. Tools used include ESRI ArcMap and Geodatabase, GPS devices, acquired orthorectified aerial photography.

GIS data covering the project area were provided by the OPO at the start of project development in the form of the OPO's stand layer. The stand layer contains a wide variety of forest attributes and is developed and maintained by the OPO using internal typing standards. Stand typing includes the delineation of non-forest areas that are excluded from their forest land base. Non-forest areas typed by the OPO include roads, powerline ROWs, and other non-forest areas. Using this stand layer as a starting place for determining the project's boundaries, inventory design, and stratification, Finite Carbon performed the following steps before implementing the carbon inventory to improve project area boundaries:

- Public roads not already removed from the OPO provided data were digitized out of the project area using the observable forest edge on NAIP 2018 aerial imagery at a map scale of 1:2,500 in ArcGIS using NAD83/UTM 10N projected coordinate system.
- Private roads not already removed from the OPO provided data were digitized out of the project area using the observable forest edge using NAIP 2018 aerial imagery at a map scale of 1:2,500 in ArcGIS using NAD83/UTM 10N projected coordinate system based on the following rules:
  - Roads appearing to be navigable by truck were removed from the project area.
  - Roads or paths not appearing to be navigable by truck were not removed from the project area.
  - Differences appearing to result from orthophoto rectification were not altered.
- Powerline ROWs not already removed from the OPO provided data were digitized out of the project area using the observable forest edge on NAIP 2018 aerial imagery at a map scale of 1:2,500 in ArcGIS using NAD83/UTM 10N projected coordinate system.
- Non-Forest areas not already removed from the OPO provided data with an apparent size of approximately 5 acres or greater were digitized out of the project area using the observable forest edge on NAIP 2018 aerial imagery at a map scale of 1:2,500 in ArcGIS using NAD83/UTM 10N projected coordinate system.
- Structures not already removed from the OPO provided data were digitized out of the project area using the observable forest edge on NAIP 2018 aerial imagery at a map scale of 1:2,500 in ArcGIS using NAD83/UTM 10N projected coordinate system.

## Stratification Process

Stratification of the project area occurred post-inventory and resulted in 3 strata based on the OPO's forest management operating areas and delineated Watercourse and Lake Protection Zones (WLPZs). We conducted a standard post-stratification process by incorporating inventory data with attributes from the OPO's stand layer to inform a final stratification that satisfied the goals and objectives of the project from a statistical perspective and OPO project monitoring perspective. The basis of this stratification was derived from attributes contained in the OPO's stand layer which includes pre-defined spatially explicit forest management operating areas and delineated WLPZs. Project area strata are: Klamath, Korbelt, and WLPZ.

## ARB Supersection and Assessment Areas

The project area is comprised of 2 ARB Supersections: 1) Northern California Coast and 2) Southern Cascades. Using OPO provided data and the carbon inventory, acres in these respective Supersections were assigned to Assessment Areas<sup>5</sup> as follows:

- Acres classified by the OPO as True Oak High Conservation Value Forest were assigned to the Mixed Oak Woodland Assessment Area.
- Identified oak woodland inventory plots (7 plots) and conducted imagery classification on acres surrounding those plots to assign additional acres into the Mixed Oak Woodland Assessment Area. Imagery classification was conducted using aerial photo-interpretation on NAIP 2018 aerial imagery at a map scale of 1:2,500 in ArcGIS using NAD83/UTM 10N projected coordinate system.
- All other project area acres were assigned to the Northern California Coast Redwood/Douglas-fir Mixed Conifer or Southern Cascades Mixed Conifer Assessment Areas.

Table 4, below, shows the results of the project area's stratification and assessment area assignments.

**Table 4. Stratification Results**

| Supersection              | Strata Name | Assessment Area                   | Project Acres    |
|---------------------------|-------------|-----------------------------------|------------------|
| Northern California Coast | Klamath     | Redwood/Douglas-fir Mixed Conifer | 12,796.98        |
| Northern California Coast | Klamath     | Mixed Oak Woodland                | 181.58           |
| Northern California Coast | Korbelt     | Redwood/Douglas-fir Mixed Conifer | 3,466.56         |
| Northern California Coast | Korbelt     | Mixed Oak Woodland                | 294.83           |
| Northern California Coast | WLPZ        | Redwood/Douglas-fir Mixed Conifer | 4,743.30         |
| Northern California Coast | WLPZ        | Mixed Oak Woodland                | 97.27            |
| Southern Cascades         | Klamath     | Mixed Conifer                     | 4,358.45         |
| Southern Cascades         | Korbelt     | Mixed Conifer                     | 4,925.38         |
| Southern Cascades         | WLPZ        | Mixed Conifer                     | 2,353.18         |
| <b>Total</b>              |             |                                   | <b>33,217.53</b> |

The final results of the inventory stratification process are not complete until analysis of site class is performed. That process, and the final results of stratification and site class analysis, are described below in the "Site Class, Site Index, and Growth Determination" section of this document.

<sup>5</sup> Assessment Areas (i.e., broad forest vegetative communities) for the project's Supersections are listing the Assessment Area Data File as published on the ARB website and associated Forest Offset Protocol (FOP), version June 25, 2015.

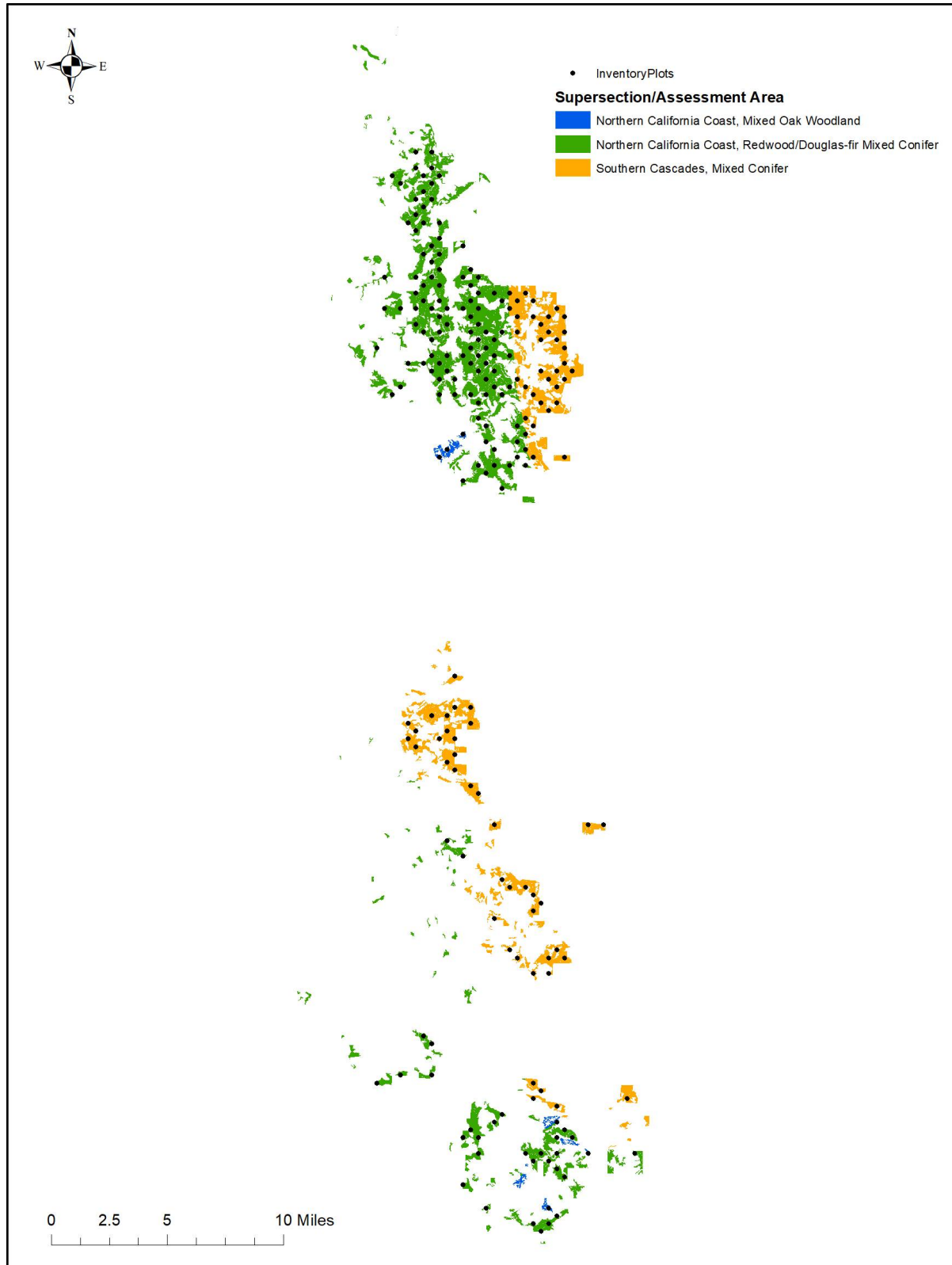


Figure 5. Cruise Plots, Supersection, and Assessment Areas

## Data Management & Analytical Systems

This section describes the data management and analytical systems used to estimate the baseline and project carbon stocks of selected carbon pools within the Project Area.

### Data Creation

Finite Carbon, in coordination with the inventory contractor, implemented a continuous forest inventory (CFI) completed in August 2019 on behalf of the Forest Owner. These plots will be re-measured over time per the specification outlined in the inventory specifications document. Once field measurements have been collected, the raw inventory data will be compiled by the inventory contractor. A database is then transferred to Finite Carbon in an MS Excel worksheet and/or MS Access database. The database contains multiple tables with the plot and individual tree measurements recorded by the cruisers.

Spatial data is provided to Finite Carbon from the Forest Owner's GIS department while the forest inventory data in tabular form is provided to Finite Carbon from the inventory contractor. The two most relevant spatial files are the forest area polygons and the inventory points; they are provided in either ESRI shapefiles or feature classes. All GIS files are then input into the project geodatabase which is the underlying foundation of the Project's Monitoring, Reporting and Verification System (MRVS) and will serve as the central carbon data spatial repository.

### Converting Data Formats

After receiving the data, Finite Carbon reviews it and executes a quality control/assurance process for validation. Keys are also setup to standardize relations between spatial and tabular data. Once the raw data has been assured for quality, it is formatted into a MS Access database for input to FVS. The FVS input database tables are read by the FVS program using the Database Extension of FVS (Crookston 2003).

## Forest Vegetation Simulator (FVS)

### General Overview

Finite Carbon uses the Forest Vegetation Simulator (FVS) model to accept processed inventory data from the Preparatory Module and to output tree lists for the current inventory year so that carbon can be calculated in the Carbon Modules. The growth functions of FVS are applied if necessary to grow carbon stocks forward to the current reporting period end date.

The Forest Vegetation Simulator (FVS) is a family of forest growth simulation models supported and maintained by a special unit of the USDA Forest Service ([www.fs.fed.us/fmfc/fvs/](http://www.fs.fed.us/fmfc/fvs/)). Since its initial development in 1973, it has become a system of highly integrated analytical tools. These tools are based upon a body of scientific knowledge developed from decades of natural resources research. The FVS growth model is an approved ARB FOP growth model (FOP, Appendix B, Section B (a)).

The FVS is an individual-tree, distance-independent growth and yield model (Dixon 2002). It has been calibrated for specific geographic areas (variants) of the United States. FVS can simulate a wide range of silvicultural treatments for most major forest tree species, forest types, and stand conditions. The Klamath Mountains (NC) Variant has been used for this project (Keyser 2008).

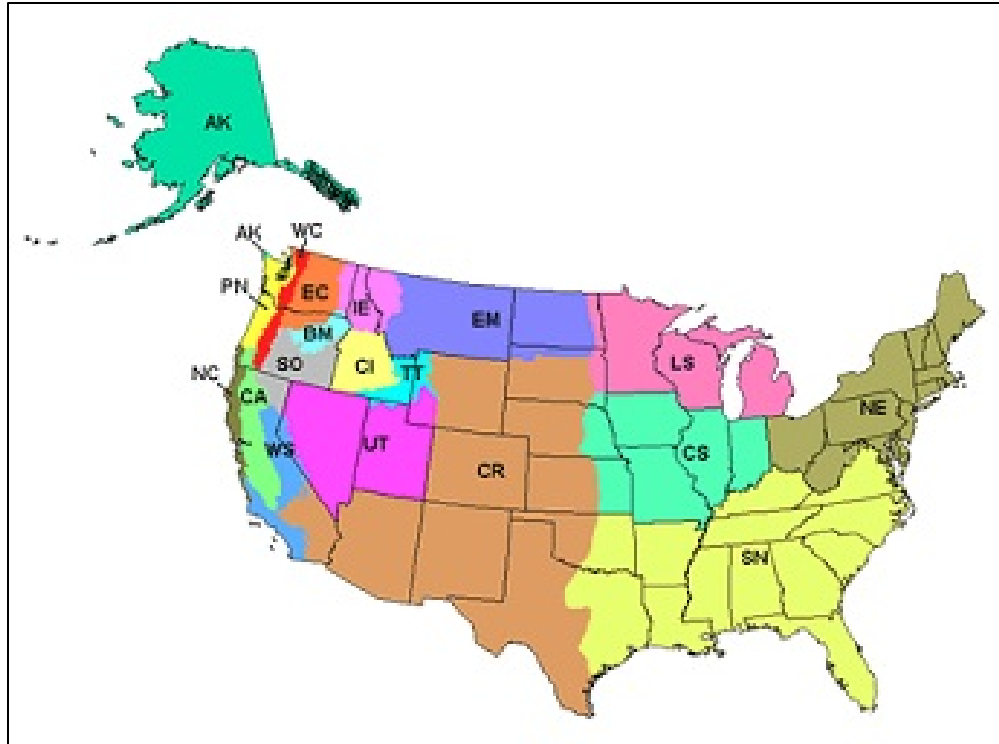


**Figure 6. FVS Variants**

The following summarizes basic FVS operation and the major model execution steps. Specific operation details will vary for different variants.

1. Process keywords and input data - FVS begins by reading keywords to establish location, environment, and stand parameters; then reads the tree record file.
2. Compute initial stand characteristics - FVS computes stand characteristics for the initial year (cycle 0). This is typically the inventory date or the stand regeneration date. Input tree records with missing heights or crown ratios have these dubbed in.
3. Backdate densities and compute calibration statistics - If sufficient large tree diameter increment data is contained in the input tree data (and/or small tree height increment data), FVS back-dates the stand one default cycle length. FVS then “grows” the stand back to the inventory date, compares the values from the actual inventory date with simulated values, and computes scale factor adjustments to account for differences in actual and model values.
4. Check event monitor (pre-treatment) - FVS continues with the steps it repeats every cycle. FVS checks the Event Monitor keywords and functions to see if the user scheduled any activities based on existing stand conditions at the start of the cycle. Event Monitor capabilities are powerful and very useful for modeling situations and creating variables not covered in standard FVS output. Crookston (1990) describes Event Monitor functions and processes along with several good examples.
5. Perform treatment - Almost any silvicultural operation imaginable can be structured using one or more treatment keywords in a direct or conditional (If..Then) context.

6. Check event monitor (post-treatment) - FVS Event Monitor checks for conditions and scheduled operations that are based on post-treatment activity conditions within the same cycle.
7. Grow large trees - If "large" trees exist in the tree-list, FVS estimates their new diameter (first) and height (second) one growth cycle into the future. The user can specify a different time interval length.
8. Grow small trees - FVS estimates small tree height (first) and diameter (second) one growth cycle into the future. FVS uses a weighting procedure to compute tree height increment to obtain a smooth height-growth transition from small to large tree models.
9. Mortality - Following growth estimation, FVS estimates mortality based on individual tree variables such as diameter and crown ratio, and on stand variables such as maximum stand density index or basal area.
10. Insect and disease impacts - If the variant has available extensions to cover specific disease or insect agents, and if the user calls for these, FVS estimates and incorporates these effects.
11. Regeneration - FVS adds new seedlings to FVS tree-lists in the regeneration step. Some FVS variants have natural regeneration routines, but most variants depend on the user to specify the species and number of trees to plant. Some variants have a stump sprouting algorithm, whereby certain species will sprout after a harvest.
12. Crown change - FVS estimates crown ratio change for all trees based on stand density and the trees position in the density distribution.
13. Update stand characteristics and compute volume - After projecting the stand for the growth cycle, FVS computes, summarizes, and records the stand attributes, including volume. Volume is computed using corporate equations from the National Volume Estimation Library.
14. Test for more cycles to be projected - FVS repeats the sequence from the initial "Check Event Monitor", to this point for each cycle until the specified number of cycles is completed.
15. Final FVS Output file reports and post-processor files - After FVS completes the scheduled cycles, it prints final output file reports and generates files specified by the user for running post-processors, including SVS.

## **Functions**

The FVS growth model is used in this project to estimate growth and mortality based on field measurements and management activities over time.

## Data and FVS Settings

### FVS Input Data

The FVS input database is comprised of three tables: FVS\_GroupAddFilesAndKeywords; FVS\_StandInit; and FVS\_Treelnit.

**Table 5. FVS Input Data**

| Table Name                   | Field Name        | Description                                                                                                                                                                                      |
|------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FVS_GroupAddFilesAndKeywords | Groups            | Used to assign keywords to all strata or a specific stratum                                                                                                                                      |
|                              | AddFiles          | Not used                                                                                                                                                                                         |
|                              | FVSKeywords       | A list of FVS Keywords which define the FVS run (described further below)                                                                                                                        |
|                              |                   |                                                                                                                                                                                                  |
| FVS_StandInit                | Stand_CN          | Stand Control Number: Used for the FVS yield curve ID number                                                                                                                                     |
|                              | Stand_ID          | Stratum                                                                                                                                                                                          |
|                              | Variant           | "NC" Inland Empire Variant                                                                                                                                                                       |
|                              | Inv_Year          | "2019" - The inventory year of the plots associated with the Stand_CN.                                                                                                                           |
|                              | Location          | "510" – Six Rivers National Forest. Indicates the closest National Forest Region and Forest Number to the project area.                                                                          |
|                              | PV_Code           | This is the habitat type or plant association code (not used in this modeling exercise).                                                                                                         |
|                              | Basal_Area_Factor | "-20" - The inverse of the fixed plot size in acres (1/20 acre) using negative value to indicate fixed radius rather than Basal Area Factor.                                                     |
|                              | Inv_Plot_Size     | "150" - The inverse of the fixed plot size in acres (1/150 acre fixed radius plot) – used for subplots, in this case to measure trees less than 5.0" DBH.                                        |
|                              | Brk_DBH           | "5.0" – indicates that all tree records $\geq 5.0$ " DBH are processed using the Basal Area Factor (1/9-acre plot in this design), all trees less than 5.0" DBH are processed using the subplot. |
|                              | Num_Plots         | Total number of plots associated with Stand_CN.                                                                                                                                                  |
|                              | NonStk_Plots      | Number of non-stockable plots associated with Stand_CN (not used because total number of plots used).                                                                                            |
|                              | Site_Species      | Used to assign the species associated with the Site_Index field. See "Site Class, Site Index, and Growth Determination" section below.                                                           |
|                              | Site_Index        | The site index at base age 50 for the assigned site species. See "Site Class, Site Index, and Growth Determination" section below.                                                               |
|                              |                   |                                                                                                                                                                                                  |

|              |            |                                                                                                                                                                                                              |
|--------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FVS_Treelnit | Stand_CN   | Stand Control Number: Used for the FVS yield curve ID number                                                                                                                                                 |
|              | Stand_ID   | Stratum                                                                                                                                                                                                      |
|              | Tree_ID    | Tree identification code for plot                                                                                                                                                                            |
|              | Plot_ID    | Plot identification code                                                                                                                                                                                     |
|              | Tree_Count | The number of trees on plot with the exact same measurements (always 1, no repetition counts used). <u>This was set to "0.1" for trees tallied on the supercanopy nested plot (1/2 acre fixed radius).</u>   |
|              | History    | Tree history code, e.g. alive, recent mortality, "older" mortality                                                                                                                                           |
|              | Species    | Tree species                                                                                                                                                                                                 |
|              | DBH        | Diameter at breast height                                                                                                                                                                                    |
|              | Ht         | Total height in feet                                                                                                                                                                                         |
|              | HtTopK     | Height to top kill in feet                                                                                                                                                                                   |
|              | Damage1    | "25" - Percent defect of tree's merchantable cubic foot volume                                                                                                                                               |
|              | Severity1  | "1-99" (99 = 100%) – percent defect                                                                                                                                                                          |
|              | Damage 2   | "55" – Custom code                                                                                                                                                                                           |
|              | Severity 2 | Product code (if dead tree then dead tree decay class)                                                                                                                                                       |
|              | TreeValue  | Tree value class, in this case it is used to distinguish live cull trees (using a code value of "3"). "8" is used to indicate a no-tally plot. All other values indicate a live tree or dead tree, e.g. "1". |

### FVS Settings

The FVS model has many program options to control the inputs and variables which affect growth and yield. These options are typically set using "FVS Keywords." They are programmed in the FVS input tables or selected in Suppose<sup>6</sup>. The following keywords are used for this project:

**SPGROUP** - Defines a group of species that can be referenced by a single name, or FVS sequence number, and will be treated as a group in management actions or event monitor functions. For this project, all commercial tree species were grouped in either the "CONIFER" or the "HARDWOOD" species group. See file "FVS Keywords" for details.

**BFVOLUME** - Sets the merchantability limits for board foot volume calculation. This keyword was used to set merchantability specs for commercial species consistent with previous stated inventories of the OPO.

**NOTRIPLE** (No tripling) – Random effects are incorporated in the Forest Vegetation Simulator in the manner originally described by Stage (1973), and subsequently updated to reflect changes in program control variables. The program assigns all random effects to the distribution of errors associated with the prediction of the logarithm

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<sup>6</sup> Suppose v2.02 is the FVS graphic user interface (GUI).

of basal area increment. Basal area increment was selected to reflect the stochastic variation because the effects of differing diameter growth rates extend in highly nonlinear ways through most of the remaining components of the model. This distribution of errors is assumed to be Normal, with a mean of zero. The variance of this Normal distribution is computed as a weighted average of two estimates; the first estimate is derived from the regression analysis that developed the prediction function, and the second estimate is the standard deviation of the differences between the recorded growth for the sample trees in the population (transformed to the logarithm of basal area increment) and their corresponding regression estimates. The weights assigned to these two estimates are (1) the number of observations by species and/or habitat type in the database for the model for the prior component of error, and (2) the number of growth-sample trees in the stand for the second component of error (Mehta 1972).

