

Gualala River Forest - ARB
Offset Project Data Report Appendices
California Air Resources Board

Forest Owner and Offset Project Operator:

The Conservation Fund

APPENDICES – April 24, 2017

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Appendix A: Forest Inventory Cruise Specifications

Forest Inventory Cruise Specifications

The Conservation Fund

Gualala River Forest, October 2015

1. Sampling Design and Overview

1.1. Plot Location – How are plots located across the property

The Gualala River Forest contains 13,448 forested acres and about 92 acres of natural openings. Only the forested acres will be cruised. The cruise will be based on a systematic sample of the ownership, and will not include stratification. The cruise design contains approximately 200 plots on a square systematic plot grid 25.4 chains on a side (1,675 feet); the grid had a random start and was created through a geospatial analysis.

Name	Acres	Description	Contains Forest Carbon?
Forest	13,447.69	Forested Area – <i>(includes small forest openings and roads)</i>	yes
Nontimber / Zero Carbon	92.02	Nontimber management acres <i>(natural openings)</i>	no
	13,539.71	Gualala River Forest Project Area	

1.2. Plot Design – Summary of Measurements

To maintain consistency with past inventory efforts, including the ongoing re-measurement of permanent growth plots, all plots will be circular.

- 1/5th acre plot (52.7 ft radius) for all conifer tree species 10.5” DBH and greater.
- 1/20th acre (26.3 ft radius) plot for all conifers from 5.0-10.4” DBH and all hardwood trees equal to or greater than 5.0”.
- 1/100th acre (11.8 ft radius) circular fixed radius plot for regeneration 2.5-4.9” DBH.

1.2.1. Circular 1/5th Acre (52.7 ft radius) Fixed-Area Plot Measurements (standing live and dead *conifer* trees >= 10.5 inches DBH)

- species
- diameter at breast height (DBH)
- height to the nearest foot (for trees ≥ 20.0” DBH)
- height to crown base (for height trees)
- % defect, % missing height, and defect code where needed
- height and decay class for all conifer snags over 10.5 inches
- Lesser vegetation – dominant lesser vegetation type (shrubs and grasses)

1.2.2. Circular 1/20th Acre (26.3 ft radius) Fixed-Area Plot Measurements (standing live and dead *hardwood* trees ≥ 5 inches DBH and conifers 5-10.4" DBH)

- species
- diameter at breast height (DBH)
- when needed, % defect, % missing height, and defect code
 - the only defect that is recorded for hardwoods is missing volume (e.g., missing height and large cavities)
- height and decay class for all hardwood snags over 5" DBH and conifer snags 5-10.4" DBH

1.2.3. Circular 1/100 acre Regeneration Plot Measurements (11.8 ft radius): (standing live trees < 5.0 inches DBH)

- species
- count of trees at least 4.5 ft tall by 0-2.4 and 2.5-4.9 in DBH classes
- average tree height (within DBH classes by species)

1.3. Plot Access and Road Point Procedures

Each plot will be accessed from the nearest road entry point. The cruiser will navigate to the plot via GPS. The plots centers have been previously established with 50 penny nails (spikes) with red and black flagging, the 2015 cruise plot shall use the same plot center (PC) whenever possible.

The plots were established in the spring and summer of 2008. A systematic grid with a random start was created in GIS; the list of coordinates and maps were provided to the cruisers in 2008. The cruisers then navigated to each plot using a combination of GPS takeoff roads points and field measurements (e.g., hipchain or electronic device, compass, etc). The plots were monumented with black and red stripped flagging; the plot number was painted on the tree nearest plot center.

1.4. Plots on Truck Roads

Plots are located throughout the project area and may fall on a truck road or property edge. Plots that fall on roads are sampled where they land. There were no property edge plots in the 2008 systematic sample. However, if in the future additional plots are added and there is a plot which falls on a clear property boundary, the walkthrough method¹ will be used to cruise the plot.

1.5. Plot Monumenting and Plot Navigation Procedures

The following monumenting should occur at all plots:

1. The plot center should be monumented with a plastic stake painted orange and shall replace the 50 penny nail. The stake should extend at least 18" above the ground and be driven securely into the soil. If the penny nail cannot be located, then the plot will be reestablished near the original plot location using available information (e.g., GPS point, old flagging, tree with painted number, plot notes).
2. The plot number should be clearly written on an aluminum tag affixed to the plot

¹ Ducey, M.J., J.H. Gove, and H.T. Valentine. 2004. A Walkthrough Solution to the Boundary Overlap Problem. Forest Science 50: 427-435.

center stake along with the date cruised and the cruiser's initials. Solid pink and solid white flagging is tied to the stake and also hung in the trees above the plot center.

3. GPS coordinates taken at plot centers and should be recorded on the plot sheet. GPS coordinates should be recorded in decimal degrees. The two GPS coordinate readings are used to confirm that the GPS units have good connections to satellites and that plots are placed in an appropriate location; these records are maintained to support the GIS-generated points.

The GPS coordinates for plot center should be recorded 2 times for each plot:

- i. When the plot center is established
 - ii. When the plot is completed
4. All trees measured on the plot should have a line spray painted **at the location they were measured for DBH** on the uphill side of the tree and facing plot center where possible. The tree number should be spray painted **above** the DBH line where possible. "Out Trees" – Trees whose center is just outside of the plot boundary should be spray painted with an "X" at DBH.
5. Trees in the 1/20th and 1/5th acre plots are numbered consecutively starting from the north and moving in a clockwise direction until the plots are completed.
6. Trees shall be numbered consecutively starting from "1" on each plot.

2. Sampling Procedure and Data Collection at Plots

2.1. 1/5th Acre and 1/20th Acre plots

2.1.1. Borderline Trees

Trees are considered in the plot if the center of the tree stem is within the plot. Any tree (live or dead) near the plot border should be measured using a tape to check for in and out trees. A laser is not recommended to determine in and out trees. When checking borderline trees, the loggers tape should be affixed to the face of the tree at DBH and then pulled to plot center. Once at plot center, the measured slope distance should be corrected to horizontal distance. The radius of the tree should be added to the horizontal distance to plot center when calculating whether or not the tree is located within the plot. When checking in and out trees be mindful of your units, plot radius is measured in feet and 1/10 of feet whereas DBH is measured and recorded in inches. To convert diameter in inches to the radius in 1/10 of feet, divide the diameter by 24. For example, a 12 in DBH tree has a radius of .5 feet (12/24). In the field a tree which is 52.5 feet horizontal distance from plot center to the face would be measured as 53.0 feet to the center of the tree or "out".

2.1.2. Live Trees

All hardwoods trees greater than or equal to 5 inches DBH are measured if the **CENTER** of the stem is within the 1/20th acre plot. All conifer trees greater than or equal to 5 inches DBH up to and including 10.4 inches DBH are also measured in the 1/20th acres plot. Live conifers greater than or equal to 10.5 inches DBH will be measured in the 1/5th acre plot. Distance to plot center should be measured at DBH. Trees will be tallied and measured in a clockwise direction beginning in the north. **All trees should be marked and numbered with a line painted at the location where DBH was measured and the tree number above this line where possible.**

The following data should be collected for each tree measured:

- **Species** – The species and species codes of trees can be found in the table below.

- **Group** – Each tree in the plot has a group assigned to it. Trees can be live (..) or snags (SN). See Table 2 below for a complete description of the group codes. **All snags (SN) must** have a decay class from 1 to 5 assigned to them. The decay class descriptions for snags can be seen in table 4 below.
- **Diameter at Breast Height (DBH) see figure below** – Diameters are measured at a point 4.5 feet above the ground level or root collar on the uphill side of the tree. Measurement accuracy is to the nearest one tenth-inch. In the case of irregularities in DBH, such as swelling, bumps, depressions, branches, etc., diameters are measured immediately above the irregularity at the place where it ceases to affect the normal stem form. There are many potential situations of irregular boles in the woods; cruisers are encouraged to use their best judgement to capture the nature of the tree. For example, a tree that forks just above DBH but has a large irregularity from below DBH through the stem fork should be measured below DBH. Measuring slightly below DBH in this situation (instead of the general “above the irregularity” rule of thumb) best captures the tree because it clear that the tree is only one stem and measuring below the irregularity is a more conservative measurement than measuring in the middle of the irregularity. For redwood stump sprouts, the ground level is considered the top of the parent stump.
 - o **DBH for Forked trees** – Forked trees are measured as two separate trees if the fork originates below DBH. When the fork originates below DBH, but has subsequently grown together, the tree is cruised as two trees and the DBH for each is estimated by the cruiser. (E.g., the beginning of the visible seam between two trees which have grown together is considered the fork origination point). If the fork originates above DBH then, the tree is measured and counted as a single tree. DBH should be measured above (for multi-stem forked trees) or below the fork (for a single stem) at the most reasonable point without swell.
 - o **DBH for Extreme Lean Trees** – If the entire lower 4.5 feet of the tree bole is leaning in excess of 45 degrees, then the tree is considered an extreme lean tree. Trees with extreme leans should be measured for DBH 4.5 feet from the point where they leave the ground. In some cases, this may be on the downhill side of the tree.

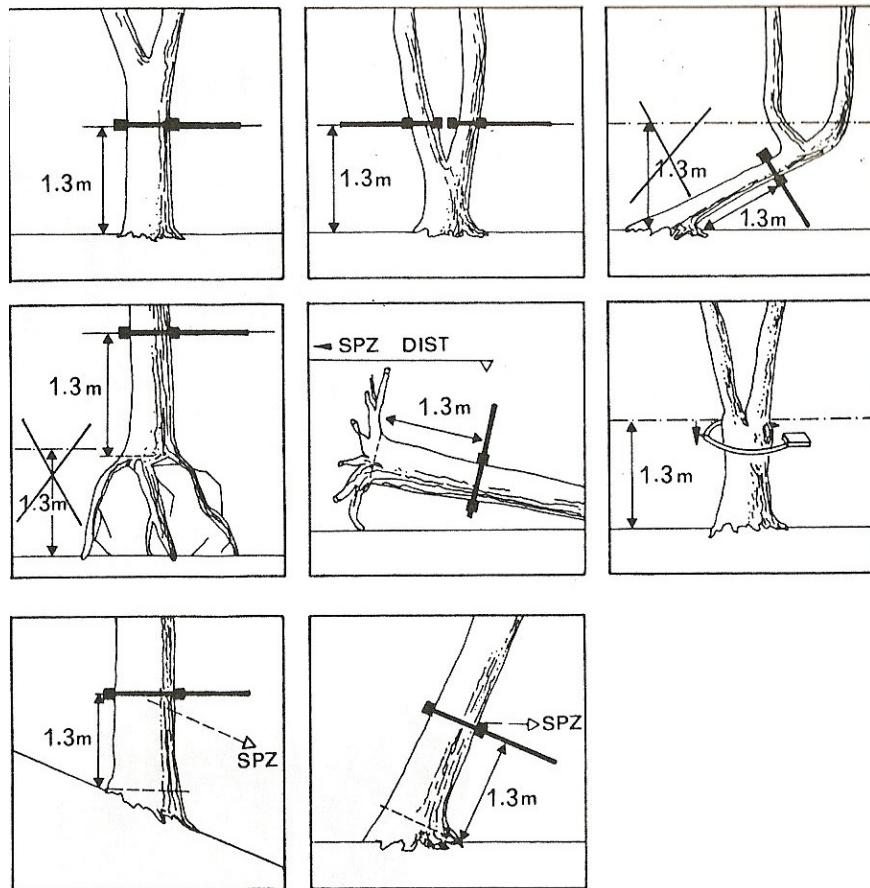


Figure 2. Point of measurement of diameter at breast height (from Pancel, 1993)² DBH is measured along the bole (as is shown in this figure).