The random component of change in tree diameter is treated in two ways, depending on how many tree records make up the stand being projected. When there are many tree records, the effects of any one random deviation on the growth rate of one tree would be blended with many other trees, and the stand totals should be quite stable estimates. Accordingly, a random deviate from the specified distribution is added to the logarithm of basal area increment.

When relatively few sample trees represent the stand, however, a different strategy is used. In order to increase the number of replications of the random effects, two additional records augment each tree record. These new records duplicate all characteristics of the tree except the predicted change in diameter and the number of trees per acre represented by the source tree record. The trees per acre value of the original tree record are reduced to 60 percent of its current value. The two new records are given 15 and 25 percent of the original value; thus, the three records together still represent the same number of trees per acre. This process is known as tripling.

Because each stratum in the project area contains an adequate number of tree observations, tripling is not used in this modeling; it is turned off with the NOTRIPLE keyword.

**MINHARV** (Minimum Harvest) - Specifies minimum acceptable harvest standards for board-foot volume, merchantable cubic-foot volume, basal area per acre, or total cubic foot volume. The accumulated removals across all thinnings in a cycle must exceed the standards for all the units of measure (fields 2, 3, 4, and 5), or none of the thinnings in that cycle will be implemented.

This keyword was used in baseline commercial thin and selection thin harvest treatments to ensure that a silvicultural treatment (harvest) satisfies a minimum harvest level for financial and operational feasibility. The minimum harvest volume was set to 7,000 merchantable sawlog board feet per acre<sup>7</sup>.

**THINBBA** (Thin from Below to Basal Area target)- Schedules a thinning from below to a basal-area-per-acre target. Only trees with dbh's and heights within the user-defined ranges are considered for removal. The tree record with the smallest diameter within the specified range is considered for removal first, and the proportion of that tree record specified in field 3 is removed. The tree record with the next smallest diameter is considered next, then the next smallest and so on until the residual basal area target is met or all records in the specified range have been considered. The residual target basal area is specified only for the user-defined range of dbh and height and does not represent the total residual unless the range of dbh's and heights includes all trees in the stand.

This keyword was used to simulate commercial thins in thin-only and combined thin-clearcut regimes as described later in the Baseline Silviculture section of this document.

**THINCC** (Thin to a canopy cover target)- Schedules a thinning from a specified dbh range for any, or all, species to a percent canopy cover target. Canopy cover is corrected for crown overlap. If the target canopy cover is nonzero

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<sup>7</sup> Minimum harvest volume of 7,000 BF/acre was determined by reviewing the 2019 Forest Biometrics Research Institutes cost survey results for average commercial thinning volume per acre in Northern California.

and the cutting control flag is zero, thinning occurs uniformly throughout the specified dbh range until the target is met.

This keyword was used to simulate selection regimes within California Watercourse and Lake Protection Zones (WLPZ's). These regimes are defined within the California FPA primarily in terms post-harvest percent canopy cover targets in the inner and outer WLPZ areas.

**THINDBH** (Thin from a DBH range) – Schedules a thinning from throughout a specified DBH range for any or all species to a basal area per acre or trees per acre target. If the target trees per acre or target basal area is nonzero, thinning occurs uniformly throughout the specified DBH range until the target is met (cutting efficiency is ignored). In other words, a calculated proportion of each of the eligible tree records is removed such that the target trees per acre or target basal area is exactly met. If both residual targets are 0 (zero), the cutting efficiency determines the proportion of trees represented by each eligible tree record that will be removed (residual targets are ignored). Only trees of the user-specified species that are within the user-defined DBH range are considered for removal. The residual target basal area per acre or trees per acre is specified only for that species and DBH range and does not represent the total residual unless the DBH range includes all trees of all species in the stand.

THINDBH was used to schedule clearcuts in even-age regimes used in the baseline model. Details of these regimes are described below in the Baseline Silviculture section of this document.

**ESTAB** (Establishment Model) – signifies the beginning of keywords for the Regeneration Establishment extension. The ESTAB keyword sequence must be terminated with an END keyword. All keywords between ESTAB and END are considered Establishment extension keywords.

Two establishment model keywords were used in all treatments: NOSPROUT and NATURAL. PLANT was used in even-age regimes.

**NOSPROUT** (No stump or root sprouting) – Suppresses the automatic scheduling of root and stump sprouting following a thinning treatment.

This keyword was used in all treatments to eliminate root and stump sprouting from occurring after a treatment except for canopy thinnings in WLPZ's following the expiration of the AHCP. In these cases, FVS simulations relied on the partial establishment model in the FVS-NC variant to account for any hardwood sprouting. In modeled treatments other than the WLPZ canopy thins (WLPZ50 and WLPZ80), the NATURAL keyword was used in conjunction with NOSPROUT to simulate naturally occurring ingrowth of conifers and hardwoods following the opening up of the canopy due to thinning or clearcutting. For thinning and clearcutting regimes other than the WLPZ canopy thins, the range of residual stand structural characteristics was well-represented by plot data from the project inventory. In these cases, the number and distribution of seedlings and sprouts was derived from inventory plot data collected across the property. The WLPZ canopy thin regimes featured 50 or more years of growth past the end of the current AHCP and FHCP terms, leading to stand conditions well outside the bounds of data sampled within the project. For this reason, the decision was made to let the partial establishment model simulate any naturally occurring sprouting on the assumption that the FVS-NC variant would have better source data upon which to predict sprouting under such stand conditions.

**NATURAL** (Natural regeneration) – Specifies natural regeneration that will be added to the stand.

This keyword was used in all treatments to simulate natural regeneration following thinning and regeneration treatments. Natural regeneration was invoked one year as the treatments occurred with a species-specific distribution in each strata and with a specific total trees per acre for each treatment. The number and distribution of seedlings was derived from inventory plot data collected across the property, classified by inventory strata and plot-level basal area per acre to correspond with post-harvest conditions, *e.g.* for commercial thins to 100 square feet of basal area per acre, the average distribution of

trees per acre by species used with the NATURAL keyword was based on the average number of trees less than 5" for plots with between 80 and 100 square feet of basal area per acre.

In all treatments, seedlings have an 100% expected survival rate, an average seedling age of 2 (default) in years for the year specified in Field 1, and a shade code of 0 (seedlings occur more uniformly on plots throughout the strata). The average seedling height in feet five years from the time of seedling appearance or at the end of the cycle, whichever is earlier is estimated by the average seedling age set in Field 5 of the keyword parameters. Thus, an average seedling height was not entered.

**PLANT** (Plant seedlings) - Specifies planting of seedlings that will be added to the stand.

This keyword was used in clearcut regimes to simulate conifer planting following clearcutting. The number and distribution of species planted is site-class specific and depends upon California FPA stocking requirements (14 CCR 913.1(b), 912.7(b)(1)(A)). The stocking requirements rely on a point count formula which gives more weight to trees with larger diameters. For clearcuts occurring during the jurisdiction of the FHCP and AHCP, lower numbers of trees per acre were planted due to the significant presence of large residual live trees. Planted species are a mix of Douglas-fir and redwood matching proportions currently observed on the property. Per the FPA regulations, lower sites (IV-V) have lower required post-harvest stocking levels than higher sites.

The ESTAB keywords used in each of the regimes modeled in the baseline are shown below in Table 6.

**SITECODE** - Sets species-specific site index values. If a SITECODE keyword is present, all species for which site index values were not explicitly set will be assigned site index values derived from the site index of the specified site species. If no SITECODE keyword is present, default site index values are assigned. Site index can be described for the site species of an entire stand, which is equivalent to entering a species code in the "Site\_Species" field in the FVS\_StandInit table, and for all other species in the stand. This keyword was used to assign site index values derived from the site index estimation procedures described below.

**Table 6. ESTAB Keyword Sequences By Project Strata and Site Class**

| Strata  | Site Class | ESTAB Keyword Sequence                                                                                                                                             |                                                                                                                                                                                                        |                                                                                                                                        |                                                                                                                                        |
|---------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
|         |            | Clearcut during FHCP / AHCP                                                                                                                                        | Clearcut following FHCP / AHCP                                                                                                                                                                         | THIN TO 50-75 sq. ft. BA                                                                                                               | THIN TO 100 sq. ft. BA                                                                                                                 |
| Klamath | II-III     | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,270,100,2)<br>PLANT 0. PARMS(OS,30,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,325,100,2)<br>PLANT 0. PARMS(OS,35,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END  |                                                                                                                                        | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,129,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,64,100,2,0)<br>END |
|         |            | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,180,100,2)<br>PLANT 0. PARMS(OS,20,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,180,100,2)<br>PLANT 0. PARMS(OS,20,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END  | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
| Klamath | IV         | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,180,100,2)<br>PLANT 0. PARMS(OS,20,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,180,100,2)<br>PLANT 0. PARMS(OS,20,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END  | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
|         |            | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,180,100,2)<br>PLANT 0. PARMS(OS,20,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,180,100,2)<br>PLANT 0. PARMS(OS,20,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END  | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
| Korbel  | II-III     | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,300,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END                                | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,360,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END                                 |                                                                                                                                        | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,129,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,64,100,2,0)<br>END |
|         |            | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,200,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END                                | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,200,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END                                 | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
| Korbel  | IV         | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,200,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END                                | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,200,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END                                 | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
|         |            | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,200,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END                                | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,200,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END                                 | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
| WLPZ    | II-III     | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,215,100,2)<br>PLANT 0. PARMS(OS,85,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,185,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,260,100,2)<br>PLANT 0. PARMS(OS,100,100,2)<br>NATURAL 0. PARMS(TO,121,100,2,0)<br>NATURAL 0. PARMS(OH,185,100,2,0)<br>NATURAL 0. PARMS(PP,67,100,2,0)<br>END |                                                                                                                                        | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,129,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,64,100,2,0)<br>END |
|         |            | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,145,100,2)<br>PLANT 0. PARMS(OS,55,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,155,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,145,55,2)<br>PLANT 0. PARMS(OS,55,55,2)<br>NATURAL 0. PARMS(TO,121,55,2,0)<br>NATURAL 0. PARMS(OH,185,55,2,0)<br>NATURAL 0. PARMS(PP,67,55,2,0)<br>END       | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
| WLPZ    | IV         | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,145,100,2)<br>PLANT 0. PARMS(OS,55,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,155,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,145,55,2)<br>PLANT 0. PARMS(OS,55,55,2)<br>NATURAL 0. PARMS(TO,121,55,2,0)<br>NATURAL 0. PARMS(OH,185,55,2,0)<br>NATURAL 0. PARMS(PP,67,55,2,0)<br>END       | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |
|         |            | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,145,100,2)<br>PLANT 0. PARMS(OS,55,100,2)<br>NATURAL 1. PARMS(TO,121,100,2,0)<br>NATURAL 1. PARMS(OH,155,100,2,0)<br>END | Estab 0.<br>NOSPROUT<br>PLANT 0. PARMS(DF,145,55,2)<br>PLANT 0. PARMS(OS,55,55,2)<br>NATURAL 0. PARMS(TO,121,55,2,0)<br>NATURAL 0. PARMS(OH,185,55,2,0)<br>NATURAL 0. PARMS(PP,67,55,2,0)<br>END       | Estab 0.<br>NOSPROUT<br>NATURAL 1. PARMS(DF,71,100,2,0)<br>NATURAL 1. PARMS(TO,182,100,2,0)<br>NATURAL 1. PARMS(OH,253,100,2,0)<br>END |                                                                                                                                        |

**SPMCDBH** - returns the trees, basal area, total cubic volume, merchantable cubic foot volume, total board foot volume, quadratic mean diameter, average height, percent cover, average mistletoe rating, stand density index, or average diameter growth per acre for a given species or species group, tree-value class, tree status, and range of diameter and height. These metrics can be obtained for live trees, cut trees, dead trees, live trees after thinning, or mistletoe infected trees. For more information on how SPMCDHB is used, please refer to Dixon (2002).

**COMPUTE** - allows the user to define variables expressed as mathematical expressions containing constants, Event Monitor variables, Event Monitor functions, and variables previously defined using the COMPUTE keyword. Variables are defined using mathematical equations in supplemental records, which are up to 80 characters long. The Event Monitor feature of FVS allows users to specify a set of conditions that must occur, or thresholds that must be reached in order for FVS to simulate a management activity or set of management activities. The COMPUTE keyword is used to define variables that are evaluated by the Event Monitor to determine if necessary conditions or thresholds have been met.

The COMPUTE keyword was used, in conjunction SPMCDDBH to help regulate the application of harvest activities in all regimes. The following variables were defined using the COMPUTE keyword simulations:

**Table 7.** Variables calculated using COMPUTE keywords in FVS simulations.

| Variable | Definition                                                                   | Usage                                                                                                                                                                                                                                                                         |
|----------|------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BAGE14   | Basal area per acre of trees greater than or equal to 14" DBH                | Used to calculate stocking levels to control commercial thinning actions in FVS. BAGE14 is used to assess whether a forest stand is composed of dominant and co-dominant trees greater than 14". If so, BAGE14 is used to govern when thinning actions take place within FVS. |
| TPALT14  | Trees per acre less than 14" DBH.                                            | Used to calculate stocking levels to control commercial thinning actions in FVS. TPALT14 is used to assess whether a forest stand is composed of dominant and co-dominant trees less than 14". If so, TPALT14 is used to govern when thinning actions take place within FVS.  |
| CCOVGE11 | Canopy cover of all trees greater than 11" DBH.                              | Used in the calculation of suitable NSO nesting (CCOVGE11 >= 60%) and foraging (CCOVGE11 >= 40%) habitat.                                                                                                                                                                     |
| BAGE11   | Basal area per acre of all trees greater than 11" DBH.                       | Used in the calculation of suitable NSO nesting (BAGE11 >= 100) and foraging (BAGE11 >= 75) habitat.                                                                                                                                                                          |
| POINT1   | Conifer trees per acre less than or equal to 4.0" DBH                        | Used to monitor and evaluate post-clearcut conifer stocking levels in accordance with California FPA requirements: 14 CCR 913.1(b), 912.7(b)(1)(A)                                                                                                                            |
| POINT2   | Conifer trees per acre greater than 4.0" and less than or equal to 12.0" DBH | Used to monitor and evaluate post-clearcut conifer stocking levels in accordance with California FPA requirements: 14 CCR 913.1(b), 912.7(b)(1)(A)                                                                                                                            |
| POINT3   | Conifer trees per acre greater than 12.0"                                    | Used to monitor and evaluate post-clearcut conifer stocking levels in accordance with California FPA requirements: 14 CCR 913.1(b), 912.7(b)(1)(A)                                                                                                                            |
| POINTCT  | $POINT1 + (POINT2 * 3) + (POINT3 * 6)$                                       | Formula to calculate point count per California FPA requirements: 14 CCR 913.1(b), 912.7(b)(1)(A)                                                                                                                                                                             |

| Variable | Definition                                                                              | Usage                                                                                                                                  |
|----------|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| CONBBA   | Basal area of conifer pre-harvest                                                       | Used to calculate PCTBACON                                                                                                             |
| PCTBACON | Basal area of conifer as percent of total basal area, pre-harvest                       | Used to govern harvesting within California WLPZ's.                                                                                    |
| CTPABigC | Conifer trees per acre greater than 16"                                                 | Used to govern harvesting within California WLPZ's.                                                                                    |
| BAHWGE18 | Pre-harvest large hardwood trees (hardwood trees greater than or equal to 18" DBH)      | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |
| BASWGE30 | Pre-harvest large conifer trees (conifer trees greater than or equal to 30" DBH)        | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |
| LVBBABIG | BAHWGE18 + BASWGE30                                                                     | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |
| PROPHW18 | BAHWGE18/LVBBABIG                                                                       | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |
| PROPSW30 | BASWGE30/LVBBABIG                                                                       | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |
| TENPCTBA | 10 % of pre-harvest basal area                                                          | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |
| LVBBAHW  | Calculated basal area of large hardwood trees to retain under FHCP retention guidelines | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |
| LVBBASW  | Calculated basal area of large conifer trees to retain under FHCP retention guidelines  | Used in the calculation of 10% basal area leave tree requirements for live tree retention following clearcuts as specified in the FHCP |

**IF-THEN-END IF** - also known as scheduling by condition, the IF-THEN-END IF code block is used to execute FVS actions once certain conditions are met. The Event Monitor keyword sequence must begin with an IF keyword. The next record must be a condition statement that evaluates to true or false. The next record is a THEN keyword. The

sequence ends with an ENDIF keyword. All keywords contained between the THEN and ENDIF keywords will be executed whenever the condition is true. The condition is checked every cycle, unless that cycle falls within the minimum waiting time since the last time the condition was true. The IF-THEN-END IF scheduling method was used, in conjunction with COMPUTE to help regulate the application of harvest activities in all regimes.

**NUMCYCLE** - Specifies the number of cycles to run the projection. A cycle is the period of time for which tree characteristics are predicted, and for which inventories are reported (see TIMEINT).

**TIMEINT** - Specifies the length, in years, of any or all projection cycles. This keyword is used to ensure that an action can be implemented in the same year that it is scheduled rather than the FVS default, which is the first year of a cycle. The default projection cycle for the NC variant of FVS is 5 years. TIMEINT was used in conjunction with NUMCYCLE and IF-THEN-END IF code blocks to offer different timing possibilities of silvicultural actions throughout the 100-year planning horizon for each stand type. Having multiple prescriptions available for each stand in which different sequences and timing of harvest events and other silvicultural events occur ensures that property-level constraints, such as upper or lower limits on harvest volumes, can be met in the baseline planning model described below.

**RESETAGE** - Sets the stand age to zero to make FVS model output correspond to the actual age of the stand. Age is strictly for reporting purposes and has no effect on growth or survival prediction. Its only effect is on the calculation of mean annual increment. This keyword is useful when average stand age has changed due to thinnings and plantings. This keyword was used to reset stand age after regeneration harvests so that the age of subsequent harvests could be calculated and controlled programmatically if necessary.

## Site Class, Site Index, and Growth Determination

### Site Productivity Class

Some ARB Assessment Areas are distinguished by site class. The ARB FOP defines high site classes as USDA Forest Service Sites I, II, III and IV; low site classes are Forest Service Sites V – VII. The Forest Service separates site classes by potential yield, or mean annual increment expressed as merchantable cubic feet per acre (see USDA Forest Service Forestland Productivity Classes table below). Using this type of classification to determine site quality is known as the Yield Method (Avery and Burkhart 2002).

**Table 8. USDA Forest Service Forestland Productivity Classes**

| Code | Potential Yield, Mean Annual Increment |
|------|----------------------------------------|
| 1    | 225 or more cubic feet per acre        |
| 2    | 165 to 225 cubic feet per acre         |
| 3    | 120 to 165 cubic feet per acre         |
| 4    | 85 to 120 cubic feet per acre          |
| 5    | 50 to 85 cubic feet per acre           |
| 6    | 20 to 50 cubic feet per acre           |
| 7    | Less than 20 cubic feet per acre       |

In the subject Supersections, the Northern California Coast Redwood/Douglas-fir Mixed Conifer and Southern Cascades Mixed Conifer Assessment Areas in the project are separated into site classes (i.e. High and Low). The Project Area site classes for these Assessment Areas were determined by using the combination of the Yield - Soils Overlay method and linear regression. These methods determine the potential productivity of each Assessment Area (MAI in Cubic Feet per Acre per Year) within the Project Area from soil survey data obtained from the USDA Natural Resources Conservation Service (NRCS) and then performing linear regression to predict potential productivity on Assessment Area acres without soil survey data coverage; these results are then compared to the Forest Service site classes to assign “High” or “Low.”

The NRCS provides soil survey data at no cost from their *Web Soil Survey (WSS)* platform for almost all the contiguous United States. The data can be delivered in SSURGO format, which has spatial and tabular components allowing users to group and report soils data for a focus area.

The steps to perform the Yield Method using NRCS SSURGO soils overlay data are as follows:

1. Download soil dataset and coverage for Project Area (<https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx>).
2. Use ArcGIS Overlay Identity Analysis Tool to attribute Project Area with soil survey Mapping Unit Key (mukey).
3. Relate soil mapping units with soil series components.
4. Relate soil series components with forestland productivity values and determine the average MAI for all suggested species.

5. Aggregate forestland productivity by strata and soil mapping unit weighted by component representative percent (i.e. weighted average method).

The results of this Soils Overlay – Yield Method shows that about 86% (22,053.83 acres) of the project area is High Site Class and about 14% (3,729.13 acres) of the project area is Low Site Class

Approximately 7,434.57 acres of the project area did not yield an average forest productivity because of misclassification or outdated soils data (ARB Site Class = No Data). On these “No Data” acres, we conducted linear regression to predict average forest productivity.

The linear regression analysis utilized variables contained within the same NRCS SSURGO dataset used in Soils Overlay – Yield Method described above. The dataset was filtered to only include Mapping Unit Keys (MUKEYs) that contained average site productivity values; this value represented our dependent variable. A step-wise approach to formulating the final regression form was conducted using a wide range of soil data attributes that would be associated with soil productivity as the independent variables. For each regression ‘run’ we reviewed and assessed the regression statistics for robust R Square values, significant independent variable P-values, correlation among independent variables, and heteroskedasticity (See Table 9 and Table 10 for regression statistics).

The final regression form incorporated 2 independent variables:

1. Available Water Storage (AWS): 0 – 150 cm (weighted average)  
Available water storage or available water capacity (AWS) refers to the quantity of water that the soil can store for use by plants. AWS is an indicator of the soil’s ability to retain water and make it sufficiently available for plant use.
2. Frost Free Days (FFD): (representative value)  
Frost free days is the expected number of days between the last freezing temperature in spring and the first freezing temperature in fall. Frost free days is an indicator of growing season length.

Both the dependent and independent variables were transformed to their natural logarithm to account for heteroskedasticity. The final regression form is as follows:

$$y(\ln) = -3.49286 + (0.47748 * AWS(\ln)) + (1.32697 * FFD(\ln))$$

Where:

$Y(\ln)$  = Predicted average forest productivity expressed as its natural logarithm

$AWS(\ln)$  = Available water storage value expressed as its natural logarithm

$FFD(\ln)$  = Frost free days value expressed as its natural logarithm

**Table 9: Regression Statistics**

| <i>Regression Statistics</i> |             |
|------------------------------|-------------|
| Multiple R                   | 0.764078403 |
| R Square                     | 0.583815806 |
| Adjusted R Square            | 0.561911375 |
| Standard Error               | 0.181939251 |
| Observations                 | 41          |

**Table 10: Dependent and Independent Variable Statistics**

|                         | <i>Coefficients</i> | <i>Standard Error</i> | <i>t Stat</i> | <i>P-value</i> |
|-------------------------|---------------------|-----------------------|---------------|----------------|
| Intercept               | -3.492865898        | 1.418612316           | -2.462170854  | 0.018458715    |
| Available Water Storage | 0.477480986         | 0.117308256           | 4.070310175   | 0.000229089    |
| Frost Free Days         | 1.326970699         | 0.263631907           | 5.033422229   | 1.19597E-05    |

The predicted average site productivity on the 7,434.57 “No Data” acres resulted in 5,611.13 acres of High Site Class and 1,823.44 acres of Low Site Class. Table 10 shows the final site class distribution across the project area.

**Table 11: ARB Site Class Soils Overlay – Yield Method w/ Linear Regression Results**

| <b>Supersection</b>       | <b>Strata Name</b> | <b>Assessment Area</b>            | <b>Site Class Low Acres</b> | <b>Site Class High Acres</b> |
|---------------------------|--------------------|-----------------------------------|-----------------------------|------------------------------|
| Northern California Coast | Klamath            | Redwood/Douglas-fir Mixed Conifer | 2,538.41                    | 10,258.58                    |
| Northern California Coast | Klamath            | Mixed Oak Woodland                | 0.00                        | 181.58                       |
| Northern California Coast | Korbel             | Redwood/Douglas-fir Mixed Conifer | 605.49                      | 2,861.07                     |
| Northern California Coast | Korbel             | Mixed Oak Woodland                | 21.39                       | 273.44                       |
| Northern California Coast | WLPZ               | Redwood/Douglas-fir Mixed Conifer | 901.17                      | 3,842.13                     |
| Northern California Coast | WLPZ               | Mixed Oak Woodland                | 0.00                        | 97.27                        |
| Southern Cascades         | Klamath            | Mixed Conifer                     | 1,112.46                    | 3,245.99                     |
| Southern Cascades         | Korbel             | Mixed Conifer                     | 160.06                      | 4,765.32                     |
| Southern Cascades         | WLPZ               | Mixed Conifer                     | 213.29                      | 2,139.90                     |
| <b>Total</b>              |                    |                                   | <b>5,552.27</b>             | <b>27,665.27</b>             |

## Site Index

Site index across the project area was determined through the same process as the Soils – Yield Overlay Method described above for Site Class. Soils series components with site index values were aggregated by strata and soil mapping units weighted by component representative percent (i.e. weighted average method). The NRCS SSURGO soils data covering the project area also contains site index values derived from different site index systems. For this project, whose dominant conifer species was Douglas-fir with less than 20% of the basal area in redwood, we use the McCardle, Meyer, Bruce (1961) site index values (McCardle et al. 1961). This approach is consistent with Timber Site Classification rules presented in Article 4 Section 1060 (Timber Site Classification) in the California Forest Practice Rules (CDF, 2019).

Similar to the case with forest site productivity, approximately 7,615 acres of the project area did not yield an average site index because of misclassification or outdated soils data (ARB Site Class = No Data). Recognizing that forest site productivity and site index are inextricably linked, we conducted linear regression to predict average site index using the same independent variables as presented above for the site productivity linear regression on these “No Data” acres (See Table 12 and Table 13 for regression statistics).

Both the dependent and independent variables were transformed to their natural logarithm to account for heteroskedasticity. The final regression form is as follows:

$$y(\ln) = 0.85314 + (0.24959 * AWS(\ln)) + (0.61573 * FFD(\ln))$$

Where:

$Y(\ln)$  = Predicted average site index expressed as its natural logarithm

$AWS(\ln)$  = Available water storage value expressed as its natural logarithm

$FFD(\ln)$  = Frost free days value expressed as its natural logarithm

**Table 12: Regression Statistics**

| <i>Regression Statistics</i> |             |
|------------------------------|-------------|
| Multiple R                   | 0.589372059 |
| R Square                     | 0.347359424 |
| Adjusted R Square            | 0.311101615 |
| Standard Error               | 0.146683924 |
| Observations                 | 39          |

**Table 13: Dependent and Independent Variable Statistics**

|                         | <i>Coefficients</i> | <i>Standard Error</i> | <i>t Stat</i> | <i>P-value</i> |
|-------------------------|---------------------|-----------------------|---------------|----------------|
| Intercept               | 0.8531354           | 1.219455595           | 0.699603498   | 0.488671184    |
| Available Water Storage | 0.249592874         | 0.096864796           | 2.576713986   | 0.014220546    |
| Frost Free Days         | 0.615735061         | 0.229343594           | 2.684771131   | 0.010903274    |

Site index values, either derived directly from the NRCS SSURGO data or predicted through regression, were also assigned a Timber Site Classification as presented in Article 4 Section 1060 (Timber Site Classification) in the California Forest Practice Rules (CDF, 2019) based on the McArdle et al. Site Index Values (Table 15). Assigning a CA FPR site class to each stand provides the necessary detail to maintain compliance with the legal constraints related to harvest activities in the CA FPRs when developing FVS prescriptions for the baseline model.

**Table 14: Soils Overlay – Site Index Method w/ Linear Regression Results: McArdle et. al. (1961) Site Class Results**

| Site Class | Douglas-fir Site Index (feet @ 100 years) | Acres     |
|------------|-------------------------------------------|-----------|
| I          | 194 or more                               | 0.00      |
| II         | 164 – 193                                 | 3,439.13  |
| III        | 134 – 163                                 | 12,112.96 |
| IV         | 103 – 133                                 | 12,107.10 |
| V          | Less than 103                             | 5,558.34  |
| Total      |                                           | 33,217.53 |

#### FVS Growth Calibration Site Index

The FVS NC Variant uses a base age 50 (breast height age) version of the Dunning 1942 site index commonly used for Mixed Conifer stands in Northern California (Dunning 1942). A series of transformations was applied to the final set of McArdle site indices to arrive at average 50-year Dunning site index (Dunning SI 50) values by site class for input into FVS prescriptions.

First, McArdle site indices were converted to King (1966) 50-year Douglas-fir site indices using the following equation from his publication “Site index curves for Douglas-fir in the Pacific Northwest” (King 1966):

$$SI_{50} = 21.5 - 0.18127 * (TOTAL\_AGE) + 0.72114 * SI_{100}$$

where:

SI<sub>50</sub> = King (1966) 50-Year Douglas-fir site index

SI<sub>100</sub> = McArdle et al(1966) 100-Year Douglas-fir site index

TOTAL\_AGE = 100

Next, King site indices were transformed to 300-year total age Dunning (1942) site indices using the following equation from Hanson et al (2002):

$$DSI_{300} = 3.07 * SI_{50}^{0.9}$$

where:

SI<sub>50</sub> = King (1966) 50-Year Douglas-fir site index

DSI<sub>300</sub> = Dunning(1942) 300-Year mixed conifer site index

Finally, Dunning 300-year site index values were transformed to their respective 50-year site index values using the following linear regression based on matching Dunning's original 300-year site indices by site class to the corresponding 50-year site indices by site class cited in table 3.4.1.1 in the FVS NC Variant user guide (Keyser 2008) as follows:

$$DSI_{50} = 0.5451 * DSI_{300} - 5.7905$$

where:

$DSI_{50}$  = Dunning(1942) 50-Year mixed conifer site index

$DSI_{300}$  = Dunning(1942) 300-Year mixed conifer site index

Since Site Class II and III are subject to the same legal constraints regarding commercial thinning, selection harvesting, clearcut harvesting, and post-harvest minimal required stocking levels, these two classes were combined for the purposes of modeling FVS prescriptions.

The results of the final site classification by strata and site class along with both McArdle and Dunning SI 50 calculated site index values are shown below in Table 15.

**Table 15. Results of Site Index and Site Classification**

| Strata        | Site Class | Acres    | Dunning SI 50 | McArdle SI 100 |
|---------------|------------|----------|---------------|----------------|
| Klamath       | II-III     | 7,574.3  | 108           | 147            |
| Klamath       | IV         | 6,109.3  | 91            | 122            |
| Klamath       | V          | 3,653.4  | 73            | 95             |
| Klamath Total |            | 17,337.0 | 95            | 127            |
| Korbel        | II-III     | 4,231.3  | 114           | 155            |
| Korbel        | IV         | 3,668.4  | 91            | 121            |
| Korbel        | V          | 787.1    | 72            | 94             |
| Korbel Total: |            | 8,686.8  | 101           | 135            |
| WLPZ          | II-III     | 3,746.5  | 111           | 151            |
| WLPZ          | IV         | 2,329.4  | 91            | 121            |
| WLPZ          | V          | 1,117.9  | 73            | 95             |
| WPLZ Total:   |            | 7,193.8  | 99            | 132            |

### Annual Growth and the Initial Project Inventory

The initial project inventory took place effectively one growing season after the commencement date for the project, requiring the inventory stocks to be degrown to reflect the initial onsite carbon stocks. This was modeled by growing the inventory forward five years (the default cycle length for the NC variant) and determining the annual diameter and height increment for each individual tree record. Data was grown using the average Dunning SI 50 at the strata level. The annual increment was subtracted from each tree in the 2019 tree list to create a 2018 tree list. Initial carbon stocks were calculated from the degrown 2018 tree list using the same methodology as was employed for initial carbon stocks. This tree list also served as the starting point for all yield tables modeled for the project's 100-year baseline.

## Carbon Modules

This section describes the steps to process the FVS output data subject to the ARB volume and biomass equations for projects located in California, Washington and Oregon using the *carbon modules*. The carbon modules are a set of proprietary MS Access relational databases setup primarily to calculate carbon stocks from the FVS\_TreeList and FVS\_CutList. The carbon modules are based on a series of queries that select data and perform the calculations necessary to summarize onsite and harvested carbon stocks by stratum in a fashion that is compliant with the Forest Offset Protocol.

### Step 1: Run FVS and create tables for FVS module.

Inventory data is processed in the FVS to obtain modeled data. This includes: growth (accretion and in-growth), mortality, and harvesting. FVS output tables are maintained in output databases (e.g. ForestCarbon\_FVS\_OUT.mdb) and include the following tables: FVS\_Cases; FVS\_Summary (or FVS\_SummaryEast for eastern variants); FVS\_TreeList; and FVS\_CutList.

### Step 2: Run the Central Module.

The purpose of this module is to calculate the cubic foot volume, biomass, and ultimately carbons stocks by stratum and year, from the tree list and cut list output from FVS. The database is programmed to relate each tree by species to the appropriate volume equation and biomass coefficients associated with the project. The database includes a form with instructions and buttons to execute commands.

Step 2a: Calculate cubic foot volumes (VOLCFGRS & VOLCFSND) using “Volumetric Equations for California, Oregon, and Washington (September 19, 2014)” as published by ARB on their website.

- a. Open the CRM\_Central\_Module.mdb database.
- b. Follow instructions in tab 1 of the form (Setup) to make the Strata-Species-Site Index table (StrataSppSI) for species that require site index as a volume equation input.
- c. Follow instructions in tab 3 the form (ORWACA + AK Methods) to make the ORWACA Species Table to create a crosswalk table for cubic foot volume and biomass equation references, wood density values, and Harmon Density Reduction factors for the ORWACA method.
- d. Follow instructions in tab 3 of the form (ORWACA + AK Methods) to calculate cubic foot volumes which will apply the appropriate ARB cubic foot volume equations as indicated in the species look up table.

**Quality Control Note:** After making these tables, open them up and sort the ‘VOLCFGRS’ column in descending order. Observe the highest value. If the value equals 5,000,000 then an error occurred because the species was not recognized, i.e. a species code or equation reference was not related correctly.

Step 2b: Calculate biomass using the “Biomass Equations for California, Oregon, and Washington (September 19, 2014)” as published by ARB on their website and the volumes calculated in the previous step.

- a. Still within the CRM\_Central\_Module.mdb database.
- b. Follow instructions in tab 3 of the form (ORWACA + AK Methods) to calculate biomass which will apply the appropriate biomass equations as indicated in the species look up table by species.

### Step 2c: Create Final Stand Summary

- a. Still within the CRM\_Central\_Module.mdb database.
- b. Follow instructions in tab 4 of the form (Summary) to create a Final Stand Summary. This will execute several sub-queries to convert biomass to carbon and then aggregate volumes and carbon stocks by strata by year.

## Further description of Carbon Pool Calculation Assumptions

### Allometric Equations used

The Forest Protocol requires estimates of total above-ground and below-ground biomass. OPOs/APDs with projects located in Alaska, California, Oregon, and Washington should use these instructions<sup>8</sup> to estimate volume and convert biomass to tons of CO<sub>2</sub>e emissions or removal enhancements. The Protocol requires use of specific volume equations found in “Volumetric Equations for California, Oregon, and Washington (September 19, 2014)” and “Biomass Equations for California, Oregon, and Washington (September 19, 2014)”. See Table 16 below, which is also provided in Excel format in the OPDR Worksheet Calculations.

### IFM-1: Standing Live Carbon (carbon in all portions of living trees)

1. Live trees were inventoried. Rotten material was measured by percent of the main bole and deducted from gross volume to determine sound volume.
2. Growth data (diameter and total height increment) is processed in the FVS-NC Variant.
  - a. Species with a volume equation that required total height used the FVS output estimated total height. The total heights of each tree from the inventory were input to FVS; FVS projects total height increment in subsequent years. The height to top kill was used if this type of height was present for a tree.
3. FVS is only being used for DBH and height data – the FVS\_TreeList cubic foot volumes are not used in carbon calculations. Carbon calculations are based on the ARB Cubic Foot Volume Equations for gross cubic volume (VOLCFGRS) in the United States for projects located in California, Oregon, and Washington. Gross cubic foot equation references used for this project are shown below in.
4. Sound volume (VOLCFNSD) is calculated for both standing live and standing dead trees by deducting the volume of wood that is rotten or missing from the VOLCFGRS based on the percentage of missing or rotten volume estimated in the field during the inventory
5. The CRM Central Module houses the volumetric and biomass equations tables which contain the species-specific formulas as provided by ARB in the “Volumetric Equations for California, Oregon, and Washington (September 19, 2014)” and “Biomass Equations for California, Oregon, and Washington (September 19, 2014)” documents under the Forest Offset Protocol instructions page.
6. The central module stores a species table that relates the FVS\_TreeList.SpeciesFIA field to the Species\_LU\_ORWACA.SpeciesFIA field to match the equation reference numbers and wood density.
7. The FVS\_TreeList, CRM\_CFVolume, and CRM\_biomass tables are then related to each other and tree records are summed by stratum to calculate standing live trees per acre, basal area, merchantable cubic feet, and forest carbon.

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<sup>8</sup> [https://www.arb.ca.gov/cc/capandtrade/protocols/usforest/2015/instructions-ca-or-wa\\_2015.htm](https://www.arb.ca.gov/cc/capandtrade/protocols/usforest/2015/instructions-ca-or-wa_2015.htm)

**Table 16. Volume and Biomass Equation Assignments by Species**

| Species Name            | FIA Code | ARB ORWACA (CA) CuFt Reference | ARB ORWACA (CA) Biomass Live Branches Reference | ARB ORWACA (CA) Biomass Stem Bark Reference | ARB ORWACA Wood Density |
|-------------------------|----------|--------------------------------|-------------------------------------------------|---------------------------------------------|-------------------------|
| white fir               | 15       | 23                             | 1                                               | 1                                           | 23.09                   |
| grand fir               | 17       | 23                             | 1                                               | 2                                           | 21.84                   |
| Port Orford cedar       | 41       | 8                              | 10                                              | 13                                          | 24.34                   |
| incense cedar           | 81       | 19                             | 10                                              | 12                                          | 21.84                   |
| ponderosa pine          | 122      | 5                              | 7                                               | 9                                           | 23.71                   |
| Douglas-fir             | 202      | 3                              | 6                                               | 8                                           | 28.08                   |
| redwood                 | 211      | 24                             | 10                                              | 13                                          | 22.46                   |
| western red cedar       | 242      | 8                              | 10                                              | 13                                          | 19.34                   |
| western hemlock         | 263      | 6                              | 12                                              | 15                                          | 26.21                   |
| bigleaf maple           | 312      | 37                             | 0                                               | 0                                           | 27.46                   |
| red alder               | 351      | 26                             | 16                                              | 20                                          | 23.09                   |
| Pacific madrone         | 361      | 40                             | 0                                               | 0                                           | 36.19                   |
| giant chinquapin        | 431      | 32                             | 0                                               | 0                                           | 26.21                   |
| Pacific dogwood         | 492      | 37                             | 0                                               | 0                                           | 36.19                   |
| Oregon ash              | 542      | 38                             | 0                                               | 0                                           | 31.2                    |
| tanoak                  | 631      | 34                             | 0                                               | 0                                           | 36.19                   |
| canyon live oak         | 805      | 42                             | 0                                               | 0                                           | 43.68                   |
| Oregon white oak        | 815      | 41                             | 0                                               | 0                                           | 39.94                   |
| California black oak    | 818      | 38                             | 0                                               | 0                                           | 31.82                   |
| willow species          | 920      | 40                             | 0                                               | 0                                           | 22.46                   |
| California laurel       | 981      | 33                             | 0                                               | 0                                           | 31.82                   |
| tree, deciduous species | 998      | 41                             | 0                                               | 0                                           | 32.45                   |

**IFM-3: Standing Dead Carbon (carbon in all portions of standing dead trees or snags)**

Standing dead trees (i.e., snags) were inventoried using the same sampling methodology as live standing trees. Dead tree decay status was classified using the classes and density reduction factors described by Harmon, et al. (2011) for inventoried standing dead trees. The five decay classes (listed below) are qualitative, based on the physical characteristics of the standing dead tree. The decay class is indicated in the inventory data in the FVS\_TreeList.SSCD column. The dead tree decay status codes are concatenated with a 3 for programmatic reasons (e.g. 23 = “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.”; 33 = “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.”). The five decay classes are described below in Table 17.

**Table 17. Decay Class Definition**

| Decay Class | Description                                                                                                                                                                                    |
|-------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 still sound and hard.                          |
| 2           | There are few limbs or fine branches, the top may be broken, a variable amount of bark remains, sapwood is sloughing, heartwood has advanced decay in upper bole and is beginning at the base. |
| 3           | Only limb stubs exist, the top is broken, variable bark remains, sapwood is sloughing, heartwood has advanced decay at the base and is sloughing in the upper bole.                            |
| 4           | Few or no limb stubs remain, top is broken, variable bark remains, sapwood is sloughing, heartwood has advanced decay at the base and is sloughing throughout.                                 |
| 5           | No evidence of branches remains, the top is broken, less than 20 percent of the bark remains, sapwood is gone, heartwood is sloughing throughout.                                              |

**Applying density reduction factors (DRF) and Structural Loss Adjustments (SLA):**

The standing dead carbon pool must be adjusted for density reduction and structural loss. Density Reduction Factors can be found in Harmon (2011) Appendix B and D. For projects located in Alaska, California, Oregon, and Washington, the Domke method of applying Structural Loss Adjustment Factors by tree component using the Component Ratio Method is not applicable. To account for structural loss on standing dead trees in these states, any observed soundness deduction from the inventory for standing dead trees is applied to the gross cubic foot volume before applying the density reduction factors.

The central module stores a species table that relates the FVS\_TreeList.SpeciesFIA field to the Species\_LU\_step2.SpeciesFIA field to match the equation reference numbers and wood density. It also matches the FVS\_TreeList.SSCD code (described at the beginning of this section) to the same look-up table which also contains the Harmon DRF values for each species.

Note: The reductions and adjustments described above are made to the sound volume (VOLCFSND), which is calculated for each record using the steps outlined for IFM-1 above.

**Table 18. Density Reduction Factors**

| Species Name            | FIA Code | rel1  | rel2  | rel3  | rel4  | rel5  |
|-------------------------|----------|-------|-------|-------|-------|-------|
| white fir               | 15       | 0.996 | 0.873 | 0.625 | 0.541 | 0.541 |
| grand fir               | 17       | 1.013 | 0.966 | 0.855 | 0.574 | 0.574 |
| Port Orford cedar       | 41       | 0.994 | 0.951 | 0.902 | 0.605 | 0.605 |
| incense cedar           | 81       | 1.04  | 0.972 | 1.011 | 0.596 | 0.596 |
| ponderosa pine          | 122      | 0.925 | 1.007 | 1.154 | 0.481 | 0.481 |
| Douglas-fir             | 202      | 0.892 | 0.831 | 0.591 | 0.433 | 0.433 |
| redwood                 | 211      | 0.994 | 0.951 | 0.902 | 0.605 | 0.605 |
| western red cedar       | 242      | 1.04  | 0.96  | 1.064 | 0.656 | 0.656 |
| western hemlock         | 263      | 0.9   | 0.83  | 0.661 | 0.38  | 0.38  |
| bigleaf maple           | 312      | 0.979 | 0.766 | 0.565 | 0.45  | 0.45  |
| red alder               | 351      | 1.03  | 0.903 | 0.535 | 0.393 | 0.393 |
| Pacific madrone         | 361      | 0.982 | 0.793 | 0.618 | 0.525 | 0.525 |
| giant chinquapin        | 431      | 0.982 | 0.793 | 0.618 | 0.525 | 0.525 |
| Pacific dogwood         | 492      | 0.982 | 0.793 | 0.618 | 0.525 | 0.525 |
| Oregon ash              | 542      | 0.899 | 0.622 | 0.575 | 0.525 | 0.525 |
| tanoak                  | 631      | 0.982 | 0.793 | 0.618 | 0.525 | 0.525 |
| canyon live oak         | 805      | 1.02  | 0.841 | 0.705 | 0.591 | 0.591 |
| Oregon white oak        | 815      | 1.02  | 0.841 | 0.705 | 0.591 | 0.591 |
| California black oak    | 818      | 1.02  | 0.841 | 0.705 | 0.591 | 0.591 |
| willow species          | 920      | 0.982 | 0.793 | 0.618 | 0.525 | 0.525 |
| California laurel       | 981      | 0.982 | 0.793 | 0.618 | 0.525 | 0.525 |
| tree, deciduous species | 998      | 0.99  | 0.8   | 0.54  | 0.43  | 0.43  |

## Assessment Area Analysis

This section describes the steps followed in the FOP (Appendix F Determining a Value for Common Practice) to determine the standing live, above-ground carbon common practice statistic.