- **Height** – Total height is measured to the nearest foot on all trees in every third plot, height measure plots are randomly pre-selected, the cruiser will be given a list of height measure plots. Additionally, all conifers ≥ 20 " DBH will have a total height and HTCB measured. Height is measured to the top of live branches. (Broken top trees may be missing part of their original stem, but the top of the tree is the tallest part of the tree standing. For non-height measure trees, the defect must be noted and the % missing height estimated, see Defect section below.)
- **Leaning or Sweep/Crook Trees** – Trees with lean and/or crook or sweep are measured for total height from the ground to the tree top. If the lean, sweep, or crook is more than 45° (100% slope), the bole length should be estimated using correction factors based on the lean. These factors will be supplied to cruisers in 5 degree increments (bole length = tree height / [SIN (lean degrees)]).
- **Height to Crown Base (HTCB)** – This measurement (in feet) provides an estimate of the total vertical crown area. The measurement is taken on every height measure tree. The

² Pancel, L., ed. 1993. Tropical forestry handbook. Berlin, Germany, Springer-Verlag. Volume 1, 738 pp

measurement is taken from the base of the tree on the uphill slope to the visually balanced base of the crown, since tree crowns are often irregular. Figure 2 below provides examples of how the height to crown base measurement is acquired.

- Damage/Defect** – A damage code is assigned to damaged trees. See codes in Table 5 below for descriptions of these codes. Damaged trees should have a defect % recorded in the Age/Defect % column of the plot card. Cruisers should use 10% defect classes when estimating percentage defect. For example, trees with forks or crooks generally have 0-10% defect. Fire scars can be 10-20% defect. Butt rot is generally not more than 50% defect. Conk rot may be from 10 to 100% defect depending on the severity of the rot.

Percent missing height should be recorded on trees with broken tops and is an estimate of the percent of the tree height missing from the estimated total height. Large hollows or other bole defects that impact the gross volume of the tree should be noted and a % missing volume estimated. Percent missing volume is an estimate of the volume of the void missing from the estimated total volume. Both of these deductions are based on ocular estimates in the field. Defect deductions are only taken for trees ≥ 8 inches in DBH.

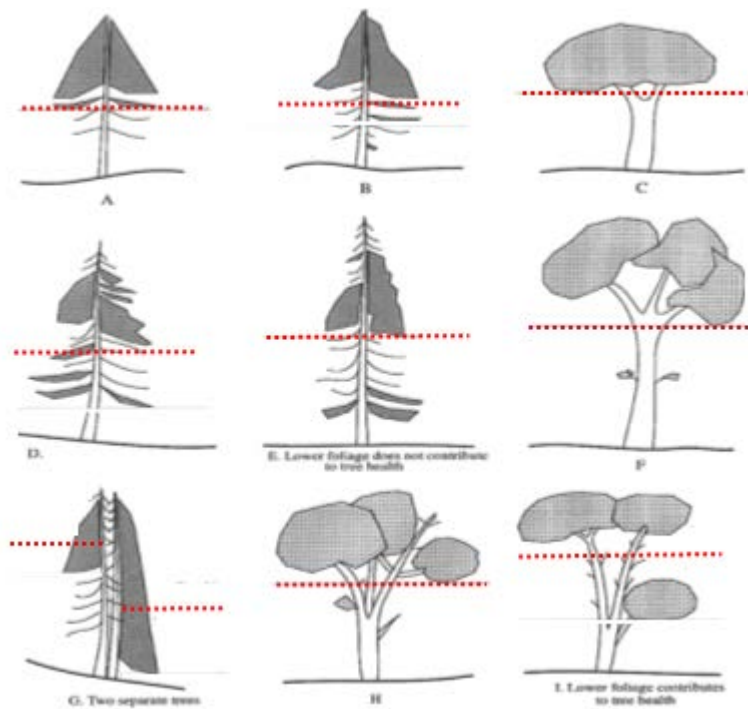


Figure 3. Height to Crown Base Measurement Examples (use the dotted line)

2.1.3. Snags (Standing Dead Trees³) > 15ft Tall

All snags over 15ft tall should be measured for **DBH** and **height** and should have their species noted. All snags must have their **decay class** noted in the defect column (see Table 3). All snags should have a line painted where they were measured for DBH and their tree number painted above this line. They should be given a number in sequence with the live trees.

³ Standing dead trees and snags are synonyms, and are used interchangeably in this document.

Table 2: List of Tree Species and their Species Codes

Species Code	Scientific Name	Common Name
AS	<i>Fraxinus sp.</i>	Ash species
BM	<i>Acer macrophyllum</i>	Big Leaf Maple
BO	<i>Quercus kelloggii</i>	Black Oak
BP	<i>Pinus muricata</i>	Bishop Pine
CB	<i>Umbellularia californica</i>	California Bay
CO	<i>Quercus chrysolepis</i>	Canyon Live Oak
CU	<i>Aesculus californica</i>	California Buckeye
DF	<i>Pseudotsuga menziesii</i>	Douglas-fir
EF	<i>Ficus carica</i>	Edible Fig
GC	<i>Chrysolepis chrysophylla</i>	Giant Chinquapin
GF	<i>Abies grandis</i>	Grand Fir
LO	<i>Quercus wislizenii</i>	Interior Live Oak
MD	<i>Cornus nuttallii</i>	Mountain Dogwood
MP	<i>Pinus radiata</i>	Monterey Pine
NM	<i>Torreya californica</i>	California Nutmeg
OL	<i>Olea europa</i>	Olive
PM	<i>Arbutus menziesii</i>	Madrone
PP	<i>Pinus ponderosa</i>	Ponderosa Pine
PY	<i>Taxus brevifolia</i>	Pacific Yew
RA	<i>Alnus rubra</i>	Red Alder
RW	<i>Sequoia sempervirens</i>	Redwood
SO	<i>Quercus parvula var. shrevei</i>	Shreve's Oak
SP	<i>Pinus lambertiana</i>	Sugar Pine
TO	<i>Lithocarpus densiflorus</i>	Tanoak
TY	<i>Heteromeles arbutifolia</i>	Toyon
UK	N/A	Unknown
WA	<i>Alnus rhombifolia</i>	White Alder
WH	<i>Tsuga heterophylla</i>	Western hemlock
WI	<i>Salix sp.</i>	Willow species
WM	<i>Myrica californica</i>	Wax Myrtle
WO	<i>Quercus garryana</i>	Oregon White Oak

Table 3: Status Code Descriptions

Status Code	Code Definition	Description
..	Live	Default code for trees with normal form. <i>All regeneration also should have this code.</i>
SN	Snag	Standing trees that are dead. Snags have no branches or leaves and are greater than 15 ft tall.
LV	Lesser Vegetation	Lesser vegetation is noted in the 1/5 th acre plot.

Table 4: ⁴. Snag Decay Class Descriptions

Decay class	Limbs and branches	Top	% Bark Remaining	Sapwood presence and condition *	Heartwood condition *
1	All present	Pointed	100	Intact; sound, incipient decay, hard, original color	Sound, hard, original color
2	Few limbs, no fine branches	May be broken	Variable	Sloughing; advanced decay, fibrous, firm to soft, light brown	Sound at base, incipient decay in outer edge of upper bole, hard, light to reddish brown
3	Limb stubs only	Broken	Variable	Sloughing; fibrous, soft, light to reddish brown	Incipient decay at base, advanced decay throughout upper bole, fibrous, hard to firm, reddish brown
4	Few or no stubs	Broken	Variable	Sloughing; cubical, soft, reddish to dark brown	Advanced decay at base, sloughing from upper bole, fibrous to cubical, soft, dark reddish brown
5	None	Broken	Less than 20	Gone	Sloughing, cubical, soft, dark brown, OR fibrous, very soft, dark reddish brown, encased in hardened shell

*Characteristics are for Douglas-fir. Dead trees of other species may vary somewhat. Use this only as a guide.

⁴ Forest Service. 2012. Forest Inventory and Analysis National Core Field Data Collection Procedures for Phase 2 Plots. Version 6.0. Page 427. National Core Field Guide, U.S. Department of Agriculture, Forest Service

Table 5: Damage Codes

First Digit	Second Digit	Third Digit
0 - No Damage	N/A	N/A
1 - Unspecified	0 – (always code 0)	0 - Unspecified
		1 - Light Damage
		2 - Moderate Damage
		3 - Severe Damage
		4 - Fatal Damage
2 - Mechanical	1 - Fire	0 - Unspecified
	2 - Logging	1 - Light Damage
	3 - Crown	2 - Moderate Damage
	4 - Bole	3 - Severe Damage
	5 - Roots	4 - Fatal Damage
	6 - Tags, Nails, etc.	
3 - Chemical	1 - Foliar (broadcast)	0 - Unspecified
	2 - Stem (spot treatment)	1 - Light Damage
	3 - Soil (root treatment)	2 - Moderate Damage
		3 - Severe Damage
		4 - Fatal Damage
4 - Disease	0 - Unknown	0 - Unspecified
	1 - Mistletoe	1 - Light Damage
	2 - Needle Rusts	2 - Moderate Damage
	3 - Stem Decay	3 - Severe Damage
	4 - Stem Rusts	4 - Fatal Damage
	5 - Stem Cankers	
	6 - Root Disease	
	7 - Armillaria mellea	
	8 - Phellinus weirii	
5 - Insects	1 - Defoliators	0 - Unspecified
	2 - Bark Beetles	1 - Light Damage
	3 - Sucking Insects	2 - Moderate Damage
	4 - Pitch Moths	3 - Severe Damage
		4 - Fatal Damage
	1 - Deer & Elk	0 - Unspecified
	2 - Bear	1 - Light Damage

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Appendix A

6 - Animal	3 - Livestock	2 - Moderate Damage		
	4 - Porcupine	3 - Severe Damage		
	5 - Mt. Beaver	4 - Fatal Damage		
	6 - Small Mammals			
	7 - Birds			
7 - Weather	1 - Windthrown	0 - Unspecified		
	2 - Snow, Ice, Freezing	1 - Light Damage		
	3 - Drought (Summer)	2 - Moderate Damage		
	4 - Desiccation (Winter)	3 - Severe Damage		
	5 - Sunscald	4 - Fatal Damage		
	6 - Lightning			
	7 - Flooding			
8 – Suppression	0 – (always code 0)	0 - Unspecified		
		1 - Light Damage		
		2 - Moderate Damage		
		3 - Severe Damage		
		4 - Fatal Damage		
9 - Physical	1 - Broken top	Fork codes	Lean Codes	Codes For Others
	2 - Dead Top	1 - Below 1.3m	0 - Unspecified	0 - Unspecified
	3 - Multiple Tops	2 - Above 1.3m	1 - <25 degrees	1 - Light
	4 - Forked Tree	3 - Above 5m	2 - 26 to 45 degrees	2 - Moderate
	5 - Leaning Tree		3 - >45 degrees	3 - Severe
	6 - Crook or Sweep		4 - Tree Down	4 - Fatal
	7 - Bole Cracks			
	8 - Epicormic Branching			

2.2. Hundredth Acre (11.8 ft radius) Plot

2.2.1. Regeneration – Trees < 5 in DBH

All trees less than 5 inches DBH are measured on every plot. The sample area measured for regeneration is a fixed 1/100th acre plot (11.8 ft radius). All species that could potentially have a tree form are measured, see table 1 for species that should be measured as trees, if the individual is at least 4.5 ft tall

- **Species** – Record species for all trees
- **DBH** – Count the trees by species within 2.4 inch DBH classes (0 to 2.4 and 2.5 to 4.9), if the base of the tree is within the 1/100th acre plot.
- **Height** – record the estimated average height by species and DBH class for each tree record.

2.2.2. Lesser Vegetation

Record the dominant lesser vegetation type and height in the regeneration plot and density of the ground cover in 20% classes (**Open**: 0-20%, **Low**: 20-40%, **Medium**: 40-60%, **Dense**: 60-80%, **Extremely Dense**: 80-100% cover). Lesser vegetation should be given the LV status code.

Table 5: Lesser Vegetation Type Codes

Lesser Vegetation Type	Name	Description
WS	Woody Shrub	Woody plants
FE	Fern	Fern species
IN	Invasive Species	French Broom or Pampas Grass
LV	Unknown	
GR	Grass species	Grass species
XX	None	No LV present

2.3. Additional Plot Information

Any further information concerning the stand being cruised can be extremely important.

- GPS coordinates should be recorded at each plot center when the plot is established, and again when the plot is completed. GPS coordinates should be recorded in decimal degrees.
- The cruiser should also record plot aspect, % slope, cruiser, and date
- Items that should be noted are the location of skid trails that occur within the plot, springs, watercourses and historical artifacts when they assist in relocating the plot.
- Wildlife species of concern observed should be noted including raptors and their nests pileated wood peckers, tree vole, red legged frog, mountain lions, bears, etc.
- The distance to the nearest Class I watercourse should also be noted if the plot is within 200 feet of a Class I watercourse.
- If a plot has no trees, please make a note of the plot conditions and record one species with species code XX, DBH equal to 12, and tree count equal to 0.
- If there is a plot center from a previous cruise nearby (e.g., within 90 ft), the plot will be established using the existing plot center.

2.4. Site Class Sampling

A site tree should be selected at least once per day for each cruiser or cruising team from the population of dominant conifer trees encountered throughout the day. Site trees should be **redwood, Douglas-fir, grand fir, or sugar pine**. To be considered eligible for site tree measurement, a tree must have the following qualities:

- be a conifer located within or near the plot (preferably within)
- be a robust, dominant tree at least 25 years in age
- demonstrate good phenotype and vigor
- free of defect (conks) and disease (beetles, mistletoe, etc.)

Final selection should be made on the basis of determining which of the eligible trees is the most vigorous. Relative vigor should be assessed by evaluating the crown condition, foliage complement, and bole condition of the trees present on the plot. Trees with full, healthy crowns, and no apparent disease or damage should be considered more vigorous than trees lacking these qualities. In many stands it may be difficult to find trees meeting these criteria; thus, it is important to look for such trees at each plot (until the minimum number have been identified and measured within a given stand).

Trees selected for site tree measurement shall be marked with an “ST” on two sides of the tree with paint.

If no site trees are found meeting the criteria mentioned above, the cruiser may find an appropriate site tree off of the plot. In this case, the cruise notes shall clearly indicate that the measurement occurred off plot. The tree shall be painted as described above. Record the tree in the tree list for the nearest plot giving it a number in sequence with the last numbered tree in the plot. Note the count as 0 for this off-site tree.

3. Data Transfer

Data may be collected using iPad tablets or data loggers that will be provided by the cruising contractor. The cruising contractor will also be responsible for purchasing the required licenses. Cruisers shall email completed data to TCF at the end of each work day. Cruisers should carry paper data sheets in the field so that data can be collected in the event that an iPad stops functioning.

4. Check Cruise Specifications

Total plot carbon and gross board foot volume must be within 5% of the check cruise results. Any cruiser who has more than 25% of their plots outside of this 5% range must have all of their plots re-cruised at their expense.

Forest inventory data are check-cruised for accuracy. Check cruising identifies and corrects errors found in field measurements. Plots are check cruised on a cruiser-by-cruiser basis. A cruiser is considered to have passed the check cruise if their total merchantable BF/acre and MtCO₂e/acre are within 10% of the check cruiser's estimate and if these estimates are not statistically different using a paired t-test at the 90% confidence level.

5. Example Paper Plot Card

See below for the data form that should be used in case the data logger does not work.

[illegible]

Appendix A

Slope Correction Table and Extreme Lean Trees

Slope correction table for finding horizontal distances on steep sites, and finding the bole length for extreme lean trees.

Slope Correction Table									
			26.3	52.7	33.0	50.0	66.0	100.0	ratio
% slope :	degrees	SIN(degrees)	(1/20th)	(1/5th)	ft	ft	ft	ft	
10.0	5.71	0.10	26.4	53.0	33.2	50.2	66.3	100.5	0.9950
15.0	8.53	0.15	26.6	53.3	33.4	50.6	66.7	101.1	0.9889
20.0	11.31	0.20	26.8	53.7	33.7	51.0	67.3	102.0	0.9806
25.0	14.04	0.24	27.1	54.3	34.0	51.5	68.0	103.1	0.9701
30.0	16.70	0.29	27.5	55.0	34.5	52.2	68.9	104.4	0.9578
35.0	19.29	0.33	27.9	55.8	35.0	53.0	69.9	105.9	0.9439
40.0	21.80	0.37	28.3	56.8	35.5	53.9	71.1	107.7	0.9285
45.0	24.23	0.41	28.8	57.8	36.2	54.8	72.4	109.7	0.9119
50.0	26.57	0.45	29.4	58.9	36.9	55.9	73.8	111.8	0.8944
55.0	28.81	0.48	30.0	60.1	37.7	57.1	75.3	114.1	0.8762
60.0	30.96	0.51	30.7	61.5	38.5	58.3	77.0	116.6	0.8575
65.0	33.02	0.54	31.4	62.9	39.4	59.6	78.7	119.3	0.8384
70.0	34.99	0.57	32.1	64.3	40.3	61.0	80.6	122.1	0.8192
75.0	36.87	0.60	32.9	65.9	41.3	62.5	82.5	125.0	0.8000
80.0	38.66	0.62	33.7	67.5	42.3	64.0	84.5	128.1	0.7809
85.0	40.36	0.65	34.5	69.2	43.3	65.6	86.6	131.2	0.7619
90.0	41.99	0.67	35.4	70.9	44.4	67.3	88.8	134.5	0.7433
95.0	43.53	0.69	36.3	72.7	45.5	69.0	91.0	137.9	0.7250
100.0	45.00	0.71	37.2	74.5	46.7	70.7	93.3	141.4	0.7071
% slope :			HD = COS(ARCTAN(X/100)*SD, where X is % slope						
slope in degrees :			HD = COS(X)* SD, where X is slope in degrees						
ratio method :			HD =ratio*SD, where ratio corresponds to % slope						
leaning trees :			bole length = tree height/[SIN(lean degrees)]						

6. Height Estimation

Tree height is an important variable in volume and biomass equations; however, tree height measurements are time consuming and often difficult to collect. Tree heights are measured to the nearest foot for approximately a third of the plots and for conifers 20 inches DBH and greater. To improve data collection efficiency, tree heights estimates are used for the remaining subset of trees. For plots where tree heights were not collected, species-specific regressions equations developed for the Project, or created in FORSEE, are used to estimate height. When total tree height is estimated using a height regression, the height to crown base (HTCB) measurement is assumed to be half of the height.

Height regression models were developed by species for Gualala using data collected on the property. The height-diameter models were based on equation forms developed from research on managed coastal redwood/Douglas-fir forests in Mendocino County⁵ (Eng 2012). Eng identified equation forms which adequately predicted height from DBH by species.

A 2013 forest inventory of the Gualala Forest provided an expansive dataset from the Project for fitting the models. There were adequate sample sizes for species-specific models for common species – redwood, Douglas-fir, sugar pine, tanoak, and pacific madrone. True oaks – canyon live oak, interior live oak, and Oregon white oak – have very similar growth forms and lineages and were grouped together for a more robust dataset; the species grouping is referred to as ‘QX’ for the *Quercus* grouping.

To select the best model for the Project, models were built and compared. The first model used the coefficient values published by Eng and the second used property-wide species datasets. (Note: Two species did not have published coefficients in the Eng paper, so substitutions were used in the fitting processes.) Model fitting was completed in R⁶ (R Core Team) using the hash⁷ and ggplot2⁸ packages; fitting also used in-house R code and functions. The models were reviewed and compared. Model fit was also assessed with the 2015 inventory. Models with the best root-mean-square error (RMSE) were selected to be used for height estimation in the Project.

The height-diameter height regressions developed for the Project were based on the following equation forms published for coastal redwood/Douglas-fir forests (Eng 2012):

Equation form 1: $\text{Height} = 4.5 + \exp(a + b \cdot \text{DBH}^c)$

Equation form 2: $\text{Height} = 4.5 + a \cdot (1 - \exp(b \cdot \text{DBH}^c))$

Two models were fit for each species/species grouping: coefficient values published by Eng (Eng) and property-wide species data sets (All). The model with the best root-mean-square error (RMSE) was selected to estimate heights for the Project. There were limited records or poor fit in the “grand fir” and “western hemlock” groups; the recommended values by Eng were used.

⁵ Eng, H. 2012. Tree Height Estimation in Redwood/Douglas-fir Stands in Mendocino County. Pages 649–654. General Technical Report - Proceedings of coast redwood forests in a changing California: A symposium for scientists and managers, Pacific southwest Research Station, Forest Service, U.S. Department of Agriculture, Albany, CA.

⁶ R Core Team. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <http://www.R-project.org/>.

⁷ C. Brown. 2013. hash: Full feature implementation of hash/associated arrays/dictionaries. R package version 2.2.6. <http://CRAN.R-project.org/package=hash>

⁸ H. Wickham. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2009.

Species	Equation Form	Model	Coefficients			RMSE
			a	b	C	
Douglas-fir	1	All	6.0982	-4.6982	-0.3523	13.183
Grand Fir	1	Eng	5.8095	-6.3265	-0.6015	NA
Pacific Madrone	2	All	46.7400	-0.0365	1.8216	9.183
Oak Grouping	2	All	66.6034	-0.0723	0.9058	8.528
Redwood	1	All	6.0390	-5.1576	-0.3632	18.139
Sugar Pine	1	All	5.3210	-4.4854	-0.5519	9.277
Tanoak	1	All	4.3014	-5.3734	-1.0235	10.594
Western Hemlock	2	Eng	162.7225	-0.05723	0.9763	NA

Note: Coefficient values have been rounded for ease of display.

A number of species present on the Project did not occur in sufficient numbers in the 2013 Project inventory to have species-specific models built. These species – ash, big leaf maple, California bay, California buckeye, California nutmeg, edible fig, giant chinquapin, pacific yew, red alder, white alder, Shreve's oak, toyon, willow and wax myrtle – are estimated using the FORSEE internal height estimation process. FORSEE estimates values for missing heights during data input processing from measured sub-samples.

The FORSEE growth and yield model estimates heights using provided subsamples of measured heights. The regressions are fit and calculated within the FORSEE growth and yield model; the equations are not provided.

7. Data Management Approach

After data collection, values are transferred into Microsoft Access. Cruisers may collect data electronically or on paper plot cards. If using a data logger, collection options are customized for the Gualala Project cruise design (e.g., species codes, required fields). Plot values are double-checked after entry. The raw data logger outputs or the paper plot cards, whichever is applicable, are retained. Next, the data are imported into the Access database through an import macro procedure. Once in the database, a suite of QA/QC tests are run to identify any irregularities or problems. The QA/QC tests alerts the inventory manager of individual trees that fail the following tests:

- values outside the defined range of max and min DBH data
- values outside the defined range of max and min HT data
- unknown species code
- incorrect or missing defect codes or defect percentages
- missing heights on large conifer trees
- measured heights < measured HTCB

If questions arise during this stage of data review, the inventory database manager reviews the data or plot cards and contacts the field technicians to clarify entries, or to collect new data if necessary. If minor missteps/oversights come to light during the desk QA/QC process, but there is deemed to be an appropriate and available substitution which will not cause a plot to fail a check cruise, then occasionally these substitutions are used for logistical reasons. Examples of field data collection oversights with appropriate substitutions include: estimating aspect from geospatial records, estimating height using a regression, or maintaining only 1 unique GPS point for a plot location. When the plot is re-measured during the next forest inventory effort, these missing data points will be collected.

Following the QA/QC procedures, the data for the reporting period are ready for analysis. Microsoft Access databases for inventory and modelling are created and maintained for each reporting period. Unique datasets are maintained for each reporting period; datasets from previous reporting periods are archived when applicable verification and reporting activities are completed.

As plots are re-measured following disturbance events or inventory updates, the measurements are data checked and then incorporated into a new copy of the databases; old plot data is removed using replicable queries. The old data are archived and retained. Activities on each plot, such as re-measurement or disturbance events, will be tracked in a separate database which will serve as a plot level activity log.

All biological data are stored on personal computers and at least one other external backup device. Data backups are accomplished using the SyncBack file synchronization software. Data and worksheets used for project reporting are archived and saved following each submission. Any future work on these data sources is done on copies and the originals are saved for future reference. Additionally, all databases, worksheets, forms, and reports provided to the third-party verifiers are uploaded to the Conservation Fund's cloud-based ShareFile account for file transfer and record retention during the verification process.