### Supersection

The project area lies within the *Northern California Coast* and *Southern Cascades* FOP Supersections (see CAR1339 OPDR RP1 Attachment E and F Maps.pdf).

### Assessment Areas

The project area was stratified by Finite Carbon as described in the Stratification Rules section of the Sampling Methodology.

### Site Class

Site class acres by Assessment Area were determined using the methods described previously in the Site Class, Index, and Growth Determination section.

The final dispensation of the project inventory by inventory strata and assessment area is shown below in Table 19 along with the calculation of the common practice statistic for this project. The common practice carbon stocking for the Project Area is calculated to be 166.14 tons per acre.

**Table 19. Common Practice Carbon Stocks**

| Supersection              | Assessment Area                   | Strata  | Site Class | Project Area (Acres) | CP Stock | Area Weight | Weight CP |
|---------------------------|-----------------------------------|---------|------------|----------------------|----------|-------------|-----------|
| Northern California Coast | Redwood/Douglas-fir Mixed Conifer | Klamath | High       | 10,258.58            | 205.15   | 30.9%       | 63.31     |
| Northern California Coast | Redwood/Douglas-fir Mixed Conifer | Klamath | Low        | 2,538.41             | 152.72   | 7.6%        | 11.66     |
| Northern California Coast | Mixed Oak Woodland                | Klamath | High       | 181.58               | 114.38   | 0.5%        | 0.62      |
| Northern California Coast | Mixed Oak Woodland                | Klamath | Low        | -                    | 114.38   | 0.0%        | -         |
| Northern California Coast | Redwood/Douglas-fir Mixed Conifer | Korbel  | High       | 2,861.07             | 205.15   | 8.6%        | 17.66     |
| Northern California Coast | Redwood/Douglas-fir Mixed Conifer | Korbel  | Low        | 605.49               | 152.72   | 1.8%        | 2.78      |
| Northern California Coast | Mixed Oak Woodland                | Korbel  | High       | 273.44               | 114.38   | 0.8%        | 0.94      |
| Northern California Coast | Mixed Oak Woodland                | Korbel  | Low        | 21.39                | 114.38   | 0.1%        | 0.07      |
| Northern California Coast | Redwood/Douglas-fir Mixed Conifer | WLPZ    | High       | 3,842.13             | 205.15   | 11.6%       | 23.71     |
| Northern California Coast | Redwood/Douglas-fir Mixed Conifer | WLPZ    | Low        | 901.17               | 152.72   | 2.7%        | 4.14      |
| Northern California Coast | Mixed Oak Woodland                | WLPZ    | High       | 97.27                | 114.38   | 0.3%        | 0.33      |
| Northern California Coast | Mixed Oak Woodland                | WLPZ    | Low        | 0.00                 | 114.38   | 0.0%        | 0.00      |
| Southern Cascades         | Mixed Conifer                     | Klamath | High       | 3,245.99             | 121.77   | 9.8%        | 11.89     |
| Southern Cascades         | Mixed Conifer                     | Klamath | Low        | 1,112.46             | 81.81    | 3.4%        | 2.79      |
| Southern Cascades         | Mixed Conifer                     | Korbel  | High       | 4,765.32             | 121.77   | 14.3%       | 17.46     |

|                   |               |        |      |                  |        |      |               |
|-------------------|---------------|--------|------|------------------|--------|------|---------------|
| Southern Cascades | Mixed Conifer | Korbel | Low  | 160.06           | 81.81  | 0.5% | 0.39          |
| Southern Cascades | Mixed Conifer | WLPZ   | High | 2,139.90         | 121.77 | 6.4% | 7.84          |
| Southern Cascades | Mixed Conifer | WLPZ   | Low  | 213.29           | 81.81  | 0.6% | 0.53          |
|                   |               |        |      | <b>33,217.53</b> |        |      |               |
|                   |               |        |      |                  |        |      | <b>166.20</b> |

## Baseline Model Constraints

In modeling the baseline for standing live and dead carbon stocks, the forest owner has considered and incorporated all operational, legal, and financial constraints that could affect baseline growth and harvesting scenarios.

### Characterization

The baseline scenario models timber harvesting over 100 years, as a function of what it is legally allowable, financially feasible and physically possible, while at the same time adhering to the minimum baseline level (MBL). In the baseline model, forest development was projected using a combination of even-aged and intermediate treatments, oftentimes creating two-aged or multi-aged conditions depending on the arrangement of treatment types over space and time. Forest stands were eligible for treatment types based primarily on their forest structure, site attributes, and baseline model constraints.

Constraints that affect land-use specific to forest management activities have been incorporated into the baseline carbon modeling. For this project, there are 4 primary sources of legal constraints: (1) Forest Habitat Conservation Plan on the California Timberlands of Green Diamond Resources Company (FHCP), (2) Aquatic Habitat Conservation Plan on California Timberlands of Green Diamond Resources Company (AHCP), (3) California Forest Practice Rules, 2019 (CAFPRs), and (4) High Conservation Value Forests (HCVFs) within the project area.

### Legal Constraints

#### **Forest Habitat Conservation Plan on the California Timberlands of Green Diamond Resources Company**

The intention of the FHCP is to meet all regulatory requirements necessary for the US Fish and Wildlife Service (USFWS) to issue to Green Diamond an ESA Section 10 Incidental Take Permit (ITP) authorizing incidental take of the Covered Species due to Covered Activities specified in FHCP Section 2. The FHCP assessment of direct and indirect effects on Covered Species provides information and analysis for the Service to conduct internal Section 7 consultation required for FHCP evaluation.

Approved in 2019, the FHCP authorizes the incidental take by Green Diamond of each listed Covered Species resulting from Covered Activities in the Plan Area and, upon its listing, the incidental take by Green Diamond of any currently unlisted Covered Species. The FHCP and associated ITP term is 50 years - expiring in 2069. The FHCP includes the following Covered Species: Northern Spotted Owl (NSO), fisher, Sonoma tree vole, and red tree vole. Green Diamond's commercial timber activities may cause incidental take of these Covered Species and as such, is the primary Covered Activity in the FHCP. The NSO is currently listed under the ESA as a threatened species. The other three Covered Species could become listed under the ESA in the future and are addressed in this FHCP as if they are listed.

The landscape management commitments in the FHCP benefitting the NSO will also provide high quality habitat for the fisher, Sonoma tree vole, red tree vole. The fundamental premise of the FHCP is that a mosaic of high-quality habitat will be maintained for the Covered Species within the term of the ITP. The primary mitigation strategy for NSO under the FHCP is the establishment of Dynamic Core Areas (DCAs) as the highest priority and level of protection for the most productive NSO sites distributed across the landscape. In addition, DCAs and managing for high quality NSO habitat, the FHCP also includes post-harvest retention standards.

### Baseline Model Considerations:

As part of the FHCP approval process, NSO DCAs were spatially delineated across Green Diamond's California Timberlands. DCAs that intersect with the project area have been spatially defined and designated as no harvest areas and left to grow for the entire baseline model projection. There are approximately 980 acres of DCAs within the project area.

In addition to DCAs, NSO activity centers have been identified by Green Diamond across their California Timberlands. These activity centers are point features in GIS and following FHCP guidance, each activity center has been buffered with a 0.5 mile circular buffer (502 acres) and intersected with the project area. These NSO management zones have been spatially defined within the project area to ensure that the baseline model adheres to the NSO nesting, roosting, and foraging habitat guidelines in the FHCP. NSO habitat conditions are tracked in FVS growth modeling so that the baseline model harvest prescriptions create and and/or maintain high quality NSO habitat in these management zones for the duration of the baseline model projection. Table 20 shows the habitat requirements for NSO used in the baseline model, which are derived from the USFWS document *Northern Spotted Owl Take Avoidance Analysis and Guidance For California Coast Forest District "Attachment A"*, dated March 15, 2011 and consistent with the habitat requirements in the FHCP.

**Table 20. NSO High Quality Habitat**

| <b>Foraging Habitat</b>                  | <b>Nesting/Roosting Habitat</b>          |
|------------------------------------------|------------------------------------------|
| 40% canopy cover of trees $\geq 11"$ DBH | 60% canopy cover of trees $\geq 11"$ DBH |
| BA $\geq 75$ of trees $\geq 11"$ DBH     | BA $\geq 100$ of trees $\geq 11"$ DBH    |
| Trees may be conifer or hardwood         | Trees may be conifer or hardwood         |

The FHCP also provides requirements for post-harvest live tree and standing dead (snag) retention. The FHCP details a complex scorecard system governing retention of both live and dead trees within harvest units. Although many of the criteria for scoring retention trees rely on site-specific physical examination in practice, (e.g., epicormic branching, hollow cavities, deeply furrowed bark, etc.), the scorecard system gives high priority to live conifer trees  $\geq 30"$  DBH and live hardwood trees  $\geq 18"$  DBH. FHCP guidelines also specify that all efforts should be undertaken in even-age harvest units to retain at least 10% of the pre-harvest basal area per acre. To capture these requirements in FVS, keywords were developed to calculate the amount of basal area left in 30"+ conifer and 18"+ hardwood trees that needed to remain after clearcutting to satisfy the 10% basal area leave requirement. These trees were then left remaining in any clearcut that was modeled during the term of the FHCP. Non-merchantable snags were assumed to remain standing.

The FHCP and ITP term expires in 2069. The baseline model assumes that after 2069, the FHCP will not be renewed and management activities on the project area will satisfy the requirements of the CA FPRs (see relevant legal constraints below).

### **Aquatic Habitat Conservation Plan on the California Timberlands of Green Diamond Resources Company**

The intention of the AHCP is to meet all regulatory requirements necessary for the NMFS and USFWS to issue permits authorizing incidental take of listed species in accordance with the federal ESA and federal policies regarding conservation of unlisted species.

Approved in 2007, the AHCP authorizes the incidental take by Green Diamond of each listed Covered Species resulting from Covered Activities in the Plan Area and, upon its listing, the incidental take by Green Diamond of any currently unlisted Covered Species. The AHCP and associated ITP term is 50 years – expiring in 2057. The AHCP includes the following Covered Species: chinook salmon, coho salmon, steelhead and resident rainbow trout, coastal cutthroat trout, tailed frog, and the southern torrent salamander.

The primary mitigation strategy for these covered species under the AHCP is the establishment of key conservation measures for Riparian Management in designated RMZs based on stream class (Table 21).

**Table 21. AHCP Riparian Management Standards**

|                                         | <b>AHCP Class I</b>                                                                                                                                    | <b>AHP Class II</b>                                                       | <b>AHP Class III</b>                                                                       |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| Core Zone                               | N/A                                                                                                                                                    | N/A                                                                       | N/A                                                                                        |
| Inner Zone - Width                      | 50' (<30%) [add 30' if adjacent to floodplain]<br>60' (30 - 60%) [add 40' if adjacent to floodplain]<br>70' (>60%) [add 50' if adjacent to floodplain] | 30'                                                                       | 50' Equipment Exclusion Zone                                                               |
| Inner Zone - Overstory Canopy Retention | 85%                                                                                                                                                    | 85%                                                                       | N/A                                                                                        |
| Inner Zone - Large Tree Retention       | Maintain at least 15 conifers > 16" DBH per acre                                                                                                       | Maintain at least 15 conifers > 16" DBH per acre                          | All hardwoods and non-merch trees<br>1 conifer 15" DBH or greater per 50' of stream length |
| Inner Zone - Silvicultural Requirements | One harvest entry coinciding with an even-aged harvest of adjacent stand.                                                                              | One harvest entry coinciding with an even-aged harvest of adjacent stand. | Light thinning is allowed with specific objectives of enhancing wildlife structure         |
| Outer Zone – Width                      | Extending from outside limit of Inner Zone to at least 150 feet (with addition of floodplain buffer if needed)                                         | 70'                                                                       | N/A                                                                                        |
| Outer Zone - Overstory Canopy Retention | 70%                                                                                                                                                    | 70%                                                                       | N/A                                                                                        |

|                                         |                                                                           |                                                                           |     |
|-----------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|-----|
| Outer Zone - Large Tree Retention       | Maintain at least 15 conifers stems > 16" DBH per acre                    | Maintain at least 15 conifers stems > 16" DBH per acre                    | N/A |
| Outer Zone - Silvicultural Requirements | One harvest entry coinciding with an even-aged harvest of adjacent stand. | One harvest entry coinciding with an even-aged harvest of adjacent stand. | N/A |
| Special Operating Zone                  | N/A                                                                       | N/A                                                                       | N/A |

#### Baseline Model Considerations:

In practice, for the purposes of meeting its AHCP habitat targets and developing internal harvest planning schedules, Green Diamond has modeled these WLPZs in GIS as one buffer rather than defining buffer zones and widths as presented in the above table. The modeled WLPZs are based on actual THP layouts and conservative assumptions on stream buffer rules that represent acres unavailable for harvesting under the AHCP. Green Diamond's harvest scheduling does include a very minor percent of selection harvesting in the modeled WLPZs as follows:

- Klamath Tracts (Klamath carbon strata): 4.7% selection in WLPZ areas [95.3% retention].
- Korbelt Tracts (Korbelt carbon strata): 15.5% selection harvest in WLPZ areas [84.5% retention].

The baseline model follows this same approach in the WLPZ strata (which represents the modeled WLPZs). For modeling purposes, it was assumed during the duration of the AHCP that the equivalent of 4.7% and 15.5% of the Klamath and Korbelt tract areas, respectively, could be modeled as clearcuts for WLPZ inventory strata in those tracts. Prescriptions for WLPZ clearcuts followed the same live tree and snag retention guidelines as described previously. The remainder of WLPZ area was off limits to any type of harvesting during the duration of the AHCP.

The AHCP also includes standards and best management practices for slope stability, road management, and harvest related ground disturbances. The baseline model assumes that harvest related activities will follow the key conservation measures detailed in the AHCP.

The baseline model assumes that after 2069, areas within the AHCP will not be renewed and management activities on the project area will satisfy the requirements of the CA FPRs (see relevant legal constraints below).

**California Forest Practice Rules (2019)**

The purpose of the Forest Practice Rules is to implement the provisions of the Z'berg-Nejedly Forest Practice Act of 1973 in a manner consistent with other laws, such as the Timberland Productivity Act of 1982, the California Environmental Quality Act (CEQA) of 1970, the Porter Cologne Water Quality Act, and the California Endangered Species Act. The goals of the FPA are to restore, enhance, and maintain the long-term productivity of the state's timberlands, and achieve maximum sustained production of high-quality timber products. Protect recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment and aesthetic enjoyment.

The FPA is implemented through regulations known as the Forest Practice Rules (FPRs), which are applied through THPs reviewed and approved by California Department of Forestry and Fire Protection (CalFire). The FPRs include standard prescriptions required in every THP, including:

- Protection measures for watercourse zones (minimum buffer sizes, canopy closure requirements, and equipment exclusion).
- Restrictions on construction, use, and maintenance of roads, trails, landings, and watercourse crossings.
- Snag Retention requirements and measures providing for retention of late seral elements.

Each THP may include site-specific language, restrictions or protection measures that are treated with the same enforcement as if they were approved regulations. The FPRs also require that THPs include a site-specific and area-specific assessment of potential individual and cumulative impacts of timber harvesting on the environment. Any significant impacts remaining after application of the standard FPRs require adoption of other site-specific measures to mitigate or avoid such impacts.

**Baseline Model Considerations:**

The baseline model adheres to the CA FPRs through FVS growth and yield modeling combined with spatially explicit area constraints in GIS. Requirements such as minimum stocking standards for harvests, minimum stand age to harvest, acreage limitations for regeneration harvests, adjacency constraints (spatial and time) are respected for the entire baseline model projection of 100-years. CA FPRs that overlap with the FHCPs and AHCPs are implemented in the baseline model after 2069 when those plans are assumed to expire. These constraints are WLPZs requirements, post-harvest live tree retention and post-harvest snag retention standards, and NSO habitat guidelines.

The baseline model assumes that all harvest activity will be accompanied by an approved THP. In addition, the baseline model accounts for any submitted, active, or approved THPs at the time of offset project commencement that intersects with the project area.

The following tables and descriptions illustrate how the baseline model incorporates the requirements set forth in the CA FPRs regarding silvicultural requirements.

### FPA Silvicultural Requirements

**Table 22. Summary of Baseline Model Even-aged Stocking Standards and Constraints**

| Standard/Constraint                       | Site Class I                                                                                                                                                                 | Site Class II and III | Site Class IV and V |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------|
| Minimum Stocking Standards for Harvest    | 85 sq.ft. BA/Acre                                                                                                                                                            | 50 sq.ft. BA/Acre     | 50 sq.ft. BA/Acre   |
| Minimum Stand Age to Harvest <sup>1</sup> | 50                                                                                                                                                                           | 60                    | 60                  |
| Acreage Limitation <sup>2</sup>           | 20-acres tractor / 30-acres cable                                                                                                                                            |                       |                     |
| Spatial Adjacency <sup>2</sup>            | Units separated by a logical logging unit at least as large as the area being harvested or 20 acres, whichever is less, and separated by at least 300 ft. in all directions. |                       |                     |
| Time Adjacency                            | Adjacent evenaged regeneration stands must have an approved report of stocking and be at least 5 years of age.                                                               |                       |                     |
| Post-Harvest Live Tree Retention          | N/A                                                                                                                                                                          |                       |                     |
| Post-Harvest Snag/Dead Tree Retention     | Retain all non-merchantable snags in harvest unless safety or fire hazard                                                                                                    |                       |                     |

1. Under the California "Option A" rules for achieving Maximum Sustained Production (MSP), rotation ages can be less than the statutory minimum provided documentation is on file with CAL FIRE demonstrating "the balance of growth and harvest over time" sufficient to sustain a long-term yield of high-quality timber products. Green Diamond currently manages under an approved Option A plan assuming a 45-year rotation.

2. Per California FPR 14 CCR 913.4 (b), areas that are understocked with commercial (conifer) species (minimum point count of 300 on Sites I-III or 150 on Sites IV or lower) are not subject to acreage or adjacency restrictions if a conifer rehabilitation prescription is in effect.

**Table 23. Summary of Baseline Model Commercial Thinning Constraints (retention)**

| Standard/Constraint                                                            | Site Class I | Site Class II and III | Site Class IV and V               |
|--------------------------------------------------------------------------------|--------------|-----------------------|-----------------------------------|
| Dominant and Codominant trees primarily ≥14 inch dbh, BA/A                     | 125          | 100                   | 75 for Class IV<br>50 for Class V |
| Dominant and Codominant trees primarily < 14 inch dbh, min TPA retained 4" dbh | 100          | 100                   | 75                                |

Modeling explicit tactical harvest plans is a complex, often iterative process in practice. It was outside the scope of the baseline modeling to explicitly model spatial adjacency and acreage constraints on even-age management, but several strategic level sideboards were put in place to ensure the model harvested what was tactically, legally, and operationally feasible. A number of data points went into determining these sideboards. First, Green Diamond provided their internal 2017 10-year Stand Availability Harvest Forecast showing stands available for even-aged harvest annually along with the associated adjacent stands. The results of this effort, which attempted to adhere to FPR acreage limitations and adjacency restrictions, showed a maximum amount of even-age harvest activity of 564 acres per year in the Klamath inventory block (not stratum) and 264 acres per year in the Korbel operating block (not stratum). Second, a point-count analysis that Finite Carbon conducted of all inventory plots showed that overall, 33% of the project area (32% in the Klamath stratum and 33% in the Korbel stratum) had a point count of less than 150, the lowest stocking threshold for all site classes - meaning that approximately 1/3 of the project area would not be subject to the normal acreage or adjacency restrictions associated with even-aged harvest units in the most conservative assumption (48% of the project inventory plots were under 300 point count). Finally, due to size limitations in the Woodstock planning model, it was only possible to explicitly stagger first stand entries over the first 20-25 years of the planning horizon within the three inventory strata, so annual acreage constraints are only possible within the first two decades of the planning horizon (later acreage constraints can be thought of more in terms of periodic averages).

With the understanding that the baseline model represents what is legally, tactically, and operationally possible, a maximum harvest constraint of 1,000 even-age acres per year for the first 20 years of harvesting was set for the Klamath block and 500 even-age acres per year for the first 20 years of harvesting for the Korbel block. The annual

average during the first twenty years was constrained, however, to be less than or equal to 511 and 264 acres, respectively, for the Klamath and Korbel operating blocks. An upper limit of 80 MMBF per year was imposed to help control the timing and distribution of all harvesting activities for the entirety of the planning horizon. Commercial thinning and selection harvests are not subject to acreage limitations per year, but their harvest volume is counted towards the 80 MMBF upper limit.

#### FPA Watercourse Protection Measures, Classes and Widths, Retention Requirements

The project area falls within Watersheds with Listed Anadromous Salmonids within the Coastal Anadromy Zone. Watercourse protection measures for this zone include stream class widths/zones and retention standards. The baseline model takes a conservative approach in establishing stream class widths under the CA FPRs. The following table shows the stream class zone widths established for the baseline modeling purposes.