Data management and calculations rely heavily on Access database based tools to translate field measurements into volume and biomass estimates. A suite of in-house computer code written in several languages aid in the processing and analysis of the data stored within Microsoft Access inventory databases. The relevant computer code is stored in inventory databases and also on a remote server using the Mercurial version control software.

8. Inventory Update Methodology

The forest inventory will be updated periodically. It is likely that the forest inventory will be collected on a rolling basis; a portion of plots will likely be re-measured annually instead of conducting a forest-wide inventory at extended intervals. Plots within a harvested area or other disturbed areas will be re-measured within a year. Because plots can land on forest roads or small openings, building new roads will be considered a disturbance and will cause the plot to be re-measured, but it will not cause the plot to be relocated. Field measurements will follow the methods outlined in Appendix A. Plot data from the previous field visit will be removed, archived, and replaced by the fresh measurements. At any point in time, plot data in the forest inventory will range from being less than a year old to 12 years old. The portion of the inventory which does not have new field data will be updated using the FORSEE "update inventory" function which grows forest inventories to a common year. All plots, including data collected that year, will be adjusted to the reporting period end using FORSEE. The annual adjustments will use the "Inventory Update" feature within FORSEE; mortality will be enabled. (The Project may also use the equivalent function in Visual CRYPTOS interface.)

The growth and yield model use only applies to standing live trees; there is not an appropriate method to model standing dead trees and the field measurements are held constant until the plot is revisited.

9. Additional Inventory Considerations

At some point in the future the landowner may wish to change the sample design or intensity to reflect a change in modeling or new science in that event the new inventory design will be submitted to ARB for approval.

Currently, the Gualala Project uses a stratified systematic sampling design where all selected plots have been installed. If additional plots are required in the future, an additional 5 x 5 chain grid with the same random start will be laid over the entire property and plots which fall within the forested areas will be randomly selected for sampling. Plots will be installed and measured following the same inventory methodology, which is explained here, in Appendix A.

Appendix C: Statistical Methods for Stratified Sampling

Introduction

ARB requires that all project developers calculate the accuracy of their forest inventory. ARB also requires that projects whose inventory exceeds certain accuracy thresholds deduct a portion of their claimed reductions due to uncertainties associated with their inventories. ARB defines the measure of variability of the carbon estimate as the 90% confidence limit of the mean in metric tons of carbon per acre (Mt C/acre). The accuracy calculations must be calculated for the total of all sampled carbon pools: standing live and standing dead carbon. For temporal consistency, the reporting period end adjusted values are used to calculate sampling errors. The confidence deduction will be recalculated at the end of each reporting period.

Simple Random / Systematic Stratified Sampling (SRSS)

The Gualala Project uses a simple random/ systematic stratified sampling design (SRSS) to measure the forest carbon stocks. Plots to sample are randomly selected using a grid of plots. The Gualala Forest only has 1 stratum, and SRSS is calculated accordingly.

The overall mean and standard error (SE) equations at the end of the reporting period are calculated for the stratum and is the basis for the calculations.

1.1. Calculations and Equations

The equations and terms defined below detail how the mean and SE from a SRSS sample can be calculated.

$$\text{Equation 1: SRSS Overall Mean } \bar{y}_o = \frac{1}{N} \sum_{h=1}^L N_h \bar{y}_h$$

$$\text{Equation 2: SRSS Overall SE } SE_o = \sqrt{S_{y_o}^2} = \sqrt{\sum_{h=1}^L \left(\frac{N_h}{N} \right)^2 \left(\frac{S_{y_h}^2}{n_h} \right) \left(\frac{N_h - n_h}{N_h} \right)}$$

The table below defines the variables seen in the equations above as explained in Shiver and Borders (1996). The 90% sampling error is defined by multiplying the overall SE (SE_o) by the z-statistic that corresponds to 90% of the area under a z-distribution - 1.645. To then calculate the accuracy, the 90% sampling error is divided by the overall mean ($\bar{y}_o$) and the accuracy is the resulting percentage.

For fixed area plots, if 20 ($n_h = 20$) 1/5 acre fixed area plots are installed in a strata that is 100 acres in size, then the total potential number of plots in strata is: $N_h = 100 \text{ acres} * 5 \text{ plots/acre} = 500 \text{ plots}$.

SRSS Variable definition from Shiver and Borders (1996)

Variables	Definition
L	No. of Strata
N	Total potential sampling units (plots) in the entire population
N_h	Total potential sampling units (plots) in strata h
n_h	Actual number of sampling units (plots) in strata h
strata weight = $\frac{N_h}{N}$	The strata weight (in terms of total potential plots).
Finite population Adjustment (FPA) = $\frac{N_h - n_h}{N_h}$	Finite population adjustment - this adjusts the sample estimate based on the proportion of the area of the strata that was not sampled. The more of a stratum is actually sampled, the less potential error there is. At the extreme, if every tree in a stratum was measured, there would be no sample variance as the entire population would have been measured. In the case of most forest inventories, this value will be close to 1 as most trees are not sampled.
$\bar{y}_h = \frac{1}{n_h} \sum_i y_{h,i}$	The mean for strata h where each plot value is y _{h,i} . The strata mean is found by summing all of the plot values and dividing by the number of plots.
$S^2_{y_h} = \frac{1}{n_h - 1} \left[\sum_{i=1}^{n_h} y_{h,i}^2 - \frac{\left(\sum_{i=1}^{n_h} y_{h,i} \right)^2}{n_h} \right]$	The simple variance among plots is calculated as any variance would be calculated; using the sum of the squared differences of each plot value from the mean value and adjusting by the degrees of freedom.

1.2. Accuracy Assessment Process

The first step in calculating the accuracy based on the method outlined above is to calculate each plot's total carbon per acre at the end of the reporting period. This calculation is done using the Reserve approved equations for biomass and carbon for both live and dead material and then calculating the belowground carbon and summing to find the total carbon per acre for each plot. The variance is then calculated for each stratum based on the individual plot results.

If the sampling error is above 5.0%, then the Protocol requires that a confidence deduction is taken. The confidence deduction is the sampling error minus 5.0%, rounded to the nearest 1/10th of a percent (see Protocol, Appendix A.4). If the sampling error is 20.0% or above, the confidence deduction is 100%.

1.3. Accuracy Results

The table below shows the 90% accuracy of the Gualala Project inventory.

Gualala 90% accuracy levels from Reporting Period 1 End

Mean standing live & standing dead	57.45	MgC/Acre
SE of mean	1.91	MgC/Acre
SE*1.645 (90% CI)	3.15	(1.91)*(1.645)
Sampling Error of 90% CI	5.48%	(3.15)÷(57.45)
Inventory Confidence Deduction	0.5%	5.5% - 5%

Appendix D: Calculation of GHG Reductions and GHG Removals Enhancements

The reporting period between 1/1/2015-5/31/2016 is the first reporting period that the Gualala River Forest Project is under the Protocol, therefore only the pertinent calculations are reported here. There was a negative credit difference between the early action protocol and the Compliance Offset Protocol.

Calculation of GHGs for Reporting Period Ending 12/31/2015

	Reporting Period 1 (Ending 5/31/2016)
Calculating GHG Reductions/Removals for Onsite Carbon Stocks	
Actual Onsite Carbon Stocks (MtCO ₂ e)	2,830,842
Confidence Deduction	0.5%
Adjusted Actual Onsite Carbon Stocks (adjusted for confidence deduction) (MtCO ₂ e)	2,816,688
Increment in Actual Onsite Carbon Stocks (MtCO ₂ e)	140,662
Baseline Onsite Carbon Stocks (MtCO ₂ e)	2,031,646
Increment in Baseline Onsite Carbon Stocks (MtCO ₂ e)	0
Quantified GHG Reductions / Removals for Onsite Stocks (MtCO ₂ e)	140,662
Calculating Carbon Stored in Wood Products Including Market Effects and Leakage	
Actual Wood Products In-use (MtCO ₂ e)	0
Actual Wood Products Including Landfill (MtCO ₂ e)	0
Actual Wood Products PDM (MtCO ₂ e)	0
Baseline Wood Products In-use (MtCO ₂ e)	11,339
Baseline Wood Products Landfill (MtCO ₂ e)	7,326
Baseline Wood Products PDM (MtCO ₂ e)	75,727
Difference in Actual and Baseline Carbon Stored in Wood Products (MtCO ₂ e)	(18,664)
Quantified GHG Reductions/Removals for Carbon Stored in Wood Products (MtCO ₂ e)	(14,932)
Calculating Other Secondary Effects - Improved Forest Management Projects	
PDM Difference (MtCO ₂ e)	(73,904)
Secondary Effects Adjustment (MtCO ₂ e)	(14,781)
Calculation of Total Net GHG Reductions/Removals and Buffer Pool Contribution	

Gualala River Forest - ARB

Appendix D

Negative Carryover from Prior Year (MtCO2e)	0
Total Net GHG Reductions/Removals (MtCO2e)	110,950
Total Credits Issued (MtCO2e)	110,950
Risk of Reversal	19.236%
Required Buffer Pool	21,343
Credits Issued to the Project	89,607

Early Action Credits as Compared to COP ARBOCs

		Credits issued under early action protocol (CRTs)	Credits that would have issued under Compliance Protocol	Credits eligible to be converted to ARBOCs
Early Action Credits	2004	-	-	-
	2005	-	-	
	2006	-	-	
	2007	5,426	-	5,426
	2008	75,734	39,656	75,734
	2009	80,882	43,573	80,882
	2010	86,312	45,650	86,312
	2011	63,811	47,798	63,811
	2012	81,945	50,019	81,945
	2013	564	52,317	564
	2014	11,982	54,693	11,982

Appendix E: Demonstration of Sustainable Long Term Management

Intro

ARB's 2014 US Forest Project Compliance Offset Protocol (Protocol) requires that projects employ sustainable long-term harvesting practices (see section 3.8.1). There are three options to demonstrate sustainable long-term harvesting. TCF is using option 3 to meet the criteria for the 2015 reporting period which states:

3. The Forest Owner must employ uneven-aged silvicultural practices (if harvesting occurs) and must maintain canopy cover averaging at least 40 percent across the entire forestland owned by the Forest Owner in the same Assessment Areas covered by the Project Area, as measured on any 20 acres within the Forest Owner's landholdings found in any of these Assessment Areas, including land within and outside of the Project Area (areas impacted by Significant Disturbance may be excluded from this test). (Protocol, pg 18)

Naturally occurring openings and meadows as well as areas disturbed by wildfire are excluded from this test according to guidance from CAR/ARB (Nickerson pers email 9/17/2015).

The Conservation Fund owns a total of approximately 53,000 acres within the Coast Redwood/Douglas-fir Mixed Conifer Assessment Area. These are – Big River 11,707, acres; Salmon Creek, 4,205 acres; Garcia River Forest, 23,780 acres; Gualala River Forest, 13,540 acres; and the Hardell Tract, 185 acres. All properties are forested and have been managed for forest products since the early 1900's.

Analysis

In June of 2015, digital aerial image information called "Phodar" was collected for all North Coast Forest carbon projects by Quantum Spatial. Using the Phodar and existing ground elevation information derived from 2011 LiDAR imagery, Quantum Spatial developed a digital canopy height model for the properties which contains canopy height and width (surface area) values for the vegetation within the assessment area. The resulting data allows 3-dimensions analysis of the properties; the digital height model was used to evaluate the forests canopy cover.

Canopy at least 3 meters tall was considered to be established woody vegetation. A 20-acre "moving window" was used to calculate the average percent canopy within all potential 20-acre polygons across the property in ArcGIS 10.1; a 20-acre area centered on each pixel was evaluated for percent canopy. All nonforested acres were removed from the data set prior to the analysis. The nonforested acres are known areas that have natural openings such as grasslands and river gravel bars which are not forestland and are not part of carbon calculations, following project specific minimum mapping unit size and stratification.

Because the Hardell Tract is not a carbon project, Phodar imagery was not collected for the entire property. Of the 185 acres, 57 acres do not have Phodar imagery. These 57 acres were analyzed for percent canopy cover using USFWS's i-Tree Canopy tool (<https://www.itreetools.org/>). To do this, the shapefile was imported into the online tool and 50 points were added and reviewed.

The attached maps show that the entire TCF forestland ownership within the Coast Redwood/Douglas-fir Mixed Conifer Assessment Area has at least 40% canopy cover. There were no areas on any of the properties evaluated which did not pass the 40% canopy test for trees greater than 3 meters tall.

Average percent canopy by tract.

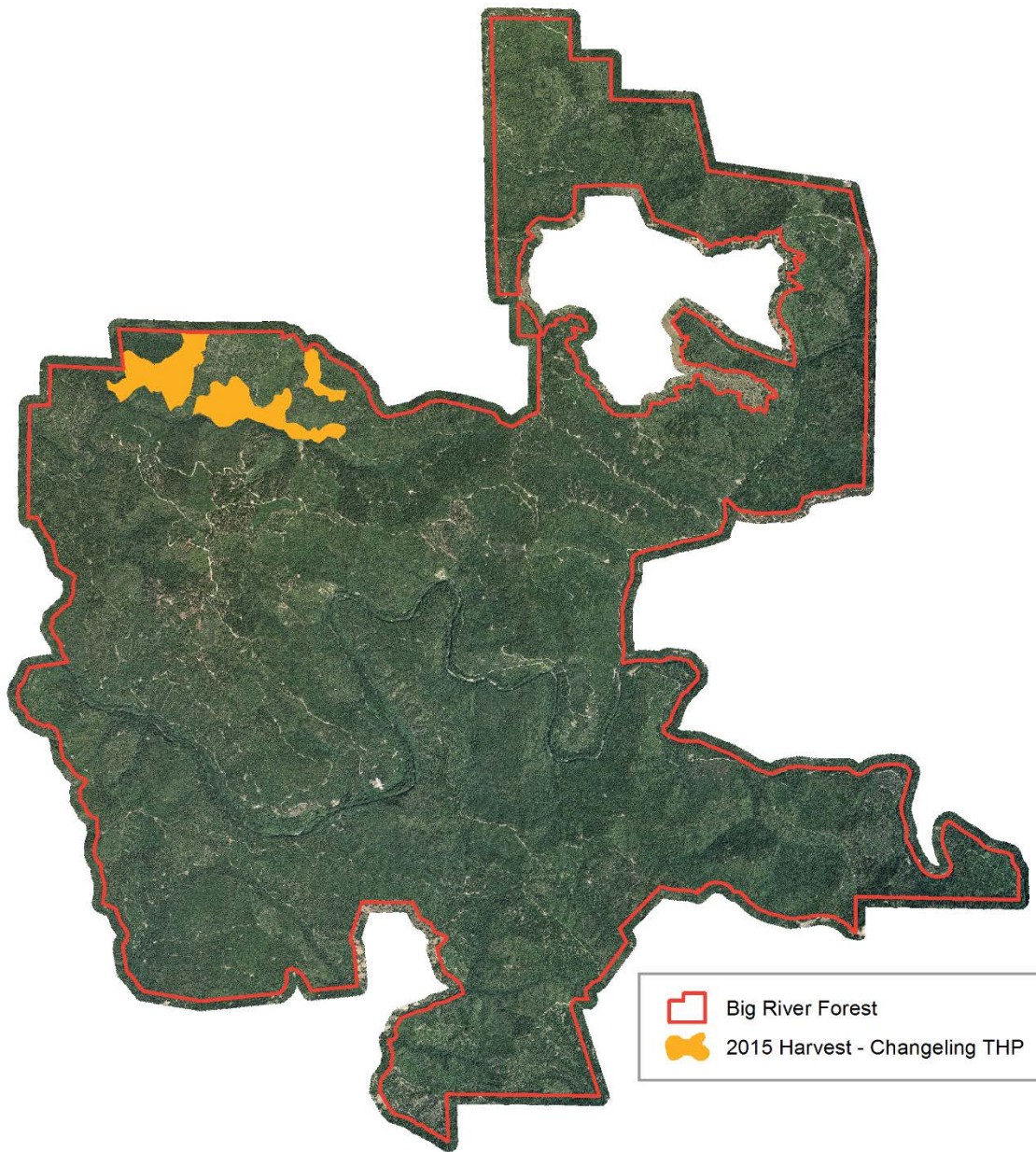
Forest Tract	Average Percent Canopy	Min Percent Canopy
Big River	91%	57%
Salmon Creek & Portion of Hardell Tract	91%	47%
Garcia River Forest	96%	57%
Gualala River Forest	95%	66%

Additional Considerations

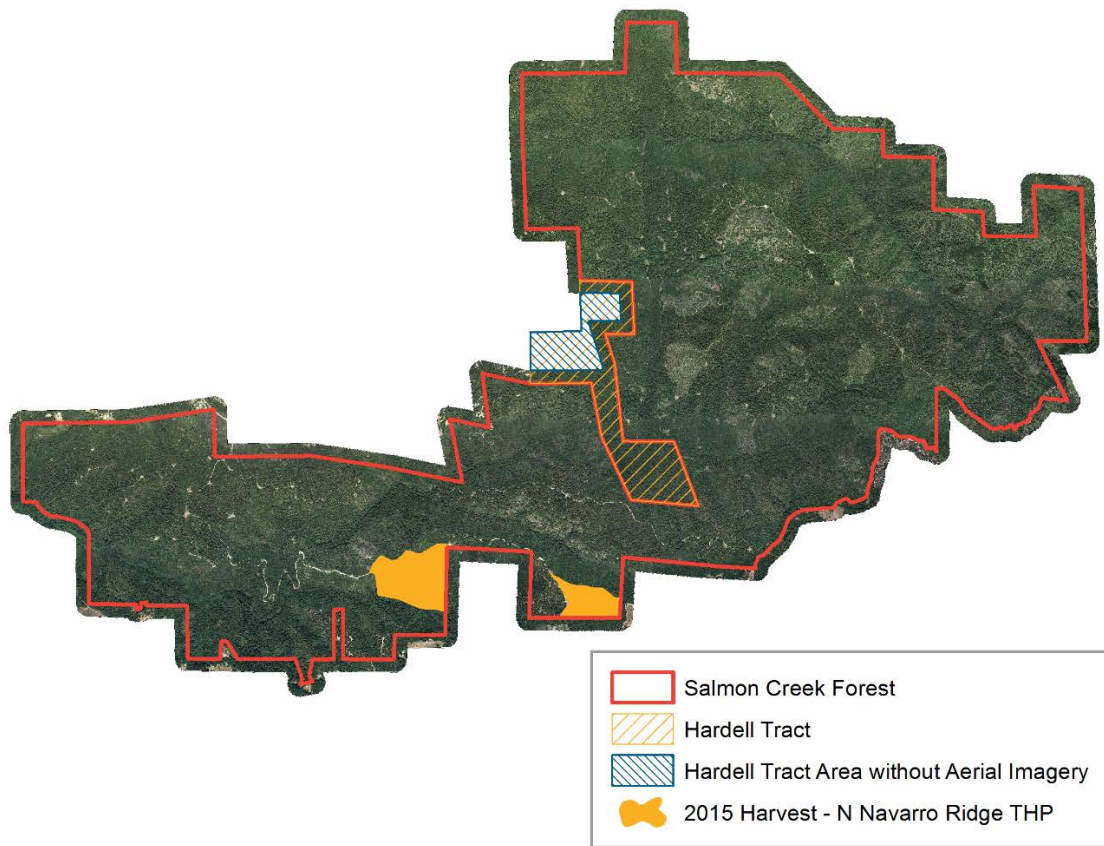
Since the Phodar imagery was collected, there have been three timber harvests in the project areas. The table below shows the approximate acres harvested after the Phodar acquisition. These harvests employed similar silviculture to other timber harvests on TCF property and are therefore presumed to meet the 40% canopy test. Most TCF harvests, including the three in the table below, have been selection harvests. Single tree and group selection harvests remove individual trees here and there from a large area; selection harvests leave significant canopy cover and forest structure. Given that the 2015 harvests employed silviculture consistent with previous timber harvests which retained at least 40% canopy, we can reasonably assume that the 2015 timber harvests also meet the test.

THPs with Harvest Operations since June 2015

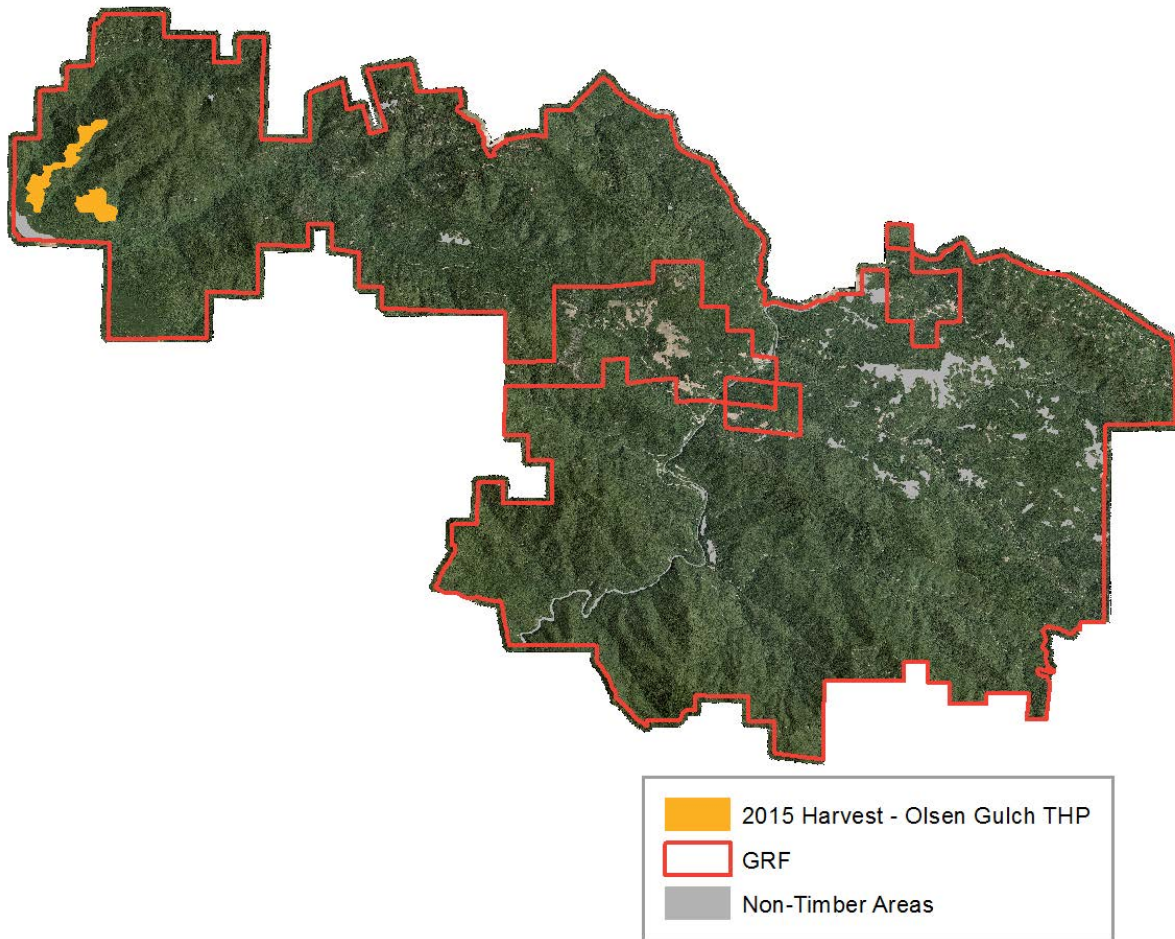
Year	THP Name	THP Number	Forest Tract	Acres
2015	Olsen Gulch	1-14-036 MEN	Garcia River Forest	152
2015	Changeling	1-14-101 MEN	Big River	192
2015	North Navarro Ridge	1-10-005 MEN	Salmon Creek	82



Big River Forest – the Big River tract had 40% canopy throughout. Areas that were operated on in 2015 with the Changeling THP are in yellow (192 acres). High-resolution aerial imagery was collected in June 2015 in conjunction with the Phodar data collection.