**Table 24. Summary of Baseline Model Steam Class Widths (feet both sides)**

| Steam Class         | Water Transition Line* | Core Zone (feet from water transition line) | Inner Zone (feet from landward edge of Core Zone) | Outer Zone (feet from landward edge of Inner Zone) |
|---------------------|------------------------|---------------------------------------------|---------------------------------------------------|----------------------------------------------------|
| I (all categories)  | 15                     | 30                                          | 70                                                | 50                                                 |
| II (all categories) | 10                     | 30                                          | 70                                                | N/A                                                |
| III                 | 5                      | N/A                                         | 50                                                | N/A                                                |

\*Centerline of watercourse was buffered to establish water transition lines of channel zone.

Source Data: Hydro data with stream classifications provided and maintained by OPO.

In each of these stream class zones, the baseline model follows requirements set forth in the CA FPRs for post-harvest stocking and retention as shows in the table below.

**Table 25. Summary of Baseline Model Harvest Constraints in CA FPR WLPZs**

| Steam Class/Zone* | Post-Harvest Stocking (% Canopy Cover) | Post-Harvest Stocking Standards, TPA                                                                                         | Post-Harvest Snag/Dead Tree Retention |
|-------------------|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| <b>Class I</b>    |                                        |                                                                                                                              |                                       |
| Inner             | 80                                     | 13 largest (live or dead / at least 2 live conifers per acre $\geq 16"$ DBH)                                                 | Retain All Snags                      |
| Outer             | 50                                     | None                                                                                                                         | Retain All Snags                      |
| <b>Class II</b>   |                                        |                                                                                                                              |                                       |
| Inner             | 50                                     | Two $\geq 16"$ DBH conifers per acre AND residual overstory must be comprised on at least 25% of existing overstory conifers | Retain All Snags                      |
| <b>Class III</b>  |                                        |                                                                                                                              |                                       |
| Inner             | None                                   | Retain 50 sq.ft. BA/Acre                                                                                                     | Retain All Snags                      |

\*Core zones in all stream classes are unavailable for harvesting in the baseline model.

During the jurisdiction period of the AHCP, harvesting restrictions protecting the WLPZ strata are assumed to supersede CA FPR watercourse protection measures. Stream regulatory buffer zones outside of the WLPZ stratum, besides the core zones, which are always unavailable, are available for regular harvest activity. After 2069, however, all the FPR watercourse protection rules described above apply. At that time, regulatory buffer zones as

described above are also available for harvest, compliant with the constraints above within the WLPZ strata. Areas of the WLPZ that fall outside these buffers are considered available for normal upland harvest activities as well after 2069 (clearcut and commercial thin).

### FPA Northern Spotted Owl Requirements

The project area is within the Northern Spotted Owl (NSO) Evaluation Area as defined in the California Forest Practice Rules (14 CCR 895.1). The California Forest Practice Rules provide several options for a project proponent to use to evaluate whether or not a proposed activity would result in the “take” of a NSO (14 CCR 919.9 (a-g).

The baseline model harvest constraints follow guidance provided under CA FPRs NSO Option E. Option E is applied where the proposed harvesting follows specific guidelines acceptable to the United States Fish and Wildlife Service (USFW). The project area falls within the coast redwood ecotype of the Coast District. Some of the easternmost areas are in the transition area from coastal redwood habitat types to inland mixed conifer types, however, based on the geographic location, forest types, climate, prey base and owl densities, we consider the entire project area within the range of the coast redwood ecotype for evaluation purposes of the NSO. Guidance in harvesting follows the U.S. Fish and Wildlife (USFW) document *Northern Spotted Owl Take Avoidance Analysis and Guidance For California Coast Forest District “Attachment A”*, dated March 15, 2011, with retention standards summarized below.

NSO activity centers have been identified by Green Diamond across their California Timberlands. These activity centers are point features in GIS and following CA FPR guidance, each activity center has been buffered with a 0.7 mile circular buffer (985 acres) and intersected with the project area. These NSO management zones have been spatially defined within the project area to ensure that the baseline model adheres to the NSO nesting, roosting, and foraging habitat guidelines in the CA FPRs. NSO habitat conditions are tracked in FVS growth modeling so that the baseline model harvest prescriptions create and and/or maintain high quality NSO habitat in these management zones for the duration of the baseline model projection. Table 26 shows the habitat requirements for NSO used in the baseline model, which are derived from the USFWS document *Northern Spotted Owl Take Avoidance Analysis and Guidance For California Coast Forest District “Attachment A”*, dated March 15, 2011 and consistent with the habitat requirements in the FHCP.

**Table 26: NSO High Quality Habitat**

| <b>Foraging Habitat</b>                  | <b>Nesting/Roosting Habitat</b>          |
|------------------------------------------|------------------------------------------|
| 40% canopy cover of trees $\geq$ 11" DBH | 60% canopy cover of trees $\geq$ 11" DBH |
| BA $\geq$ 75 of trees $\geq$ 11" DBH     | BA $\geq$ 100 of trees $\geq$ 11" DBH    |
| Trees may be conifer or hardwood         | Trees may be conifer or hardwood         |

### FPA Special Treatment Areas

Other considerations for baseline modeling constraints specific to the project area under the CA FPRs are special treatment areas include areas within 200 feet of the Watercourse Transition Line of federal, or state designated wild and scenic rivers (Klamath River) and the areas within 200 feet of national, state, regional, county or municipal park boundaries (Redwood National Park and California Redwoods State Park).

The water transition line on the Klamath River was established by using a 300-foot buffer (each side) from the GIS centerline. From the water transition line, a 200-foot buffer (each side) was established which was then intersected with the project area. Any project area within the 200-foot buffer was designated as a no harvest area in the baseline model.

The OPO provided their management buffer of the Redwood National Park and California Redwoods State Park. Any project area within that buffer was designated as a no harvest area in the baseline model.

### FPA Other T&E or Sensitive Species

For other threatened, endangered, or sensitive species that have explicit requirements under the CA FPRs, the baseline model assumes that if any of these species are encountered during harvest activities, the following standards will be met.

**Table 27: Other T&E or Sensitive Species addressed in the CA FPRs**

|                                  | Buffer Size                          | Retention                                                                                                                                                                                                                                               |
|----------------------------------|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bald Eagle                       | Min 10 Ac<br>14 CCR 919.3(b)(1)      | No clearcutting. Selection, commercial thinning, sanitation-salvage, and the shelterwood regeneration method allowed. Retain Nest, Screen, Perch and Replacement trees. 14 CCR 919.3(c)(1)                                                              |
| Golden Eagle                     | Min 8 Ac<br>14 CCR 919.3(b)(2)       | No clearcutting. Retain Nest, Screen, Perch and Replacement trees. 14 CCR 919.3(c)(2)                                                                                                                                                                   |
| Great Blue Heron/<br>Great Egret | 300 ft. radius<br>14 CCR 919.3(b)(3) | Retain all nest trees<br>14 CCR 919.3(c)(3)                                                                                                                                                                                                             |
| Northern Goshawk                 | Min 5 Ac<br>14 CCR 919.3(b)(4)       | No clearcutting. Selection, commercial thinning, sanitation-salvage, and the shelterwood regeneration method allowed. Retain Nest, Screen, Perch and Replacement trees. 14 CCR 919.3(c)(4)                                                              |
| Osprey                           | Min 5 Ac<br>14 CCR 919.3(b)(5)       | Retain Nest, Screen, Perch and Replacement trees. 14 CCR 919.3(c)(5)                                                                                                                                                                                    |
| Peregrine Falcon                 | Min 10 Ac<br>14 CCR 919.3(b)(1)      | Where timber provides part of the immediate nesting habitat, the cutting prescriptions shall protect the nesting habitat. 14 CCR 919.3(c)(6)                                                                                                            |
| Marbled Murrelet                 |                                      | Where an active murrelet site is on or adjacent to a harvest area, or where there is evidence of a potential Impact to a murrelet, consultation with California Department of Fish and Wildlife is required to determine take or no take. 14 CCR 919.11 |

### FPA Option A Requirements

The FPR Option (a) rule (CCR 913.11 (a)) requires the landowner to demonstrate achievement of MSP by satisfying the following five requirements, paraphrased below from the California Forest Practice Rules:

- Producing the yield of timber products ... while accounting for limits on productivity due to constraints imposed from consideration of other forest values, including but not limited to, recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment and aesthetic enjoyment;
- Balancing growth and harvest over time;
- Realizing growth potential as measured by adequate site occupancy adequate site occupancy by species to be managed by the landowner;
- Maintaining good stand vigor;
- Making provisions for adequate regeneration.

The “Option A” rule also stipulates specifically that “projected inventory resulting from harvesting over time shall be capable of sustaining the average annual yield achieved during the last decade of the planning horizon. Under the Option A approach, if documentation is on file with the state which demonstrates these principles, the statutory minimum rotation ages may be shortened. Green Diamond manages its California timberlands for Long

Term Sustained Yield under a Maximum Sustained Production (MSP) plan prepared and approved in accordance with the Option A rule.

In the baseline model, in addition to rehabilitating most of the upland areas from hardwood into long-term conifer production in accordance with the stocking standards established in the FPR's, the long-term sustainability requirements of the Option A approach are met by constraining the last 10 years of the planning model to produce average annual harvest volumes at or above the average harvest levels for the entirety of the 100-year planning horizon, which is the same length as Green Diamond's approved Option A plan. A 45-year minimum rotation age is also used in accordance with Green Diamond's approved plan.

### **Green Diamond High Conservation Value Forests (HCVFs)**

Green Diamond has conducted a High Conservation Value Forest (HCVF) area assessment and identified nine HCVF categories. The HCVF assessment incorporated elements of conservation planning projects that have been undertaken in the past two decades and site-specific information developed as part of the THP process. Specific areas have been identified and managed to protect and enhance their ecological values as part of the FHCP, the AHCP, the THP process and other conservation efforts. These areas include Conservation Easement (CE) areas, stands of old-growth forest/marbled murrelet habitat, Riparian Management Zones (RMZs), NSO nest sites and cultural archaeological sites. The HCVF assessment built on those identified conservation areas and identified grasslands, true oak stands, naturally occurring tan oak stands, and an area of unique soils and vegetation with low road density along Rattlesnake Ridge.

HCVFs within the Project Area include RMZs, NSO Core Areas, true oak stands, and mature hardwood (tanoak) stands.

### **Baseline Modeling Consideration:**

Baseline model considerations for RMZs and NSO Core Areas are provided for under the FHCP, AHCP, and CA FPRs.

True oak stands and mature hardwood (tanoak) stands are considered no harvest areas in the baseline model and are spatially defined in GIS.

## Operational Constraints

Outside of the legal considerations listed above, there are few operational constraints affecting timber harvesting on the property. The terrain has a well-established road system throughout, effectively making all forested area not identified already as reserves harvestable with ground-based or cable logging equipment. The primary operational considerations which affect harvesting on the project are related to sustainability, labor availability, and market saturation of chip logs from the high volume of hardwoods on the project.

**Baseline Model Considerations:** in addition to the sustainability considerations described above under the Option A approach, an upper limit of 80 MMBF harvested per year was imposed in the baseline model to ensure long-term sustainability and a reasonable upper limit of log sale activity that could be supported by local buyers and mills.

## Baseline Silviculture

### Even-age Harvest Regimes

Even-age harvest regimes consisted of an initial clearcut usually within the first 25 years of the planning horizon (during the FHCP and AHCP), followed by a commercial thinning between 30 – 40 years if minimum basal area targets were met, then a final harvest between ages 45 and 50. Clearcuts occurring during the first 51 years of the planning horizon (through 2069) were subject to the FHCP live tree requirements for large conifer and hardwood described previously, while clearcuts scheduled after 2069 were allowed to remove all live trees. Non-merchantable snags were assumed to remain in all cases per CA FPR requirements.

A handful of clearcut harvest regimes were modeled with delays in initial harvest to give the Woodstock planning model some flexibility in optimally allocating acres over time. These delayed prescriptions occurred throughout all decades of the planning model.

Even-age harvest regimes apply to all non-WLPZ upland stands as well as a handful of areas within the WLPZ strata as described previously. In the Klamath and Korbelt strata, California stream buffer areas outside of the core zones are eligible for this prescription type prior to 2070. Following 2069, limited clearcutting is allowed in Class III stream buffers provided overall canopy and basal area targets are met. No clearcutting is allowed in any Class I or Class II buffer zones anywhere in the project area after 2069.

Parameters used for even-age harvest regimes are shown below in Table 28.

**Table 28. Even-age harvest regime parameters.**

| Site Class | Commercial Thin Age | Rotation Age | Clearcut Leave Tree Requirements                                                                     |                            | Clearcut Re-planting density       |                                    | Commercial Thin                                      |                                                          |                        |
|------------|---------------------|--------------|------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------|------------------------------------|------------------------------------------------------|----------------------------------------------------------|------------------------|
|            |                     |              | 2018-2069                                                                                            | 2070 -                     | 2018-2069                          | 2070 -                             | Entry Threshold                                      | Thin Action                                              | Minimum Harvest Volume |
| II-III     | 30 - 40             | 45 - 50      | 10% of BA composed of conifer $\geq 30"$ DBH and hardwood $\geq 18"$ DBH; all non-merchantable snags | All non-merchantable snags | 300 TPA<br>(Douglas-fir + redwood) | 360 TPA<br>(Douglas-fir + redwood) | $\geq 100$ sq. ft. BA/acre in trees $\geq 14.0"$ DBH | Thin from below to 100 sq. ft. BA/Acre (all DBH classes) | 7,000 BF/acre          |
| IV         |                     |              |                                                                                                      |                            | 200 TPA<br>(Douglas-fir + redwood) | 200 TPA<br>(Douglas-fir + redwood) | $\geq 75$ sq. ft. BA/acre in trees $\geq 14.0"$ DBH  | Thin from below to 75 sq. ft. BA/Acre                    |                        |
| V          |                     |              |                                                                                                      |                            | 200 TPA<br>(Douglas-fir + redwood) | 200 TPA<br>(Douglas-fir + redwood) | $\geq 50$ sq. ft. BA/acre in trees $\geq 14.0"$ DBH  | Thin from below to 50 sq. ft. BA/Acre                    |                        |

### Commercial Thinning Regimes

All Klamath and Korbels stands were also eligible for commercial thin - only prescriptions as well. The commercial thin parameters listed above were used to govern commercial thinning actions in FVS throughout the prescription. Commercial thin entries occur at 10-15 year intervals within stands throughout the model horizon. QMD is generally maintained, or slightly increased over time through the thin-from-below approach. Periodic natural regeneration is simulated with the assumptions shown previously in Table 5, using data derived from the project inventory.

### Riparian Selection Regimes

Two riparian selection harvest regimes, WLPZ50 and WLPZ80, were modeled for CA FPR regulatory WLPZ buffers falling within the WLPZ stratum. These areas become available for harvest after 2069 subject to the silvicultural restriction described previously in Table 25.

The WLPZ50 prescription is available for Class I outer buffer zones and Class III inner buffer zones in the WLPZ strata. After 2069, these stands are thinned to 50% canopy closure provided the basal area of the stand is composed of at least 25% conifer by basal area. If less than 25% of the stand is composed of conifer by basal area, the hardwood component is thinned to 50% canopy closure. This process is designed to maintain or increase the percentage of conifers at levels greater or equal to 25% basal area. The minimum harvest volume required for entry in these prescriptions is 7,000 board feet per acre.

The WLPZ80 prescription is available for Class I and II inner buffer zones in the WLPZ strata. After 2069, these stands may be thinned from below to 80% canopy closure provided that at least 13 conifer trees greater than 16" DBH remain in the residual stand and at least 25% of the stand is composed of conifer by basal area. This prescription removes very little wood overall from these zones and is intended as "bonus" wood in conjunction with other riparian harvesting in adjacent outer buffer zones and upland areas.

In conjunction with CA FPR regulatory WLPZ buffers in the Klamath and Korbels strata that may have been harvested prior to 2070 under the AHCP, canopy cover across all Class I and Class II inner zones must average at least 80% from 2070 to the end of the 100-year baseline while Class I outer zones and class II inner zones must average greater than 50% canopy cover. No clearcutting is allowed in any Class I or Class II zone after 2069.

### Grow-only Regimes

Forest Reserves and core buffer areas were modeled as grow-only regimes for reasons previously described. No forest management activity of any sort was modeled in these areas.

## Baseline Planning Model

In compliance with the requirements of Appendix B(a) of the FOP, FVS and the carbon modules were used to create yield tables representing a variety of 100-year silvicultural regimes for each of the project strata. Over 300 regimes consisting of 100-year FVS simulations were run, and their FVS Outputs processed through the modules to create a series of yield curves based on the timing options specified by the FVS Keywords used to simulate each regime. These yield curves were then loaded into a proprietary Excel workbook in which the yield curves are interpolated to provide annual values of key carbon metrics. The final, annualized set of yield curves are next imported into Remsoft's Woodstock planning model to evaluate and allocate acres to each FVS yield table to help determine a final baseline harvest schedule that complies with the Minimum Baseline Level, legal constraints, and financial considerations. The final, optimized set of yield curves is then used to calculate 100-year averages of onsite carbon pool inventories, harvested carbon outputs, and cord volumes harvested on a per acre basis. Results of the Baseline Planning Model may be found in the CAR1339 Baseline Worksheet.

## ROC/ARBOC Monitoring Calculation Worksheet

After completion of the baseline modeling, the results are summarized in a MS Excel worksheet. The results are then inserted to the ROC/ARBOC Monitoring Calculation Worksheet and the Harvested Wood Products Calculation Worksheet tool for the baseline and project scenarios.

## Monitoring Plan (Inventory Updates and Data Management)

This portion of the Inventory Methodology describes the Project's annual monitoring plan. The primary purpose of the project's annual monitoring plan is to ensure up-to-date estimates of project carbon stocks and provide assurance that GHG reductions or removals achieved by a project have not been reversed.

### Components of the Monitoring Plan

The major components of the property's monitoring plan are:

1. Continuous forest inventory and carbon stock updates: This component focuses on updating the forest carbon inventory and includes conducting forest carbon inventories by following the *Sampling Methodology*. It also encompasses the process of recording any timber harvests or other activities that affect the overall carbon stocks. The output of this process is used to complete the Annual Forest Monitoring Report, as well as the ROC/ARBOC Monitoring Calculation Worksheet and the Harvested Wood Product Calculation Worksheet.
2. Forest carbon project verification by an ARB accredited verifier. Each year, the project is required to be verified by an accredited third-party auditor. This audit will serve to provide assurance to the ARB that the project is operating in compliance with the Forest Offset Protocol.

### Forest Health

As per the requirements of the FOP Appendix A(a) this subsection of the monitoring plan identifies any known and potential insects or diseases that may affect the health of the project's inventory, specifically above-ground standing live and dead trees. Known insects include Douglas-fir Beetle, Fir Engraver, Mountain Pine Beetle, Western Pine Beetle, and Redwood Bark Beetle. Known diseases include Fusarium Diseases, Port Orford Cedar Root Disease, and Sudden Oak Death.

## Updating Forest Carbon Stocks

There are three major inputs for updating forest carbon stocks: activity data, emissions factors, and the confidence deduction.

### Activity Data

Activity data is defined as the aerial extent of a land-use category. It is the “area data” in units of acres. In this case, land-use will be stratified across the property in order to classify forest versus non-forest, and within forests, stratification is based on primary management operating zones and WLPZs. These strata are described in the earlier Stratification Rules section, and all changes to the activity data should follow these stratification criteria.

Activity data can change for several reasons including growth, timber harvests, natural disturbances and succession or selling property within the project area; these changes in activity data are collectively labeled as *events*. Events can affect the proportion of strata within the project area and/or the age class distribution; however, the total aerial extent of the project area cannot change. For this project, activity data will be monitored and reported over time using spatially explicit datasets, also known as a Geographic Information System or GIS. On a continuous basis throughout the year, changes in activity data will be mapped, attributed and recorded by professional foresters during timber harvest operations and timber cruises. Changes will be submitted to and edited by the forest owner’s GIS controller. Edits to the activity data will be compiled and delivered to the project developer at the end of each reporting period. The project developer will store and archive all activity data by year in the project’s geodatabase in the “stands” feature class, which will also serve as the activity data change log.

### Emissions Factors

Emissions factors are defined as the emissions/removals of greenhouse gases per unit area. In this case, metric tons of CO<sub>2</sub> equivalents (tCO<sub>2</sub>e) will be used to express emission factors as a result of changes in forest carbon stocks. Emission factors vary based on the category of activity data (i.e. strata) and are derived from forest inventory plots.

Forest inventory plots will be conducted according to the Sampling Methodology and processed by Finite Carbon using the data management and analytical systems outlined under Analytical Methods and Biomass Equations. The forest owner will use permanent and temporary inventory plots as needed, to annually update the project’s forest carbon stocks. Measuring the same plots through time will reduce sampling variability and provide reliable estimates of actual growth through time. New temporary and/or permanent plots will be used where previous plots or continual forest inventory (CFI) plots are not able to accurately represent a particular change in activity data. Inventory plots input to growth & yield modeling, as well as tracking harvest volumes, will be used to assess the changes in carbon stocks. No forest inventory plot data greater than 12-years old will be used.

### Events

Events are activities that occur within the project area that affect activity data or emission factors. Events will require spatial and tabular updates to the carbon database. A list of events including harvest volume summaries will be submitted by the Forest Owner to Finite Carbon at the end of each reporting period for the previous year and prepared for verification by completing a monitoring report.

#### 1. Just Growth

Just growth events are assumed to occur in all areas of the project where no other event is assumed to occur. In this event, the activity data and emissions factors are updated by projecting inventory data using FVS growth and yield software, or with new plot data, assuming that accretion and mortality are only a function of the stand’s structure and condition from the previous reporting period. Furthermore, growth also occurs in other areas where other events take place, e.g. a timber harvest. In this case, the activity data and emissions factors are updated in the same fashion as just growth events, but accretion and mortality are adjusted based on the other event’s

effects, e.g. timber harvesting will reduce the carbon stocking, but may increase growth rates while reducing mortality because crop trees are free to grow.

Annual growth increments are determined using the method described under Data and FVS Setting. The annual height and diameter growth increments specific to each tree record are added to those records at the end of each reporting period.