Salmon Creek Forest – The Salmon Creek Tract had 40% canopy throughout. The carbon project is outlined in red. The 2015 operations area in North Navarro Ridge THP is in yellow (82 acres). The Hardell Tract is in yellow cross-hatch; the blue cross-hatch in the center of the figure is the 57-acre portion of the Hardell Tract that did not have Phodar collection and was analyzed with iTree Canopy. The Hardell tract had 40% canopy throughout.



Garcia River Forest – The Garcia River Forest had 40% canopy throughout. Areas that were operated on in 2015 with the Olsen Gulch THP are in yellow (152 acres). The areas in gray are natural openings including grasslands and the Garcia River gravel bar.



Gualala River Forest – The Garcia River Forest had 40% canopy throughout. The areas in gray are naturally occurring grasslands and are excluded from the analysis. There was no timber harvest in the forest in 2015.

Appendix F: Modeling Plan for Gualala River Forest

Gualala River Forest IFM Modeling Plan

By James D Clark, RPF #2528

April 10, 2017

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Introduction:

This Modeling Plan is intended to provide the information required by Appendix B of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014 with respect to the updating and forecasting of carbon stocks over the Project's initial crediting period. The baseline analysis described in this modeling plan is based on the analysis presented for the Early Action project CAR660 that was verified as a part of CAR660's initial reporting period.

Visual CRYPTOS (CRYPTOS Emulator):

Prior to the recent development of FORSEE, the procedure for modeling individual plots using CRYPTOS, and tracking the resulting inventory, harvest, and growth was problematic since the original CRYPTOS user interface is antiquated. The previous CRYPTOS interface was extremely difficult to manage in extended runs with many plots, while implementing various silvicultural prescriptions, multiple ingrowth files, and calibrations. To resolve these problems, Coastal Forestlands contracted with Jan Derksen, Ph.D. for the development of a timber growth and harvest modeling tool, which allows for management of the required complexity in a user-friendly manner, and for the comparison of various 100-year modeling scenarios. This tool has evolved over the years, and is currently referred to by the author as Visual CRYPTOS (VC). VC was previously named the CRYPTOS Emulator, which is listed in ARB's Forest Project Protocol, November 14, 2014 as an approved model.

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

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

VC allows users to load and maintain in a database:

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

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

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

Growth and Yield Modeling:

The baseline growth and yield modeling analysis described in this document is performed on an individual plot basis using the Visual CRYPTOS model. The growth and yield model FORSEE has been used for projecting the 2015 plot data to the project start date, the start of the initial reporting period under the Compliance Protocol, and to the end of the initial reporting period under the Compliance Protocol.

Plot Data:

The modeling presented in this document is based on 214 cruise plots installed in the fall and winter of 2015 across the Gualala River Forest. The 2015 plot data has been adjusted to 1/1/2004 which for all intents and purposes represents the Project stocks as of the 12/22/2003 project start date. These plots were installed systematically across the timbered portion of the Gualala River Forest.

In addition to data from the 2015 inventory, data has also been obtained from a series of 90 permanent plots Coastal Ridges maintains across its ownership. These plots were initially installed and measured in 1994 with

the majority being measured in late 1994 and early 1995. In 2007 and 2008, 86 of these permanent plots were remeasured. Of these 86 plots, 67 had been previously re-measured between 2000 and 2003. Data from these permanent plots has been used for the calculation of CRYPTOS basal area calibration factors as described below.

Updating the Inventory:

As timber management activities take place on the Gualala River Forest Project Area or disturbance such as fire or mortality resulting from pathogens or other factors occurs, cruise plots installed in 2015 will be relocated and remeasured within areas that have been harvested, treated for hardwood reduction, or subject to other disturbance. By 2028, all of the plots installed in 2015 will have been remeasured regardless of whether or not the plot had been harvested, treated for hardwood reduction, or subject to other disturbance. On this basis, the Gualala River Forest will maintain a forest inventory system that will meet the inventory specifications and requirements with plots which are no more than 12 years old.

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

1. Any newly installed inventory plots will be incorporated into the inventory estimate.
2. Existing inventory plots will be updated using Visual CRYPTOS or FORSEE as described in the modeling plan.
3. Updating the forest inventory for harvests or disturbances that have occurred during the previous year through the installation of new plots, or adjustments to previous plot data.
4. Inventory updates following harvest or disturbance will be re-measured within 12 months of the harvest or disturbance.

Volume Calculations:

Board foot volume calculations utilize the standard CRYPTOS volume equations taken from Bulletin 1907, by Krumland and Wensel (1983). Reported volumes are in board feet Scribner Scale for all conifers 8.0 inches DBH and larger to a 6" merchantable top. FIA cubic foot volume equations are used for the calculation of wood products cubic foot volumes delivered to the mill.

Biomass Calculations:

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

Species	Bole Cubic Ft Volume	Bark Biomass	Live Crown Biomass
Redwood	Equation 24	Equation 17 if DBH >39.37 otherwise Equation 13	Equation 10
Douglas-fir	Equation 3	Equation 8	Equation 6
Other Conifer (Sugar pine)	Equation 20	Equation 10	Equation 8
Tanoak	Equation 34	None	None
Other Hardwood (Madrone)	Equation 40	None	None

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

Adjusting the 2015 Inventory Data to 1/1/2004:

As the plots were measured between October 2015 and December of 2015, the cruise data was adjusted backward to the Offset Project Commencement date of 1/1/2004 by adjusting the height and diameter of each tree in the inventory database based on the number of days from 1/1/2004 to the date the plot on which the tree is located was cruised and applying a calculated height and diameter increment developed from data produced by growing the plot data five years forward in FORSEE.

Mortality in the inventory adjustment is assumed to be negligible. This is an appropriate assumption for several reasons. First, there is little natural mortality^[1] in the redwood region and the Gualala River Forest in particular, which is a young forest. The dominant tree species in the redwood/Douglas-fir forest are long-lived. Redwoods, Douglas-firs, and even tanoaks can live to be hundreds of years old^[2]. Thus, it is reasonable to assume that inventory

^[1] Lindquist, J. L. 2004. Growth and Yield Report for the Whiskey Springs Redwood Commercial Thinning Study: A Twenty-Nine Year Status Report (1971-1999). California Forestry Report No 3, February 2004.

^[2] Plant Guide: Tanoak *Lithocarpus densiflorus*. USDA NRCS National Plant Data Center, May 2003. Available: https://plants.usda.gov/plantguide/pdf/cs_lide3.pdf

adjustments are unnecessary given the timescale, health, and management of the forest.

After applying the calculated height and diameter increment developed from data produced by growing the plot data five years forward in FORSEE, trees less than 1 inch DBH and less than 4.5 feet tall were deleted from the 1/1/2004 database.

There has been no conifer timber harvesting since the project's start in 2003; however, approximately 1,086 acres of the timbered portion of the property have been treated with herbicides to kill hardwoods since the project's start in 2003. These treatments occurred over several years, with the most recent treatment occurring in the fall of 2009. Approximately 540 acres were treated in May of 2004, 511 acres treated in September of 2007, and 36 acres in June of 2009.

To ensure that the plot data as of 1/1/2004 reflected these hardwood treatments, the plot data was adjusted in several ways. All recorded dead hardwoods on plots within areas treated for hardwood reduction were added back into the 1/1/2004 dataset as live trees. Plots within the treatment areas were adjusted by adding live hardwoods to the 19 plots within the treatment areas. Table 1a shows the plots within the hardwood treatment areas by year.

Table 1a: Plots within hardwood treatment area.

Year	Count	Plots
2004	10	370, 383, 384, 385, 395, 396, 397, 407, 420, 421
2007	8	318, 329, 340, 341, 342, 355, 356, 357
2009	1	312

The adjustment was based on a comparison of eight adjacent plots to the 2004 treatment area. These eight plots averaged approximately 48 square feet of basal area per acre of hardwoods, in 2008 with four of the eight plots having no hardwood basal area. The four plots with hardwoods averaged 94 square feet of hardwood basal area. Using the average hardwood tree distribution from these four plots, eight tanoak trees ranging in diameter from 3 to 11 inches DBH with average tree per acre expansions as shown in table 1b below were added to each of the 19 treated plots identified in table 1a above.

Table 1b: Average tree list added to reflect hardwood treatments.

Species	DBH	TPA	Ht	LCR
TO	3	31	20.7	0.30
TO	4	25	24.2	0.40
TO	5	13	27.4	0.40
TO	6	19	30.2	0.43
TO	7	25	32.8	0.45
TO	8	56	36.3	0.50
TO	9	19	39.8	0.53
TO	11	6	44.0	0.80

Adjusting the 2015 Inventory Data to 1/1/2015:

The inventory data used to estimate carbon stocking as of 1/1/2015 or the beginning of the first reporting period was constructed in a manner similar to the adjustment to the start date described above; however, the height and diameter of each tree was increased or decreased based on the number of days between when the plot was cruised and the beginning of the reporting period. All effects of the herbicide treatments were assumed to have occurred prior to the beginning of the reporting period, so no herbicide treatment adjustments were made.

Projecting the 2015 Inventory Data to 5/31/2016:

The inventory data used to estimate carbon stocking as of 5/31/2016 or the end of the first reporting period was constructed in a manner similar to the adjustment to the start date described above; however, the height and diameter of each tree was increased or decreased based on the number of days between when the plot was cruised and the end of the reporting period. All effects of the herbicide treatments were assumed to have occurred prior to the beginning of the reporting period, so no herbicide treatment adjustments were made.

Calibration:

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

CRYPTOS' growth increments can be calibrated, that is, adjusted for local conditions. By comparing local growth measurements with growth

increments predicted by CRYPTOS for the same trees in the same stands, a basal area growth calibration factor can be computed. CRYPTOS allows both basal area growth and height growth to be calibrated.

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

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

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

Table 1c: Basal Area Calibration Factors

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

These calibration factors will be utilized for the first two periods of the 100-year baseline modeling scenario, and during future inventory updates utilizing the VC model to estimate stand growth. It is felt that calibration of the baseline is at least appropriate for the first two periods until conifer stocks increase. The frequent harvests projected in the baseline have the effect of minimizing potential inaccuracies of the growth model as growth is checked every 10 years by harvest.

Ingrowth:

The amount of ingrowth added to each plot during each decade of the planning period is calculated from several factors. The maximum number of ingrowth trees added is determined by the silvicultural prescription under which the plot is being harvested. The species composition of ingrowth is determined by calculating the species composition of the pre-harvest plot by basal area, and then adjusting the percentage of redwood seedlings to a minimum of 25% percent.

Table 2: Regeneration (Ingrowth) Assumptions

Prescription	Regeneration Assumption
Selection	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 45 seedlings per acre. Hardwood regeneration is 8 seedlings per acre.
Selection (WLPZ)	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration varies from 8 to 15 seedlings per acre. Hardwood regeneration is 3 seedlings per acre.
Transition	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 60 seedlings per acre. Hardwood regeneration is 10 seedlings per acre.
Group Opening	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 100 seedlings per acre. Hardwood regeneration is 18 seedlings per acre.
Rehabilitation	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 100 seedlings per acre. Hardwood regeneration is 18 seedlings per acre.
Non-Commercial (Release)	As these stands are well stocked prior to harvest, no ingrowth is assumed for this treatment.
Even-Aged	Natural regeneration and planted seedlings are assumed for this treatment. Conifer regeneration is 50 seedlings per acre. Hardwood regeneration is 10 seedlings per acre.

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

Site Index:

In order to conduct growth modeling for the property, it was necessary to develop an estimate of average 50-year base age site index by species for the Project Area. The Cryptos Emulator utilizes redwood site index as Wensel and Krumland 50-year breast height age, and Douglas-fir as King 50-year breast height age.

Site index is derived from data collected as part of the 2015 inventory. The inventory measured 91 site trees (54 Douglas-fir, 35 Sugar pine, and 2 Redwood). These trees were utilized by FORSEE to calculate site index for all tree species in the inventory.