## 2. Land Sales

Land sales activity has a tremendous bearing on every carbon project. Should all or a portion of the area committed to the carbon project be sold while under the project's commitment terms, Finite Carbon will need to be notified as soon as possible. The forest owner will be required to provide digital mapping and possibly other documentation for the area affected by the sale. Please note that any Land Sales taking place on the Project Area will remain subject to the Forest Offset Protocol and Regulations, and therefore remain part of the Project. Should any portion of the Project Area be sold and wish to terminate the Project, the whole project will be considered terminated, as there is no provision which currently allows the Project Area to be divided into multiple projects. Once the Project Area for Improved Forest Management Projects has been verified, the Project Area cannot be changed for the duration of the Project's lifetime.

## 3. Natural Disturbances

Natural disturbance events can include wind storms, tornadoes, ice storms, floods, land-slides, earthquakes, insect or disease infestations, or other impacts of weather or nature on the forest carbon stocks. Finite Carbon must be notified immediately following an event of this type. The forest owner will be required to supply mapping of the damaged area, and in some cases, a re-inventory of the original sample locations affected by the event performed to the specifications attached.

## 4. Harvests and Land Use Conversions

IFM projects typically encounter planned timber harvests, thinning, clearing for roadways, log yards, decks, or other uses on a regular basis. When these events occur, the forest owner is required to provide Finite Carbon with a digital (GPS or GIS) polygon file of the affected area. If harvest activities affect permanent plots, a complete re-inventory of those samples affected by the action may be required. All points re-inventoried will conform to the original specifications and shall be freshly flagged and painted for relocation. Finite Carbon shall also be informed if the activity produces or is expected to produce a forest type conversion. If the conversion is to non-forest use, such as new road construction, these areas will be mapped and the correct adjustment to the project acreage and total carbon stocks will be made. All new inventory plot data should be submitted electronically in Excel or Access formats. All areas of timber harvest will be associated with a harvest volume summary.

Harvest volume summaries will be submitted to the project developer by species group (Hardwood/Softwood) and product (Sawtimber/Pulpwood), at a minimum. All harvest volume summaries must be verifiable from mill/contractor receipts (pay-as-cut sales) and/or prospectus cruises (lump-sum sales).

### Annual Inventory Updates

Carbon accounting within the project area will require accurate harvest shapefiles and volumes. The harvest polygons will be intersected with the project area shapefile to prorate the harvest volumes to the project area. This will allow for the quantification of carbon in harvested wood products from timber cut within the project area.

Post-harvest updates to project spatial data and the corresponding carbon stocks in those areas will be handled in one of two ways depending on the verification needs of the project for the current reporting period:

- For reporting periods subject to less-intensive verifications or deferring verification, updates to the project area stratification will be based on modeling. Treatments effects will be simulated based on the prescription provided by the forest owner (and following the requirements for using models to forecast carbon stocks established in Appendix B of the FOP). The end of reporting period carbon stocks in these areas will be calculated following the methodology outlined in Part VII.B. below. The resulting tCO<sub>2</sub>e per acre will be allocated to the approximate acreage treated based on the harvest polygons to allow for accurate carbon quantification across the project area for each reporting period.
- For reporting periods subject to full site visit verifications, the stratification across the project area will be updated to reflect the changes that have occurred during the previous reported-only years and all or some of the inventory plots will be remeasured.

#### **Additional OPO Monitoring Activities**

There are several procedures the OPO currently implements to ensure that all relevant events are monitored, documented, and reported. First, the property is routinely monitored by several staff members and a hired consulting forester. These team members visually inspect the forest conditions and can report unplanned activities they were not aware of such as significant natural disturbances. For planned events, the OPO maintains a lands department consisting of staff dedicated to project coordination, deeds and records, and mapping/engineering. The lands department ensures that planned activities with respect to impact of carbon stocks are reported in a manner that conforms to the project's inventory methodology.

On-going monitoring by the forest owner and its forest managers will ensure Unintentional Reversals will be reported to ARB and where necessary, an inventory of affected portions of the forest will be inventoried to account for unintentional reversals that create a need for ARBOC replacement from the Forest Buffer Account. Inventory design to account for losses from unintentional losses will depend on the extent and intensity of the reversal should they occur.

#### **Confidence Deduction**

Offset Project Operators are required each year to apply a confidence deduction to the inventory of actual onsite carbon stocks based on field sampling (sample error based on the carbon in all carbon pools included in the forest carbon inventory calculated at the 90% confidence level). The confidence deduction must be updated each time the offset project is subject to a full, site visit verification, but must remain unchanged between verifications. If increased sampling over time results in a lower confidence deduction at the time of verification, the lower deduction must be applied to inventory estimates in the most recent reporting period subject to verification at that time. ARB or registry offset credits may be issued in the most recent reporting period for any verified increase in quantified GHG reductions and GHG removal enhancements associated with the new (lower) confidence deduction.

Conversely, if a loss of qualified sampling plots results in a higher confidence deduction, this higher deduction is applied to the inventory estimates in the most recent reporting period subject to verification at that time. Any resulting decrease in quantified GHG reductions and GHG removal enhancements from prior years as a result of the increased confidence deduction will be treated as an intentional reversal and must be compensated pursuant to the Regulation.

To determine the appropriate confidence deduction (also see ACR416 OPDR Calculations):

1. Compute the standard error of the inventory estimate by strata (based on the carbon in all carbon pools included in the forest carbon inventory).
2. Multiply the standard error by 1.645.

3. Divide the result in (2) by the total inventory estimate (strata mean tCO<sub>2</sub>e) and multiply by 100. This establishes the sampling error (expressed as a percentage of the mean inventory estimate from field sampling) for a 90-percent confidence interval.
4. Consult Table A.4 from the FOP to identify the percent confident deduction that must be applied to the inventory estimate for the purpose of calculating GHG reductions and removals.

**Table A.4.** Forest carbon inventory confidence deductions based on level of confidence in the estimate derived from field sampling.

| Sampling Error (% of Inventory Estimate) | Confidence Deduction                                                 |
|------------------------------------------|----------------------------------------------------------------------|
| 0 to 5%                                  | 0%                                                                   |
| 5.1 to 19.9%                             | (Sampling Error – 5.0%) to the nearest 1/10 <sup>th</sup> percentage |
| 20% or greater                           | 100%                                                                 |

## Monitoring Quality Control

Quality Control for this project is defined as a series of activities and documented procedures that serve to maintain an acceptable level of data quality for monitoring forest carbon stocks and demonstrating compliance with the Forest Offset Protocol. Quality control success will be measured by passing sequential sampling review by the verification body during the site visit.

### *Organization and Responsible Individuals*

Individuals responsible for maintaining project operations have been defined in the Listing Form and listed under the forest owner's account information in both the Offset Project Registry account and the CITSS account. Any changes, including new contact information, will be updated to the account information immediately.

### *Document Control*

Forest Owner and Finite Carbon will be responsible for maintaining critical documents and files that support forest carbon data collection and processing. All documents will be stored on company computers and back-up servers, as well as cloud-based data sharing folders, for a minimum of 15 years following the issuance of ARB Offset Credits related to each OPDR. The most critical documents and files necessary to be maintained include:

1. Offset Project Data Reports;
2. Project Inventory Methodology, including all requirements from the FOP Appendix A(b) (Appendix A);
3. Project geodatabase (GIS file geodatabase, Attachment I);
4. ROC/ARBOC Monitoring Calculation Worksheet; and
5. Harvest Wood Product Calculation Worksheets;

A change log specific to this monitoring plan to show updates made to raw inventory field data, inventory specifications, and data management and analytical systems will be recorded in the table below. When an update is made to the raw inventory field data or to the inventory methodology and calculations, it should be recorded in the Inventory File and Data Change Log. Modifications to inventory methodologies must be approved in advance by a third-party verification body and by ARB.

All edits and revisions to documents after project registration will be clearly marked and identified by placing a revision date or version number at the beginning of the document or within the name of the file. Outdated

versions of documents will be archived. Other forms and documents required by ARB will be maintained and stored in the forest owner's account on the OPR software.

#### *Central Data Repository*

The ESRI personal geodatabase format will be used to store spatial and tabular project data. Built-in features of the geodatabase structure, such as domains (i.e. field value validation) and relationships, will help control data quality. Edits and updates will occur at the beginning of each reporting period to account for activities in the previous year unless an event such as a reversal occurs, in which case updates will take place and be reported to ARB in the required time frame. All results will be summarized in the Offset Project Data Reports.

## Change Log

| A unique number associated with change log record | Date change was made | This indicates the file that was updated | A full description of the update made |
|---------------------------------------------------|----------------------|------------------------------------------|---------------------------------------|
| Change_ID                                         | Change_Date          | Change_Reference                         | Change_Description                    |

## Field Inventory References and Tables

### The “Walk-Through” Method For Edge Affected Plots

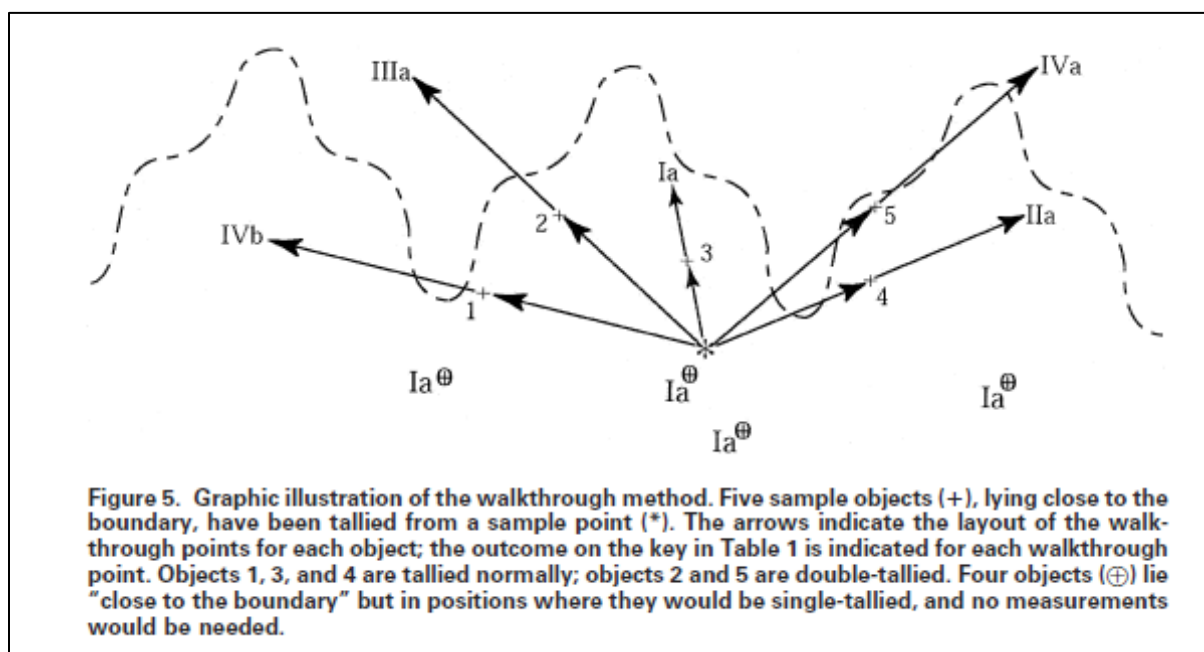
Implementation of the walk-through procedure as described above in the Inventory Specification Section of this document<sup>9</sup>:

- Inventory plots that fall near a defined hard edge shall be assessed to determine if there are any eligible trees along the plot radius edge that would qualify for the walk-through procedure.
- On every plot, when a hard edge is encountered, this method should be followed for any “in” tree along the edge:
  - o Measure the distance from the sample point (plot center) to the tree. Then, duplicate that distance in a straight line through the other side of the tree. If the doubled distance intersects the hard edge, the record that tree twice.
  - o Record as two identical measured trees with 2 separate tree numbers.
- Every hard edge is considered an absolute boundary of the sample frame (like a property boundary line). Trees within the plot radius that fall across the hard edge (if within the sampling frame) are NOT eligible and thus, not tallied.
- The plot radius itself does not have to be intersected by the hard edge. The key measurements of the walk-through procedure are defining where the hard edge is located and then the distance from plot center to the tree of interest and extending that distance through the tree in a straight line to determine whether or not the walk-through distance intersects the hard edge.
- Where the defined hard edge is a mapped road, the road edge closest to the plot center (near edge of the road) is considered the hard edge and the walk-through methodology is implemented exactly as described above.

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<sup>9</sup>The walk-through methodology on edge plots during subsequent inventories in future reporting periods will be implemented in accordance with the verification report and as detailed in Issues Log #19-16. Adjustments to the methodology will be reflected in a new inventory specification when the subsequent inventories take place.

Examples of walk-through vs. non walk-through trees near hard edges:



Source: Ducey et al. 2004.

Decision key for implementation of the walk-through method, which reference to the figure above:

**Table 1.** A decision key for field implementation of the walk-through method. The key is entered whenever a tallied object appears close to the boundary.

|       |                                                                                                                                                                                                                                                    |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I.    | Is it possible that the tallied object is closer to the boundary, than to the sample point?                                                                                                                                                        |
| Ia.   | NO—No action needed. Tally the object normally.                                                                                                                                                                                                    |
| Ib.   | YES—Proceed to II.                                                                                                                                                                                                                                 |
| II.   | Measure the distance from the sample point to the object—call this distance <i>x</i> . Now measure the distance from the object to the boundary, continuing on the same bearing. Call this distance <i>y</i> . Is <i>y</i> less than <i>x</i> ?    |
| IIa.  | NO—No action needed. Tally the object normally.                                                                                                                                                                                                    |
| IIb.  | YES—Proceed to III.                                                                                                                                                                                                                                |
| III.  | Does the boundary curve back across the walkthrough line?                                                                                                                                                                                          |
| IIIa. | NO—Walkthrough point must be outside the tract. Double-tally the object.                                                                                                                                                                           |
| IIIb. | YES—Proceed to IV.                                                                                                                                                                                                                                 |
| IV.   | Move to the walkthrough point, so that the distance to the object equals the previously measured distance <i>x</i> along the same bearing, or to a point where that location can be clearly identified. Is the walkthrough point inside the tract? |
| IVa.  | NO—Double-tally the object.                                                                                                                                                                                                                        |
| IVb.  | YES—Tally the object normally.                                                                                                                                                                                                                     |

Source: Ducey et al. 2004.

## Percent Volume Allocation – Soundness Deduction Guide

This table serves as a guide; exact values in table below do not need to be used. Source: PNW FIA Field Instructions for the Annual Inventory of California, Oregon, and Washington (2018).

Use Table 8.6: as a guideline to estimate the missing portion of a live tree because of cull. It shows the percentage of volume in typical trees of varying number of logs and heights. Use either the tree height in logs (divide the length to a 4-inch top – diameter inside bark [DIB] – by 16) or the measured TOTAL LENGTH to estimate what percentage of volume is estimated in each 16-foot log. Multiply each percentage in that log section times the percentage of rotten or missing volume. Then sum the values to get the total percentage of the tree that is rotten or missing.

- Example: A 9-log tree (measured at 160 feet TOTAL LENGTH) has a missing section that is about 1/3 of both the second and third logs. Table 8.6: shows the second log has about 18 percent of the volume in the tree, and the third log has about 16 percent of the volume in the tree.
  - Calculate the percentage of cull in each log and sum to estimate the total percentage of cull for the tree (about 11 percent):
    - $(0.18 \times 0.33) + (0.16 \times 0.33) = 0.06 + 0.05 = 0.11$

**Table 8.6: Percentage of tree cubic foot volume distribution by 16-foot logs from tree total length or tree height in logs for a tree of average dimensions**

| Average Total Length | Tree Height in LOGS | Log1 | Log2 | Log3 | Log4 | Log5 | Log6 | Log7 | Log8 | Log9 | Log10 | Log11 | Log12 |
|----------------------|---------------------|------|------|------|------|------|------|------|------|------|-------|-------|-------|
| 28                   | 1                   | 100  |      |      |      |      |      |      |      |      |       |       |       |
| 48                   | 2                   | 70   | 30   |      |      |      |      |      |      |      |       |       |       |
| 64                   | 3                   | 54   | 32   | 14   |      |      |      |      |      |      |       |       |       |
| 80                   | 4                   | 43   | 30   | 19   | 8    |      |      |      |      |      |       |       |       |
| 96                   | 5                   | 36   | 27   | 20   | 12   | 5    |      |      |      |      |       |       |       |
| 111                  | 6                   | 31   | 24   | 20   | 14   | 8    | 3    |      |      |      |       |       |       |
| 127                  | 7                   | 28   | 22   | 18   | 14   | 10   | 6    | 2    |      |      |       |       |       |
| 143                  | 8                   | 25   | 20   | 17   | 14   | 11   | 8    | 4    | 1    |      |       |       |       |
| 158                  | 9                   | 24   | 18   | 16   | 13   | 11   | 8    | 6    | 3    | 1    |       |       |       |
| 176                  | 10                  | 22   | 17   | 15   | 13   | 11   | 9    | 7    | 4    | 1    | 1     |       |       |
| 194                  | 11                  | 20   | 15   | 14   | 12   | 11   | 9    | 7    | 5    | 4    | 2     | 1     |       |
| 212                  | 12                  | 20   | 14   | 13   | 12   | 11   | 9    | 8    | 6    | 4    | 2     | 1     | 0     |

## DBH Establishment Locations

### FOREST INVENTORY AND ANALYSIS NATIONAL CORE FIELD GUIDE

#### VOLUME I: FIELD DATA COLLECTION PROCEDURES FOR PHASE 2 PLOTS

Version 8.0



## 5.9.2 DIAMETER AT BREAST HEIGHT (DBH)

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

Special DBH situations:

1. **Forked tree:** In order to qualify as a fork, the stem in question must be at least 1/3 the diameter of the main stem and must branch out from the main stem at an angle of 45 degrees or less (figs. 23-26), AND must be judged to have, or have the potential to assume an obvious "tree like" form and function as opposed to an obvious "branch like" form and function. If there is any doubt as to the form and function of a potential fork, call it a fork instead of a branch. Figure 27 provides examples where the form and function are considerations. Forks originate at the point on the bole where the piths intersect. Forked trees are handled differently depending on whether the fork originates below 1.0 foot, between 1.0 and 4.5 feet, or above 4.5 feet.

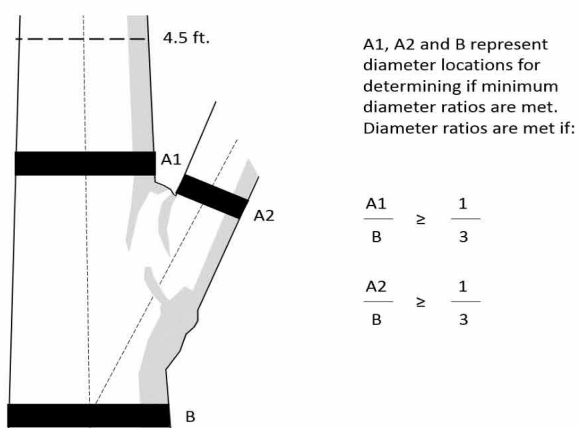
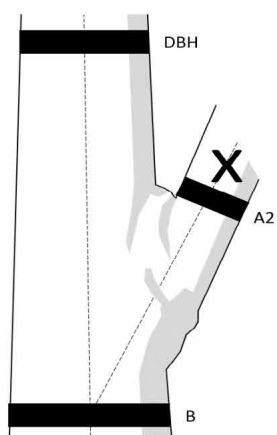


**Figure 23. Determining diameter ratio of forks.** When determining if a fork meets the 1/3 diameter requirement for qualifying as a fork, the diameter of the potential fork taken at locations A1 and A2 must be 1/3 of the diameter at location B.

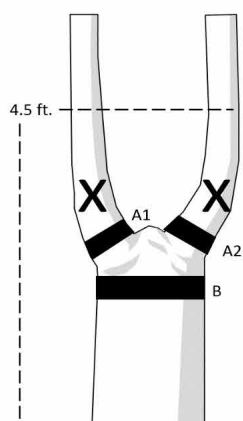
National Core Field Guide, Version 8.0, October, 2018  
Section 5.0. Tree and Sapling Data



If one of the potential forks is less than 1/3 the diameter at B, then no fork exists and the diameter would be placed at 4.5 feet from the ground on the qualifying stem.

$$\frac{A2}{B} < \frac{1}{3}$$

**Figure 24. A single non-qualifying fork.** If one of the forks does not meet the minimum ratio, then no fork exists and the diameter is placed at the normal location on the dominant stem.



If neither stem above a fork meets the minimum 1/3 diameter requirement, neither stem is tallied.

$$\frac{A1}{B} < \frac{1}{3}$$

$$\frac{A2}{B} < \frac{1}{3}$$

**Figure 25. Two non-qualifying stems.** If neither stem meets the 1/3 diameter requirement, neither is tallied. This is often associated with broken tops and is consistent with the point at which a stem is considered recovered from a break.

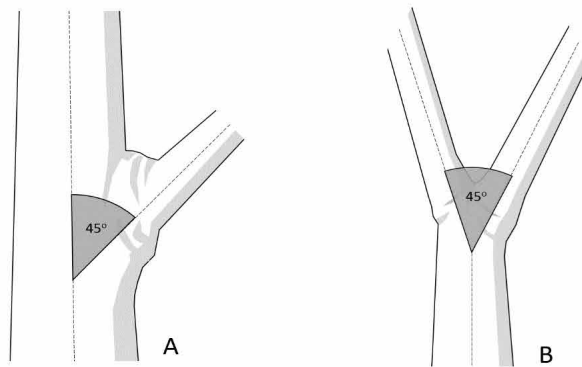


**Figure 26. Forking angle.** In order to qualify as a fork, the piths must diverge at an angle not exceeding 45 degrees from the main stem (A). In cases where there is no obvious main stem (B), consider the angle of pith separation between the two stems.

National Core Field Guide, Version 8.0, October, 2018  
Section 5.0. Tree and Sapling Data

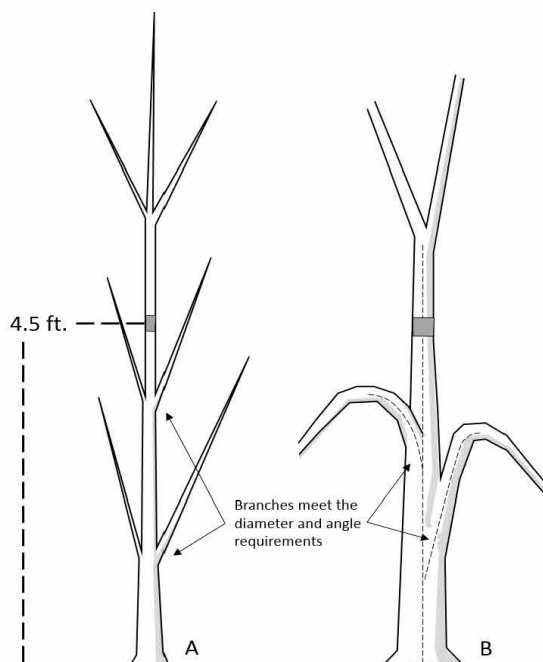


**Figure 27. Forks that have branch-like form and function, leading to the tally of a single tree instead of multiple trees.** In example A, although the potential fork is currently 1/3 the diameter of the main bole and is within 45 degrees of the main bole at the point of attachment, it appears to be serving as a branch as opposed to an additional independent tree. In addition, as the main bole continues to grow, the "branch" may reach the point where it is no longer 1/3 the main bole, dropping out of the inventory based on definition. Such potential forks would be ignored and the main bole would be tallied as a single tree with diameter measured at 4.5 feet. The tree is evaluated at each future visit and tallied following standard remeasurement procedures. In example B, although the potential fork is 1/3 the diameter of the main bole and is within 45 degrees of the main bole at point of attachment, it deviates drastically beyond 45 degrees about 1 inch from the main bole, taking on the form and function of a branch. This should be tallied as a single tree with diameter measured at 4.5 feet.

- **Trees forked below 1.0 foot.** Trees forked below 1.0 foot are treated as distinctly separate trees (fig. 28). Distances and azimuths are measured individually to the center of each stem where it splits from the stump (fig. 34 A-C). DBH is measured for each stem at 4.5 feet above the ground. When stems originate from pith intersections below 1 foot, it is possible for some stems to be within the limiting distance of the microplot or subplot, and others to be beyond the limiting distance. If stems originating from forks that occur below 1.0 foot fork

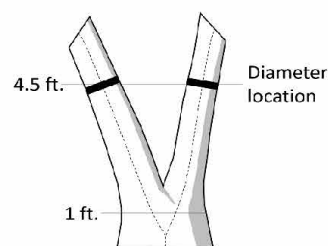


**Figure 28. Forked below 1.0 foot.**

again between 1.0 and 4.5 feet (fig. 34-E), the rules in the next paragraph apply.

- **Trees forked between 1.0 foot and 4.5 feet.** Trees forked between 1.0 foot and 4.5 feet are also counted as separate trees (fig. 29), but only one distance and azimuth (to the central stump) is recorded for each stem (fig. 34 D-F). Although a single azimuth and distance applies to all, multiple stems should be recorded as they occur in clockwise order (from front to back when one stem is directly in front of another). The DBH of each fork is measured at a point 3.5 feet above the pith intersection. When forks originate from pith intersections between 1.0 and 4.5 feet, the limiting distance is the same for all forks--they are either all on, or all off the plot.

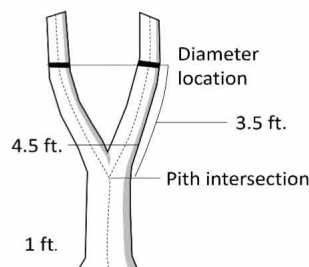


**Figure 29. Forked between 1.0 foot and 4.5 feet.**

#### **Measure Low Approach**

Crews may encounter trees of any species displaying growth forms with multiple forks that make applying traditional forking rules very difficult. In some instances these growth forms are species specific and in others they are the result of either the immediate growing conditions or the fact that the trees have been bred, pruned, or managed in a way that promotes multiple stems resulting in a specific crown shape.

In cases where such multiple forks all originate from approximately the same point on the main stem, follow the **Measure Low Approach**, where the diameter is taken at the highest, most repeatable location between the 1-foot stump and initial pith separation. This approach is applicable in instances where any of the following are present between the 1-foot stump and DBH (4.5 feet):

- (1) Multiple forks (fig. 30).
- (2) Prolific branching originating from approximately the same location that prevents accurate and repeatable diameter (fig. 31). This is a rare situation that should not be confused with normal branching patterns that allow for accurate diameter placement.
- (3) Any combination of multiple forks and prolific branching originating at approximately the same location.
- (4) The stems of a forked tree are grown together in such a fashion that an accurate DBH cannot be measured or estimated due to deformation resulting from the presence of the above mentioned criteria (fig. 32).

Figures 30, 31, and 32 illustrate a combination of forks and or branches all originating at the approximate same location will trigger a measure low approach.

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**Figure 30. Multiple forks originating from the same area.** In cases such as this the diameter is taken low and all stems are treated as one tree.



**Figure 31. Multiple forks and branches originating from the same area.** Similar to having multiple forks, when there are multiple forks and branches, the diameter is taken low and all stems are treated as one tree.

A tree can only fork once. Following are specific procedures to **secondary** forking:

Once a stem is tallied as a fork that originated from a pith intersection between 1.0 and 4.5 feet, do not recognize any additional forks (or potential forks) that may occur on that stem. When such secondary forks are encountered, measure/estimate the diameter of such stems at the most repeatable location below stem separation but above the first pith separation (fig. 34 F-I) while attempting to avoid measuring double piths (fig. 40) where possible (i.e., do not move the point of diameter the entire 3.5 feet above the first fork).

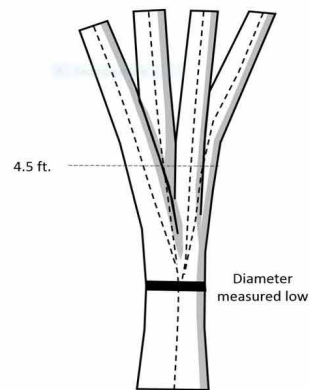


**Figure 32. Using pith separation to determine diameter locations.** In this example it is clear that all piths appear to separate from approximately the same location; this triggers the "Measure Low Approach". In cases where the piths do NOT originate within approximately the same location, normal forking rules are applied as demonstrated in figures 34 A-D and F-I.

- Trees forked at or above 4.5 feet. Trees forked at or above 4.5 feet count as one single tree (fig. 33). If a fork occurs at or immediately above 4.5 feet, measure diameter below the fork just beneath any swelling that would inflate DBH.

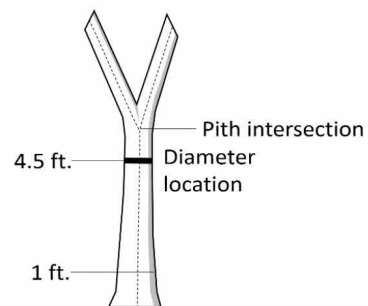


**Figure 33. One Tree.**

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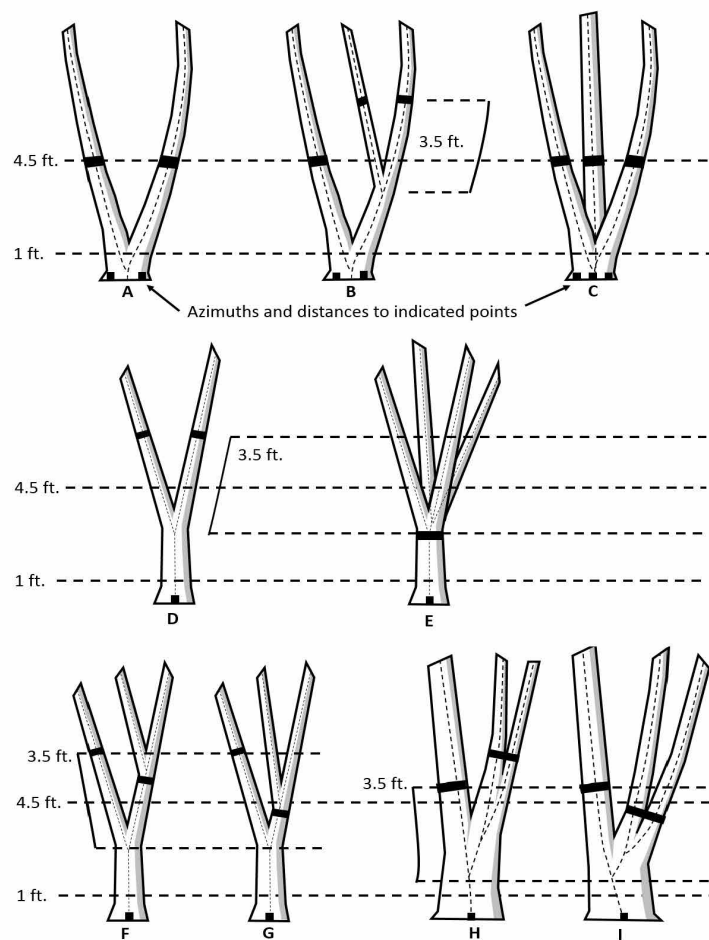


**Figure 34** Summary of where to measure diameter, distance and azimuth on trees that fork below 1.0 foot (A, B, C) and trees that fork above 1.0 foot (D, E, F, G, H, I). Figure E represents the "Measure Low Approach". Figures F and G represent secondary forks with abnormal diameters at stem separation. Figures H and I represent secondary forks with normal diameters at stem separation.

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

3. **Tree with butt-swell or bottleneck:** Measure these trees 1.5 feet above the end of the swell or bottleneck if the swell or bottleneck extends 3.0 feet or more above the ground (fig. 35).

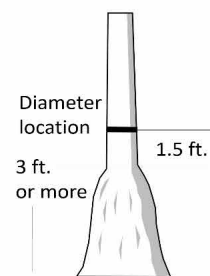


Figure 35. Bottleneck tree.

4. **Tree with irregularities at DBH:** On trees with swellings (fig. 36), bumps, depressions, and branches (fig. 37) at DBH, diameter will be measured immediately above the irregularity at the place it ceases to affect normal stem form.

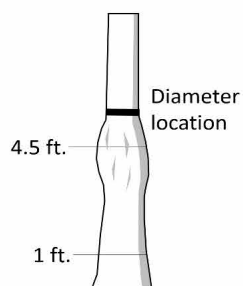


Figure 36. Tree with swelling.

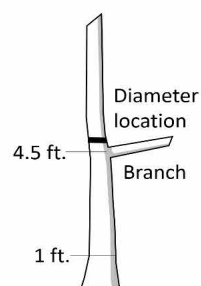


Figure 37. Tree with branch.

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5. **Tree on slope:** Measure diameter at 4.5 feet from the ground along the bole on the uphill side of the tree (fig. 38).

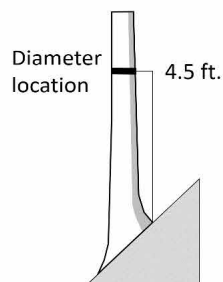


Figure 38. Tree on a slope.

6. **Leaning tree:** Measure diameter at 4.5 feet from the ground along the bole. The 4.5-foot distance is measured along the underside face of the bole (fig. 39).

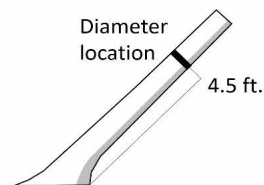


Figure 39. Leaning tree.

7. **Turpentine tree:** On trees with turpentine face extending above 4.5 feet, estimate the diameter at 10.0 feet above the ground and multiply by 1.1 to estimate DBH outside bark.

8. **Independent trees that grow together:** If two or more independent stems have grown together at or above the point of DBH, continue to treat them as separate trees. Estimate the diameter of each, set the "DIAMETER CHECK" code to 1, and explain the situation in the notes (fig. 40).

For #8, above, "double-nail" method as described above is the preferred measurement technique.

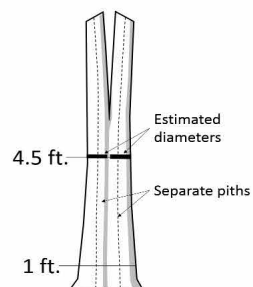


Figure 40. Independent trees grown together.

9. **Missing wood or bark:** Do not reconstruct the DBH of a tree that is missing wood or bark at the point of measurement. Record the diameter, to the nearest 0.1 inch, of the wood and bark that is still attached to the tree (fig. 41). If a tree has a localized abnormality (gouge, depression, etc.) at the point of DBH, apply the procedure described for trees with irregularities at DBH (fig. 36).

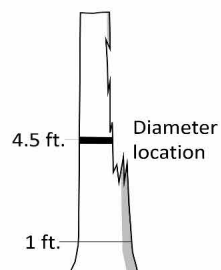


Figure 41. Tree with part of stem missing.

10. **Live windthrown tree:** Measure from the top of the root collar along the length to 4.5 feet (fig. 42).

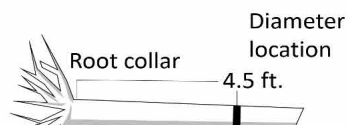


Figure 42. Tree on the ground.

11. **Down live tree with tree-form branches growing vertical from main bole:** When a down live tree, touching the ground, has vertical (less than 45 degrees from vertical) tree-like branches coming off the main bole, first determine whether or not the pith of the main bole (averaged along the first log of the tree) is above or below the duff layer.
- If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (fig. 43).

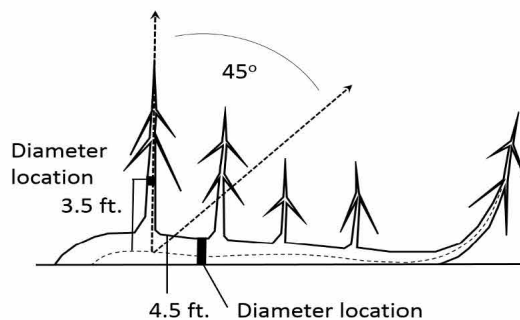


Figure 43. Down tree with pith above the duff.

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- If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 feet from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 feet above the pith intersection for both the main bole and the tree-like branch.
- If the intersection between the main down bole and the tree-like branch occurs beyond the 4.5 feet point from the stump along the main bole, treat that branch as part of the main down bole.
- If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH and length measurements from the ground, not necessarily from the top of the down bole (fig. 44). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

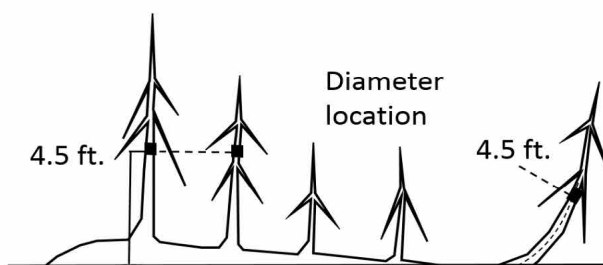


Figure 44. Down tree with pith below the duff.

12. Tree with curved bole (pistol butt tree): Measure along the bole on the uphill side (upper surface) of the tree (fig. 45).

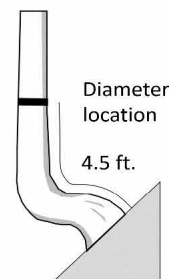


Figure 45. Tree with curved bole (pistol butt tree).

### 5.9.3 PREVIOUS DIAMETER AT ROOT COLLAR

This is the DRC assigned at the previous survey. It has been downloaded from the previous inventory. Any change made to this field signifies a misclassification at the time of the previous

inventory. "DIAMETER CHECK" should be set to 2 and an explanation is required in the notes if previous DRC is changed.

#### 5.9.4 Diameter At Root Collar (DRC)

For species requiring diameter at the root collar (refer to Appendix 3), measure the diameter at the ground line or at the stem root collar, whichever is higher. For these trees, treat clumps of stems having a unified crown and common root stock as a single tree; examples include mesquite, juniper, and mountain mahogany. Treat stems of woodland species such as Gambel oak and bigtooth maple as individual trees if they originate below the ground. For woodland trees, record DRC STEM DIAMETER and DRC STEM STATUS (described below). Then compute and record the DRC value from the individual stem diameter information.

Measuring woodland stem diameters: Before measuring DRC, remove the loose material on the ground (e.g., litter) but not mineral soil. Measure just above any swells present, and in a location so that the diameter measurements are a good representation of the volume in the stems (especially when trees are extremely deformed at the base). Stems must be at least 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point to qualify for measurement. Whenever DRC is impossible or extremely difficult to measure with a diameter tape (e.g., due to thorns, extreme number of limbs), stems may be estimated and recorded to the nearest 1.0-inch class. Additional instructions for DRC measurements are illustrated in figure 46. For each qualifying stem of the woodland tree, measure and record DRC STEM DIAMETER (5.9.4.1) and indicate the DRC STEM STATUS (5.9.4.2).

Computing and Recording DRC: For all tally trees requiring DRC, with at least one stem 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point, DRC is computed as the square root of the sum of the squared stem diameters. For a single-stemmed DRC tree, the computed DRC is equal to the single diameter measured.

Use the following formula to compute DRC:

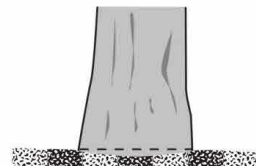
$$\text{DRC} = \text{SQRT} [\text{SUM} (\text{stem diameter}^2)]$$

Round the result to the nearest 0.1 inch. For example, a multi-stemmed woodland tree with stems of 12.2, 13.2, 3.8, and 22.1 would be calculated as:

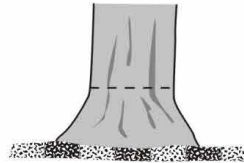
$$\begin{aligned} \text{DRC} &= \text{SQRT} (12.2^2 + 13.2^2 + 3.8^2 + 22.1^2) \\ &= \text{SQRT} (825.93) \\ &= 28.74 \\ &= 28.7 \end{aligned}$$

DRC species have been provided. It is unlikely that the species requiring a DRC measurement over DBH will be present on the project. However, all cruisers should be aware of the species and if they find any DRC species on a plot, DRC must be measured rather than DBH.

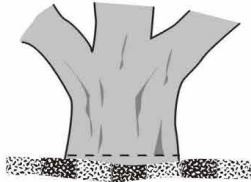
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1. Measure at ground line when reasonable.



2. Measure above root collar.



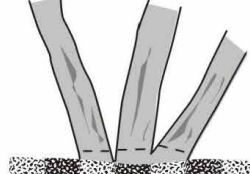
3. Multitemmed above diameter.



4. Excessive diameter below stems. Measure stems. Compute DRC.



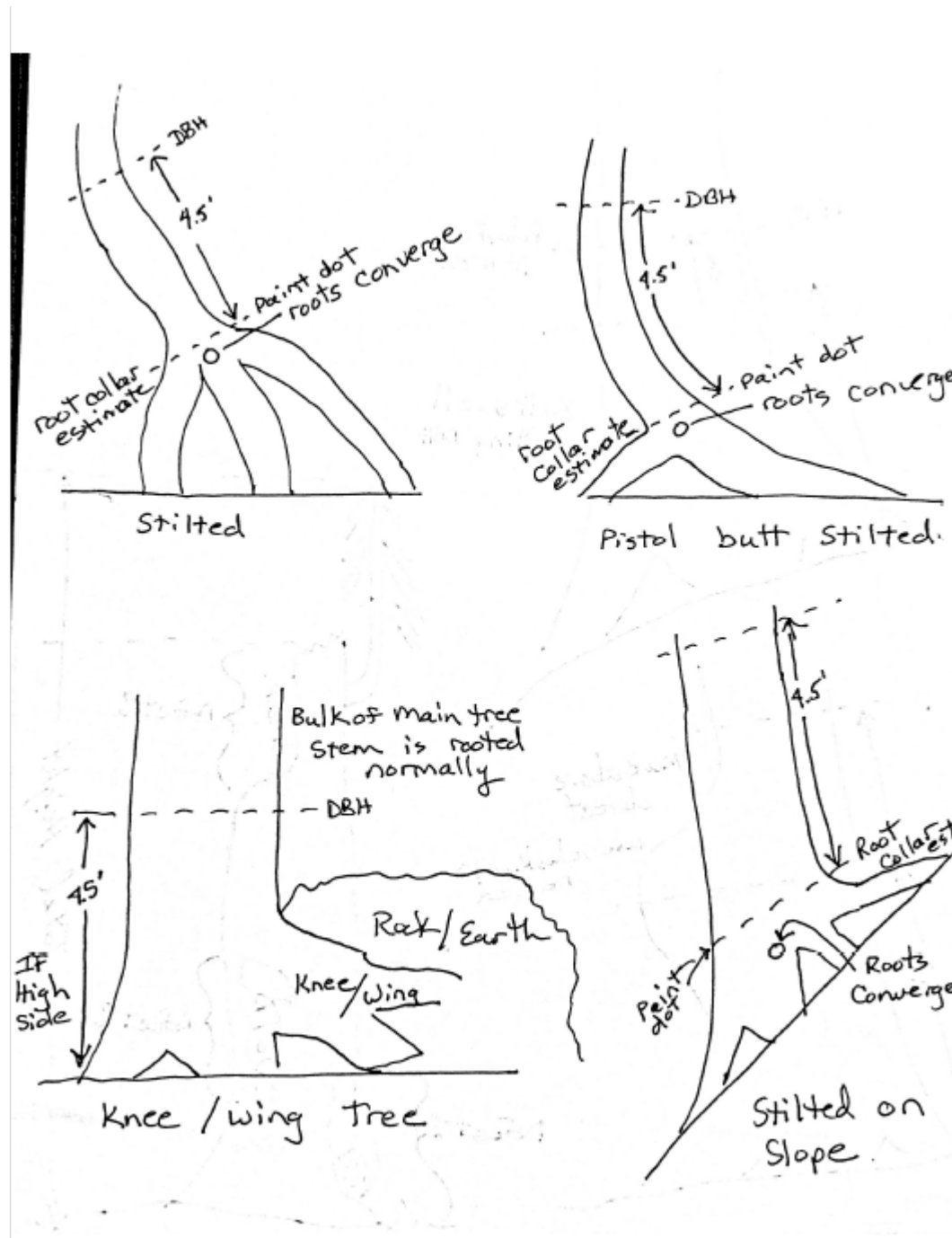
5. Ignore cut/missing stem(s). Compute DRC.