The average site index by dominant conifer species as calculated by FORSEE for the property is shown in Table 3 below. These values were entered into VC, and VC calculated site index for all other species modeled.

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

Table 3: Site Index by Species

Gualala River Forest

Species	Site Index
Douglas-fir	102
Redwood	103

Project Acreage:

The Gualala River Forest Improved Forest Management Project (the “Gualala River Forest Project”) is comprised of 13,447.69 acres of timberland on the larger 13,539.71 acre ownership block. The topographic map included in Attachment A of the OPDR shows the Project Area boundary.

Baseline Modeling:

The baseline modeling utilizes the above-described 2004 plot dataset, and an unevenaged management harvesting strategy employing selection and transition combined with small group openings not exceeding 2.5 acres in size. Portions of the Gualala River Forest's timber stands are dominated by hardwoods species, or are in an understocked condition. The baseline modeling assumes an aggressive treatment of hardwood species in order to release existing conifer regeneration, and convert areas dominated by hardwoods to conifer occupation. Since 2003, the previous landowner has treated approximately 1,086 acres on the Project Area for the purpose of reducing hardwood stocking (primarily tanoak), and releasing existing conifer regeneration. The baseline harvest scenario assumes a continuation of this intensive hardwood reduction program.

A Conservation Easement was recorded on the Gualala River Forest on November 14, 2011 which requires that the terms and conditions of the Easement be taken into account when calculating the baseline/ business-as-usual for purposes of establishing carbon credits. The baseline modeling described herein has been designed to address the terms of the Easement as they relate to limits on forestry practices on the Gualala River Forest.

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

At the Project's initiation on 12/22/2003 there were no approved Timber Harvest Plans (THPs) on the Project Area.

The OPO also obtained approval of an Option A document in 9/14/2015 which documented the manner by which sustained yield would be demonstrated on the Gualala River Forest. The Option A describes the silvicultural parameters to be employed and sets limits on conifer harvests.

In general, the baseline modeling employs the same silvicultural constraints described in the OPO's approved Option A document with the exception of heavier hardwood reduction, slightly increased WLPZ harvesting more in line with the minimums of the rules, as well as the application of some group selection. Harvests are modeled to the minimum of the Forest Practice

Rules for the ten decades of the baseline analysis while considering the constraints of the Conservation Easement.

Baseline Harvest Strategy:

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

Silvicultural treatments under the baseline scenario in the first decade of the 100-year planning period are dominated by transition harvests (38%), rehabilitation of understocked areas (19%), selection (15%), and release of well stocked conifer stands through hardwood control (5%).

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

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

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

General Harvest Constraints:

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

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

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

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

Even though the proposed Conservation Easement was not in place at the time of the project's initiation, the terms of the Easement require that the terms and conditions of the Easement be taken into account when calculating the baseline. The Easement terms place three additional forest management restrictions on the Gualala River Forest above the standard Forest Practice Rules [see section 3(c)]. The first restriction involves increased protection for watercourses as follows:

- (1) For Class I and II watercourses, within the WLPZ (as defined below), there shall be no commercial harvest of hardwoods and even-aged silviculture shall be prohibited.

- (2) The WLPZ harvest restrictions set forth in the Forest Practice Rules for Class I watercourses shall apply to the first 200 (slope distance); in addition, a commercial harvest exclusion zone shall extend 25 feet (slope distance) outward from the top of the banks, within which no commercial timber harvesting may occur, except that trees may be harvested to create stream crossings necessary for current and future timber operations.
- (3) For Class II watercourses, the minimum width of a WLPZ shall be 100 feet (slope distance).
- (4) For Class III watercourses, the minimum width of an Equipment Limitation Zone (ELZ) shall be 50 feet (slope distance).

The second restriction sets limits on allowable conifer harvest as follows:

- (1) The conifer harvest volume in any one decade for the entire Property, shall not exceed eighty percent (80%) of total conifer growth occurring in that decade for the Property. This restriction shall remain in effect until such time as the average conifer volume per acre equals or exceeds 20,000 board feet per acre (as measured in Scribner Scale). Thereafter, conifer harvest volumes shall not exceed net conifer growth for the entire Property. Before the beginning of the sixth decade Grantor reserves the right to apply an even-age management regime to transition the Property from forest stands dominated by Tan oak to a more desired ecological condition of mixed conifers and hardwoods. Thereafter, an even-age management regime may only be applied in future rotations to achieve a desired ecological condition as approved by the Grantee and WCB.

The third restriction involves specific protections for true oak (*Quercus*) and other hardwood species as follows:

- (1) Non-native vegetation and conifers may be removed from true oak (*Quercus*) woodlands and grassland areas to prevent conversion of such areas to conifer forest, provided the methods employed in connection with such removal, including controlled burns, are fully in compliance with applicable laws, rules and regulations of all governmental agencies with jurisdiction over such removal;
- (2) In areas not managed for the commercial production of conifer timber there shall be no cutting of a standing true oak (*Quercus*), Chinquapin, or madrone tree except as necessary for health and safety reasons;
- (3) In areas managed for the commercial production of conifer timber there shall be no cutting of a standing true oak (*Quercus*), Chinquapin, or madrone tree except as necessary and incidental to forest management operations as permitted by the State of California, health and safety or CDF approved road construction;

- (4) True oak (*Quercus*), Chinquapin, or madrone trees may be removed if they are infected with Sudden Oak Death disease or other diseases. They may also be removed for fire prevention and suppression purposes and in connection with road and utility line construction and maintenance to the extent such construction and maintenance are permitted hereunder; and
- (5) Cutting of naturally fallen true oak (*Quercus*), Chinquapin, or madrone tree is permitted for non-commercial fuelwood use.

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

No-harvest zones have also been established around all Northern Spotted Owl (NSO) activity sites.

These constraints are modeled by calculating the acreage of each identified constraint, to determine the combined constrained acreage. The plot data is run with a 100-year no-harvest regime. The yield stream from this reduced harvest is weighted by the constrained acreage and combined with the baseline harvest regime weighted by the unconstrained acreage to determine the final baseline carbon stocks through the 100-year analysis period.

Class I no Harvest Zone:

Utilizing the Project's GIS, it is estimated that 97.40 acres are located within 25' of either side of a class I watercourse.

Harvesting WLPZ Plots:

Plots within the WLPZ were selected by buffering class I and II watercourses within Coastal Ridges' GIS. To account for the increased WLPZ widths prescribed by the Easement, Class I watercourses were buffered 175' horizontal, and class II watercourses were buffered 80' horizontal. Using this buffer analysis, 21 plots are within class I or II WLPZs, or approximately 9.8% of the plots. These plots are harvested using the selection silvicultural prescription depending on basal area stocking (please see tables 4a-4c below). Harvest levels within the WLPZ are designed to meet FPR standards for shade canopy retention. FPR requirements for the retention of the largest trees, and restrictions on harvests within the channel zone are addressed given the basal area retention standards applied in the model. Hardwood harvesting in the WLPZ is aimed at reducing competition with conifers, recruiting in-stream large wood debris, and allowing the WLPZ zones to convert to well stocked conifer dominated stands. Hardwood retention is

modeled at 18 to 28 square feet of basal area per acre depending on conifer stocking. Hardwood modeling within the WLPZ zones limits the commercial harvest of hardwoods but not the cutting of hardwoods to promote conifer re-occupation or large woody debris recruitment.

Harvest Restrictions Imposed by the Conservation Easement:

To model the Conservation Easement restriction that harvest not exceed 80% of decadal growth in the baseline modeling scenario the minimum conifer basal area retention for the transition and selection silvicultural prescriptions were increased in the 1st through 10th decades above the minimums of the Forest Practice Rules so as to restrain conifer harvest to no more than 80% of growth in each decade.

Northern Spotted Owl:

NSO activity centers are given a 1,000 foot no harvest buffer. There are approximately 226.41 acres of no-harvest NSO buffers associated with the Gualala River Forest.

Hardwood Harvest:

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

The Conservation Easement includes specific protections for true oaks and hardwoods other than tanoak. As the entire Project area is managed for the commercial production of conifer timber, and as these restrictions allow for the harvest of true oaks, madrone, and Chinquapin (Protected Hardwoods) in areas managed for commercial production of conifer timber incidental to forest management operations permitted by the State of California, the modeled hardwood harvests are believed to be consistent with the requirements of the Conservation Easement.

In compliance with the terms of the Conservation Easement regarding maintaining Protected Hardwoods, the proper metric to be applied is relative site occupation based on basal area per acre. Therefore, as long as the current relative site occupation of Protected Hardwoods is maintained throughout the baseline analysis period, the terms of the Easement are satisfied.

In order to ensure that the baseline modeling accurately accounted for the Conservation Easement's requirement to favor the retention of hardwoods

other than tanoak, the modeling script was modified so as to retain the modeled hardwood basal area in hardwoods other than tanoak first, and then to only retain tanoak when the required hardwood basal area retention standard could not be met entirely with other hardwoods. This approach shows that the relative stocking of other hardwoods (madrone, true oaks, Chinquapin and assorted hardwoods) herein referred to as “OH” is maintained at levels close to those at the project initiation in 2004, and in fact OH stocking measured in terms of basal area per acre as a percentage of total hardwood stocking increases from 16.5% in 2004 to 41.8% at the end of the 100-year analysis, or an increase of 253%.

This modeling scenario maintains other hardwood stocking at a level in excess of the 8.9% relative basal area level of Protected Hardwoods which existed in 2004. Therefore, Protected Hardwoods are maintained close to their initial stocking levels in terms of relative basal area percentages thus maintaining biological and vegetative diversity

In order to maintain other hardwood relative stocking levels through the baseline analysis period, an additional 10 square feet of OH basal area per acre was retained in the first decade above the prescribed hardwood basal area retention level shown in Table 4c below on plots which contained adequate pre-harvest OH basal area per acre. This additional OH basal area retention was reduced to 5 square feet per acre in the second decade and beyond.

Non-Commercial Treatments:

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

Unevenaged Silviculture:

All forest stands in the project area are subject to retention standards for uneven-aged silviculture based on their “Timber Site” or site class. Forest

stands in the project area of this constraint class must follow these terms at a minimum:

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

Selection:

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

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

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

- 1) Trees to be harvested or trees to be retained shall be marked by or under the supervision of the RPF prior to felling operations. When openings greater than .25 acres will be created, the boundaries of the small group(s) may be designated in lieu of marking individual trees within the small group areas. A sample area must be marked prior to a preharvest inspection for evaluation. The sample area shall include at least 10% of the harvest area up to a maximum of 20 acres per stand type which is representative of the range of conditions present in the area.
- 2) Post harvest stand stocking levels shall be stated in the THP. The level of residual stocking shall be consistent with maximum sustained production of high quality timber products. In no case shall stocking be reduced below the following standards:
 - A. Selection System.

1. On Site I lands at least 125 square feet per acre of basal area shall be retained.
2. On Site II and III lands at least 75 square feet per acre of basal area shall be retained.
3. On Site IV and V lands at least 50 square feet per acre of basal area shall be retained.
4. Unless the plan submitter demonstrates how the proposed harvest will achieve MSP pursuant to 14 CCR § 913.11 (a) or (b), the residual stand shall contain sufficient trees to meet at least the basal area, size, and phenotypic quality of tree requirement specified under the seed tree method.

B. Group Selection.

1. At least 80% of the stocked plots must meet the Basal Area stocking standards of 14 CCR 913.2(a)(2)(A).
 2. Not more than 20% of the stocked plots may meet stocking standards utilizing the 300 point count standard with trees that are at least 10 (ten) years old.
 3. An RPF or supervised designee may offset up to 8 plots per 40 plots where those plot centers are initially placed within small group clearings created during the current harvest. Unless substantially damaged by fire, the RPF or supervised designee shall not exclude small group clearings created by previous timber harvesting from the stocking survey.
 4. Unless the plan submitter demonstrates how the proposed harvest will achieve MSP pursuant to 14 CCR 913.11 (a) or (b), the residual stand shall contain sufficient trees to meet at least the basal area, size, and phenotypic quality of tree requirements specified under the seed tree method.
- 3) Within any THP, small group clearings under the selection method shall be separated by a logical logging area.
 - 4) Following completion of timber operations (including site preparation) not more than 20 percent of the THP area harvested by this method shall be covered by small group clearings.