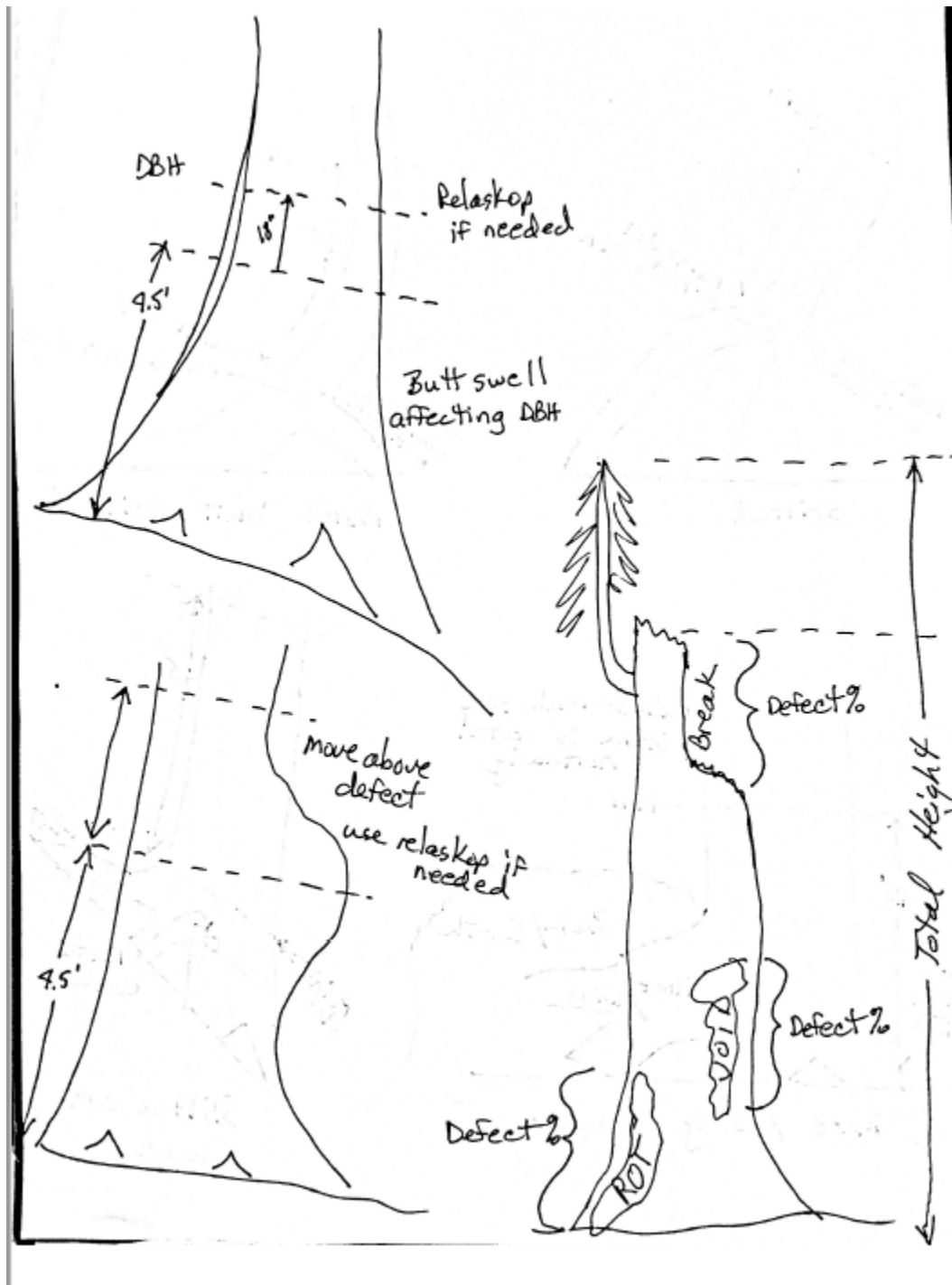


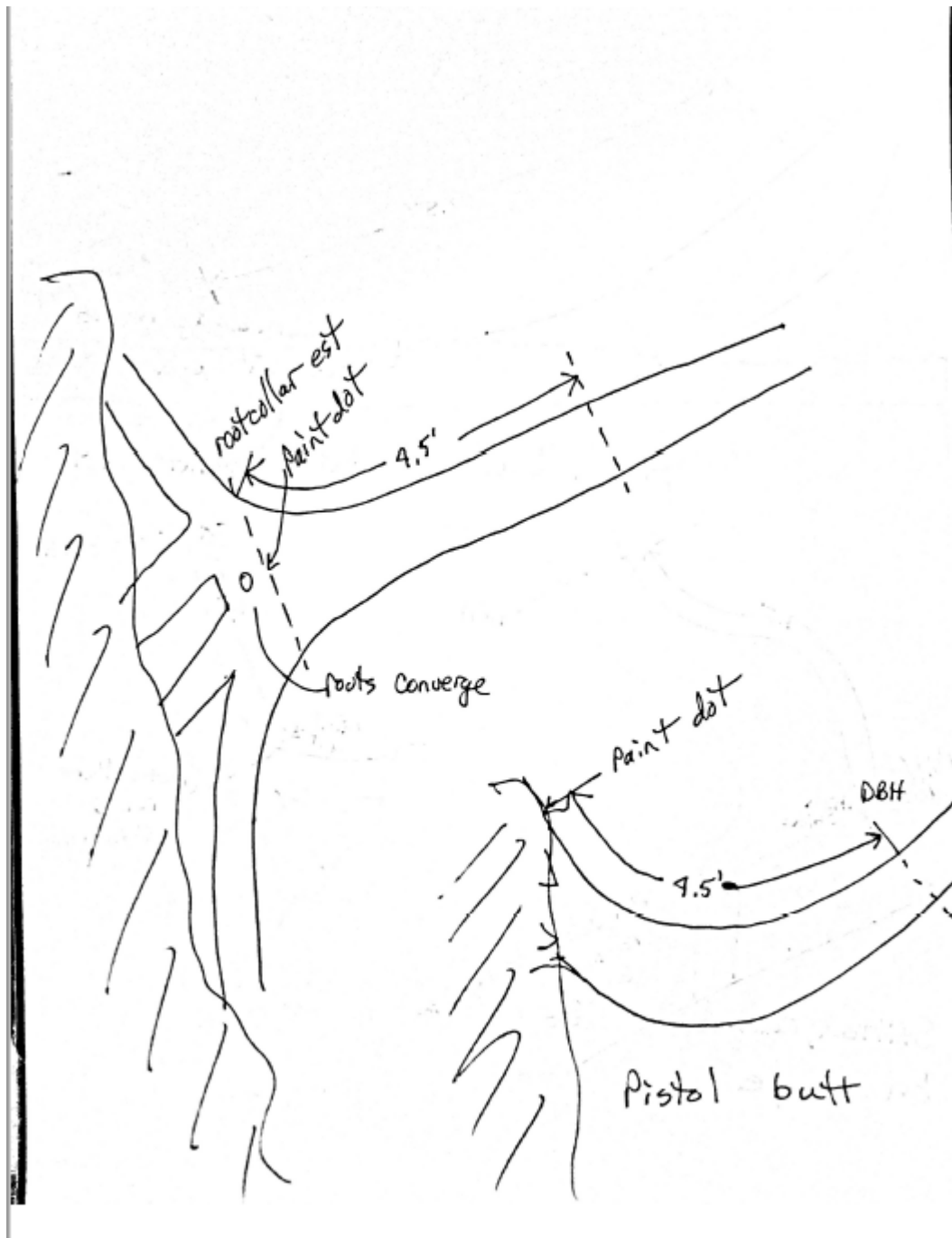
6. Multitemmed at or below ground. Compute DRC.

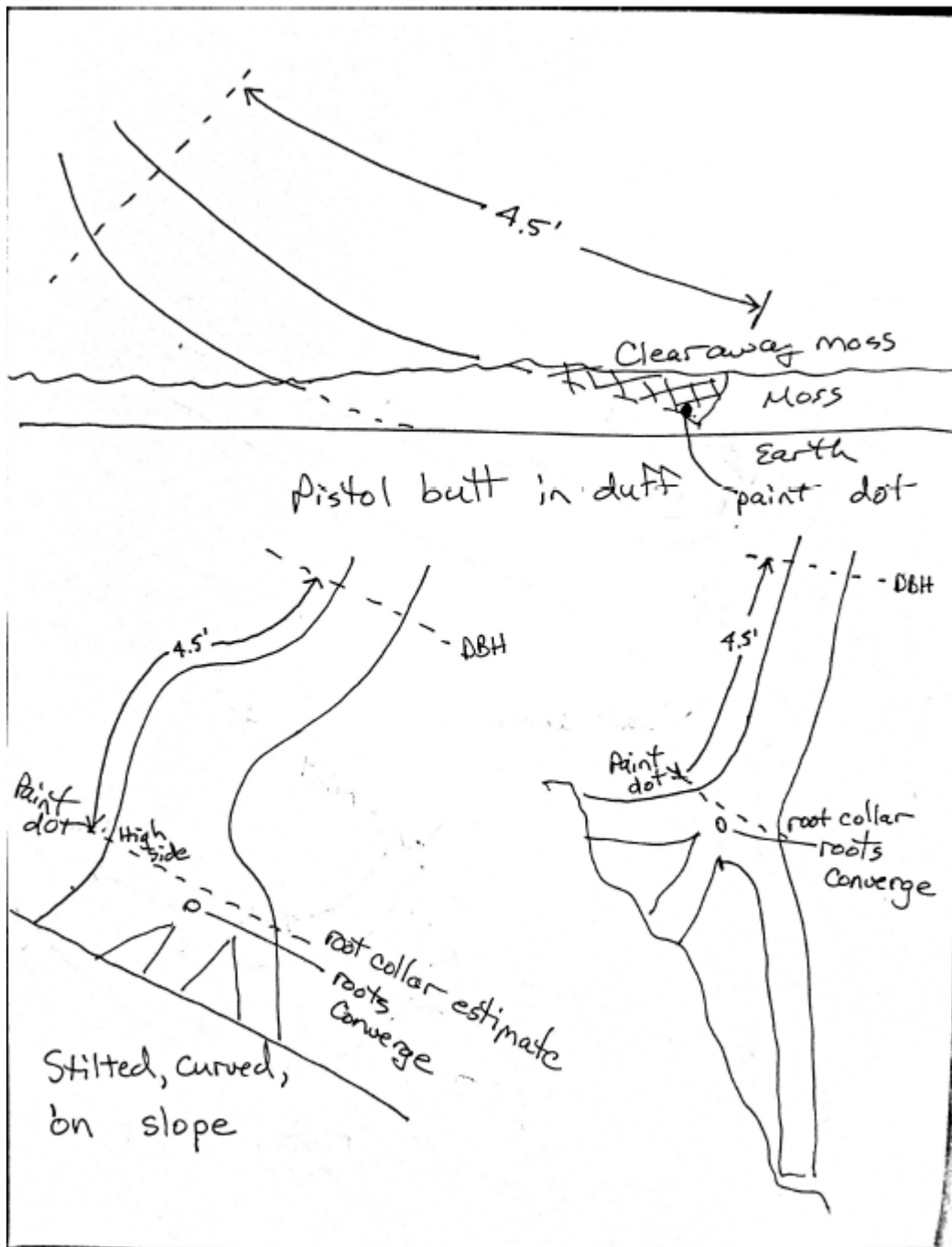
**Figure 46. How to measure DRC in a variety of situations.**

## DIAMETER BREAST HEIGHT (DBH) – Stilted Roots









## Slope Correction Table

| Percent of Slope | Degree of Slope | Correction Factor |
|------------------|-----------------|-------------------|
| 0 to 9           | 0-6             | 1.00              |
| 10 to 17         | 7-10            | 1.01              |
| 18 to 22         | 11-12           | 1.02              |
| 23 to 26         | 13-14           | 1.03              |
| 27 to 30         | 15-17           | 1.04              |
| 31 to 33         | 18              | 1.05              |
| 34 to 36         | 19-20           | 1.06              |
| 37 to 39         | 21              | 1.07              |
| 40 to 42         | 22              | 1.08              |
| 43 to 44         | 23              | 1.09              |
| 45 to 47         | 24              | 1.10              |
| 48 to 49         | 25-26           | 1.11              |
| 50 to 51         | 27              | 1.12              |
| 52 to 53         | 28              | 1.13              |
| 54 to 55         | 29              | 1.14              |
| 56 to 57         | 29              | 1.15              |
| 58 to 59         | 30              | 1.16              |
| 60 to 61         | 31              | 1.17              |
| 62 to 63         | 32              | 1.18              |
| 64 to 65         | 33              | 1.19              |
| 66 to 67         | 34              | 1.20              |
| 68 to 69         | 34              | 1.21              |
| 70               | 35              | 1.22              |
| 71 to 72         | 36              | 1.23              |
| 73 to 74         | 37              | 1.24              |
| 75               | 37              | 1.25              |
| 76 to 77         | 38              | 1.26              |
| 78 to 79         | 38              | 1.27              |
| 80               | 39              | 1.28              |
| 81 to 82         | 39              | 1.29              |
| 83               | 40              | 1.30              |
| 84 to 85         | 40              | 1.31              |
| 86               | 41              | 1.32              |
| 87 to 88         | 41              | 1.33              |
| 89               | 42              | 1.34              |

| Percent of Slope | Degree of Slope | Correction Factor |
|------------------|-----------------|-------------------|
| 90 to 91         | 42              | 1.35              |
| 92               | 43              | 1.36              |
| 93 to 94         | 43              | 1.37              |
| 95               | 44              | 1.38              |
| 96 to 97         | 44              | 1.39              |
| 98               | 44              | 1.40              |
| 99 to 100        | 45              | 1.41              |
| 101              | 45              | 1.42              |
| 102              | 46              | 1.43              |
| 103 to 104       | 46              | 1.44              |
| 105              | 46              | 1.45              |
| 106 to 107       | 47              | 1.46              |
| 108              | 47              | 1.47              |
| 109              | 47              | 1.48              |
| 110 to 111       | 48              | 1.49              |
| 112              | 48              | 1.50              |
| 113              | 48              | 1.51              |
| 114 to 115       | 49              | 1.52              |
| 116              | 49              | 1.53              |
| 117              | 49              | 1.54              |
| 118 to 119       | 50              | 1.55              |
| 120              | 50              | 1.56              |
| 121              | 50              | 1.57              |
| 122              | 51              | 1.58              |
| 123 to 124       | 51              | 1.59              |
| 125              | 51              | 1.60              |
| 126              | 52              | 1.61              |
| 127 to 128       | 52              | 1.62              |
| 129              | 52              | 1.63              |
| 130              | 52              | 1.64              |
| 131              | 53              | 1.65              |
| 132 to 133       | 53              | 1.66              |
| 134              | 53              | 1.67              |
| 135              | 53              | 1.68              |
| 136              | 54              | 1.69              |
| 137 to 138       | 54              | 1.70              |
| 139              | 54              | 1.71              |
| 140              | 54              | 1.72              |

| Percent of Slope | Degree of Slope | Correction Factor |
|------------------|-----------------|-------------------|
| 141              | 55              | 1.73              |
| 142 to 143       | 55              | 1.74              |
| 144              | 55              | 1.75              |
| 145              | 55              | 1.76              |
| 146              | 56              | 1.77              |
| 147              | 56              | 1.78              |
| 148 to 149       | 56              | 1.79              |
| 150              | 56              | 1.80              |

## Carbon Inventory Specification Addendum (7/1/2019)

### Clarifications and Additions:

1. When plots fall in areas treated with “hack and squirt” herbicide, cruise all frilled and treated trees as dead.
2. Should cruisers run into hybrids between knobcone pine and Monterrey pine, cruise the hybrid as knobcone pine.
3. When measuring DBG on redwoods, pull the tape snug to the bark, but not so tight as to cut into the bark.
4. Redwoods with bear damage that partially girdles the tree frequently have dead portions at DBH that persist completely to the top of the tree. The remaining live cambium continues to grow creating irregular cross sections at DBH. As the DBH measurement captures the reduced diameter for lost wood at DBH, no additional soundness deduction will be made. Exceptions to this rule would persist for missing bark, wood, or advanced decay that is not captured at the DBH measurement location.
5. Cruisers are asked to use nails for any basal measurement locations on edge trees whenever the tree is within .4 feet of the plot radius.
6. Down living trees in vs out of the duff: Key consideration is whether the pith is in or above the duff. Trees may have portions that meet each criteria and should be cruised accordingly. Below is the USDA FS section from the 2018 Field Guide for FIA plots on the issue.

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

- If the pith of the main bole is above the duff layer, use the same forking rules specified for a forked tree, and take all measurements accordingly (fig. 43).

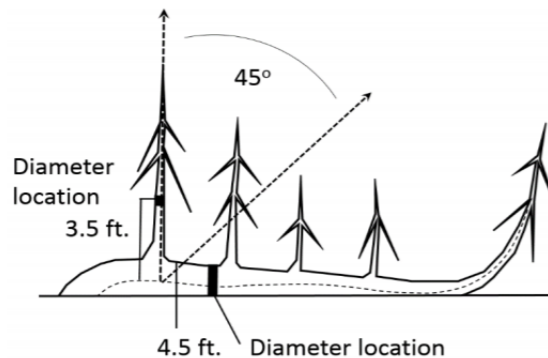


**Figure 43. Down tree with pith above the duff.**

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- If the pith intersection of the main down bole and vertical tree-like branch occurs below 4.5 feet from the stump along the main bole, treat that branch as a separate tree, and measure DBH 3.5 feet above the pith intersection for both the main bole and the tree-like branch.
- If the intersection between the main down bole and the tree-like branch occurs beyond the 4.5 feet point from the stump along the main bole, treat that branch as part of the main down bole.
- If the pith of main tree bole is below the duff layer, ignore the main bole, and treat each tree-like branch as a separate tree; take DBH and length measurements from the ground, not necessarily from the top of the down bole (fig. 44). However, if the top of the main tree bole curves out of the ground towards a vertical angle, treat that portion of that top as an individual tree originating where the pith leaves the duff layer.

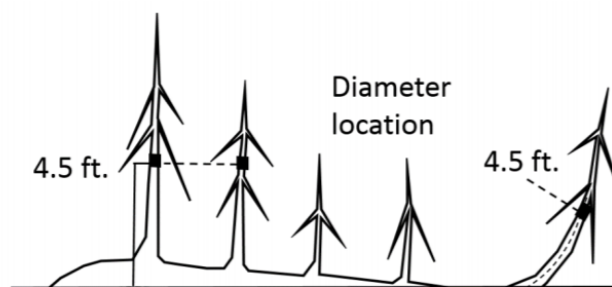


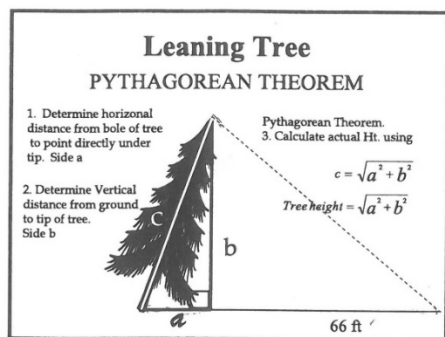
Figure 44. Down tree with pith below the duff.

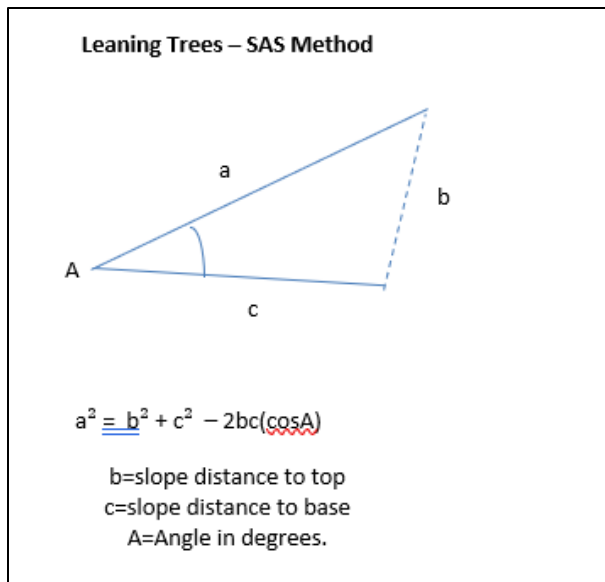
7. Leaning trees can be measured accurately using many techniques. The specification document refers to the Pythagorean theorem as one option. Other options include the Side Angle Side and Slope Correction methods. Cruisers are permitted to use any of these techniques as well as some direct measurement techniques. Procedural guidance on these techniques is provided below.

#### Pythagorean Theorem

1. Determine the horizontal distance by measuring from the tree bole to a point directly under the tip of the leaning tree (a).
2. Determine the vertical distance from the ground to the tip of the tree (b).
3. Determine the actual tree height by using the Pythagorean theorem.

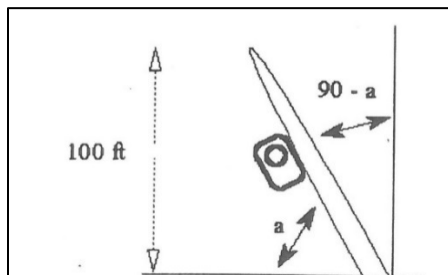
$$\text{Tree Height} = \sqrt{a^2 + b^2}$$





#### Slope Correction Method:

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



| Angle of Lean | Slope Correction Factor** |
|---------------|---------------------------|
| 15            | 1.035                     |
| 20            | 1.064                     |
| 25            | 1.103                     |
| 30            | 1.155                     |
| 35            | 1.221                     |
| 40            | 1.305                     |
| 45            | 1.414                     |
| 50            | 1.556                     |
| 55            | 1.743                     |
| 60            | 2.000                     |
| 65            | 2.366                     |

## References

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