Transition:

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

- b) Transition.** The transition method may be used to develop an unevenaged stand from a stand that currently has an unbalanced irregular or evenaged structure. The transition method involves the removal of trees individually or in small groups from irregular or evenaged stands to create a balanced stand structure and to obtain natural reproduction.
- 1) Area for determination of preharvest seed tree retention levels shall be no greater than 20 acres in size.
 - 2) This method is to be used to increase stocking and improve the balance of age classes so as to allow the residual stand to be managed by the selection regeneration method. This method shall not be used more than two times for a stand. The RPF shall delineate areas previously treated by the transition method on the plan map.
 - 3) Stands suitable for the transition method contain adequate quantity and quality of seed producing trees to provide adequate regeneration for new age classes. Stands suitable for this method shall have no more than 25 sq. ft. of basal area greater than the selection basal area standards.
 - 4) Trees to be harvested or trees to be retained shall be marked by or under the supervision of a RPF before felling operations. A sample area must be marked before the preharvest inspection for evaluation. The sample area shall include at least 10% of the harvest area up to a maximum of 20 acres per stand type which is representative of the range of conditions present.
 - 5) Immediately following the completion of timber operations, the minimum basal area standards in 14 CCR 912.7(b)(2) shall be met.
 - 6) The post harvested residual stand shall contain at least 15 square feet of basal area per acre of seed trees at least 12 inches dbh or greater for timber sites I, II or III; or 12 square feet of basal area per acre of seed trees 12 inches dbh or greater for timber sites IV or V. Unless obviously stocked, these basal area requirements will be determined from sampling

averaged across each harvested area required in 14 CCR § 913.2(b)(1). Unless the plan submitter demonstrates how the proposed harvest will achieve MSP pursuant to 14 CCR § 913.11(a) or (b) [953.11(a) or (b)], where present in the preharvest stand, disease free, undamaged seed trees 18 inches dbh or greater shall be retained post harvest until the stand exceeds the minimum seed tree requirements of 14 CCR § 913.1(c)(1)(A). The seed trees shall be full crown, capable of seed production and representative of the best phenotypes available in the present stand.

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

14 CCR 912.7: Resource Conservation Standards for Minimum Stocking:

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

- b) An area on which timber operations have taken place shall be classified as acceptably stocked if either of the standards set forth in (1) or (2) below are met within five (5) years after completion of timber operations unless otherwise specified in the rules.
 - 2) The average residual basal area measured in stems 1 inch or larger in diameter, is at least 85 square ft. per acre on Site I lands, and 50 square ft. per acre on lands of Site II classification or lower. Site classification shall be determined by the RPF who prepared the plan.

Commercial Thinning:

14 CCR 913.3: Intermediate Treatments:

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

- 1) Post harvest stand stocking levels shall be stated in the THP. The level of residual stocking shall be consistent with maximum sustained production of high quality timber products. Generally, stands will develop stand structures with considerably higher levels of basal area than provided in these minimum standards as stand age increases. In no case shall stocking be reduced below the following standards:
 - A. Where the preharvest dominant and codominant crown canopy is occupied primarily by trees greater than 14 in. DBH:
 1. On Site I lands, at least 125 sq. ft. per acre of basal area shall be left.
 2. On Site II and III lands, at least 100 sq. ft. per acre of basal area shall be left.
 3. On Site IV lands, at least 75 sq. ft. per acre of basal area shall be left.
 4. On Site V lands, at least 50 sq. ft. per acre of basal area shall be left.
 - B. Where the preharvest dominant and codominant crown canopy is occupied primarily by trees less than 14 in. DBH, a minimum of 100 trees per acre over 4 in. DBH shall be retained for site I, II and III. For site IV and V - 75 trees per acre over 4 in. dbh shall be retained.

Rehabilitation of Understocked Areas:

14 CCR 913.3: Special Prescriptions:

The following special harvesting methods are appropriate under certain conditions:

- b) Rehabilitation of Understocked Area Prescription.** For the purposes of restoring and enhancing the productivity of commercial timberlands which do not meet the stocking standards defined in 14 CCR 912.7 prior to any timber operations on such lands, an area may be harvested provided it is restocked in accordance with Subsections (1) or (2). To facilitate restocking, a regeneration plan must be included in the THP. The regeneration plan shall include site preparation, method of regeneration, and other information appropriate to evaluate the plan.

- 1) If the area meets the standards of 14 CCR 912.7 within five years of completion of timber operations, the area shall be considered acceptably stocked, or shall be considered acceptably stocked if it contains at least 10 planted countable trees for each tree harvested on sites I, II, and III, and 5 planted countable trees for each tree harvested on site IV and V.
- 2) On understocked timberlands where no countable conifer trees are to be harvested and the broadleaf species are not designated for management, the area shall be planted to equal or exceed the stocking standards of 14 CCR 912.7(b)(1) [932.7(b)(1), 952.7(b)(1)] and shall be considered acceptably stocked if within five years of completion of timber operations it contains at least an average point count of 150 of Group A species on all site classifications.

This overall constraint is emulated in the baseline by setting a minimum basal area target for uneven-aged stands when they are treated. Approximately 12% of the Project Area is harvested as small groups each decade of the 100-year baseline analysis period.

MSP:

All forest stands and baseline activities in the project area are subject to the Maximum Sustained Production (MSP) of High Quality Timber Products section of the California Forest Practice Rules. It is assumed in the baseline model that MSP is achieved pursuant to 14 CCR 913.11(a)(1) through (5), paraphrased below:

(1) Producing the yield of timber products specified by the landowner, taking into account biologic and economic factors, 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.

(2) Balancing growth and harvest over time, as explained in the THP for an ownership, within an assessment area set by the timber owner or timberland owner and agreed to by the Director. For purposes of this subsection the sufficiency of information necessary to demonstrate the balance of growth and harvest over time for the assessment area shall be guided by the principles of practicality and reasonableness in light of the size of the ownership and the time since adoption of this section using the best information available. The 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. The average annual projected yield over any rolling 10-year period, or over appropriately longer time periods for ownerships which project harvesting at intervals less frequently than once every ten years, shall not exceed the projected long-term sustained yield.

(3) Realizing growth potential as measured by adequate site occupancy by species to be managed and maintained given silvicultural methods selected by the landowner.

(4) Maintaining good stand vigor.

(5) Making provisions for adequate regeneration.

This overall constraint is emulated in the baseline by balancing growth with harvest in each decade of the baseline analysis period while giving consideration to biologic and economic factors.

Silvicultural Prescriptions

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

Table 4a: Silvicultural Prescriptions used on the Gualala River Forest

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

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

Prescription		Pre-Harvest Conifer Basal Area (Square Feet per Acre)		Other Pre-Harvest Considerations
		Lower Limit	Upper Limit	
Uneven-Aged Management				
	Single Tree Selection	100	None	
	Single Tree Selection Low Stocking (WLPZ)	150	200	
	Single Tree Selection Medium Stocking (WLPZ)	200	250	
	Single Tree Selection High Stocking (WLPZ)	250	None	
	Group Selection	125	None	
	Transition	50	100	
	Commercial Thinning	50	125	
Even-Aged Management				
	Even-aged	15	60	Greater than 50% of conifer basal area in trees larger than 18” DBH
	Rehabilitation	0	50	Less than 300 point count
	Hardwood Release	0	50	

Table 4c: Post-harvest Stocking by Silvicultural Prescription

Prescription		Stocking Considerations	Conifer Basal Area Retention (sq. ft. per acre)	Hardwood Basal Area Retention (sq. ft. per acre)	Time to Next Treatment
Uneven-Aged Management					
	Single Tree Selection	All age, evenly distributed	>75	6	At Least 10 Years
	Single Tree Selection Low Stocking (WLPZ)	All age, evenly distributed	>140	28	At Least 10 Years
	Single Tree Selection Medium Stocking (WLPZ)	All age, evenly distributed	>175	23	At Least 10 Years
	Single Tree Selection High Stocking (WLPZ)	All age, evenly distributed	>225	18	At Least 10 Years
	Group Selection	Less than 20% of stand in group openings	>75	5	At Least 10 Years
	Transition	Less than 20% of stand in group openings, at least 15 sq. ft. >12" DBH	>50	6	Selection within 10-20 Years
	Commercial Thinning	Equal to or Greater average stand diameter than pre-harvest stand	>100 if QMD >14" and 100 4"+ trees if QMD <14"	6	Selection within 10-20 Years
Even-Aged Management					
	Even-aged	Retain/recruit 2-3 snags per acre	>8	6	Selection within 20-40 Years
	Rehabilitation	Retain/recruit 2-3 snags per acre	>8 where conifer >8 pre-harvest	6	Selection within 30-40 Years
	Hardwood Release	No Commercial Conifer Harvest	No Commercial Conifer Harvest	6	Selection within 20-40 Years

Growth and Yield Analysis:

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

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

Elapsed Time (year)	Beginning Inventory (board feet)	Average Decadal Growth (board feet)	Average Decadal Harvest (board feet)	Ending Inventory (board feet)
10	5,294	452	330	6,509
20	6,509	610	404	8,574
30	8,574	609	438	10,291
40	10,291	625	481	11,727
50	11,727	659	506	13,258
60	13,258	686	529	14,833
70	14,833	702	540	16,452
80	16,452	728	562	18,120
90	18,120	757	581	19,883
100	19,883	786	603	21,714

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

Elapsed Time (year)	Beginning Inventory (Mg Carbon)	Average Decadal Growth (Mg Carbon)	Average Decadal Harvest (Mg Carbon)	Ending Inventory (Mg Carbon)
10	36.49	2.07	3.03	26.87
20	26.87	1.82	1.32	31.77
30	31.77	1.53	1.28	34.28
40	34.28	1.53	1.32	36.35
50	36.35	1.53	1.25	39.12
60	39.12	1.54	1.23	42.24
70	42.24	1.55	1.27	45.04
80	45.04	1.56	1.32	47.52
90	47.52	1.59	1.28	50.64
100	50.64	1.61	1.37	53.00

Table 5c: Average Total Live Carbon Growth and Yield through the Planning Horizon (Total Mg C)

Elapsed Time (year)	Beginning Inventory (Mg Carbon)	Average Decadal Growth (Mg Carbon)	Average Decadal Harvest (Mg Carbon)	Ending Inventory (Mg Carbon)
10	490,659	27,775	40,712	361,294
20	361,294	24,413	17,814	427,277
30	427,277	20,581	17,212	460,980
40	460,980	20,540	17,757	488,794
50	488,794	20,576	16,846	526,093
60	526,093	20,739	16,548	567,982
70	567,982	20,830	17,055	605,730
80	605,730	21,017	17,687	639,042
90	639,042	21,356	17,156	681,030
100	681,030	21,610	18,446	712,683

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

Elapsed Time (years)	0	10	20	30	40	50	60	70	80	90	100
Conifer	66	75	85	89	96	101	108	113	121	127	134
Hardwood	75	22	24	23	21	21	22	23	21	22	20
Total	141	97	108	112	117	122	130	135	142	148	154

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

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

Decade	Silviculture						
	Selection	Transition	Group Select	Rehabilitation	Release	Even-aged	No Harvest
1	15%	38%	11%	19%	5%	2%	10%
2	13%	38%	9%	0%	13%	0%	28%
3	41%	21%	9%	0%	0%	0%	29%
4	36%	30%	12%	0%	0%	0%	22%
5	50%	14%	12%	0%	0%	0%	24%
6	63%	0%	11%	0%	0%	0%	26%
7	60%	0%	14%	0%	0%	0%	25%
8	64%	0%	8%	0%	0%	0%	28%
9	64%	0%	11%	0%	0%	0%	25%
10	71%	0%	9%	0%	0%	0%	20%

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

Baseline Carbon Stocks

The baseline modeling scenario defined in this document follows the guidelines presented in section 6.2 of the Compliance Offset Protocol U.S. Forest Projects, November 14, 2014.

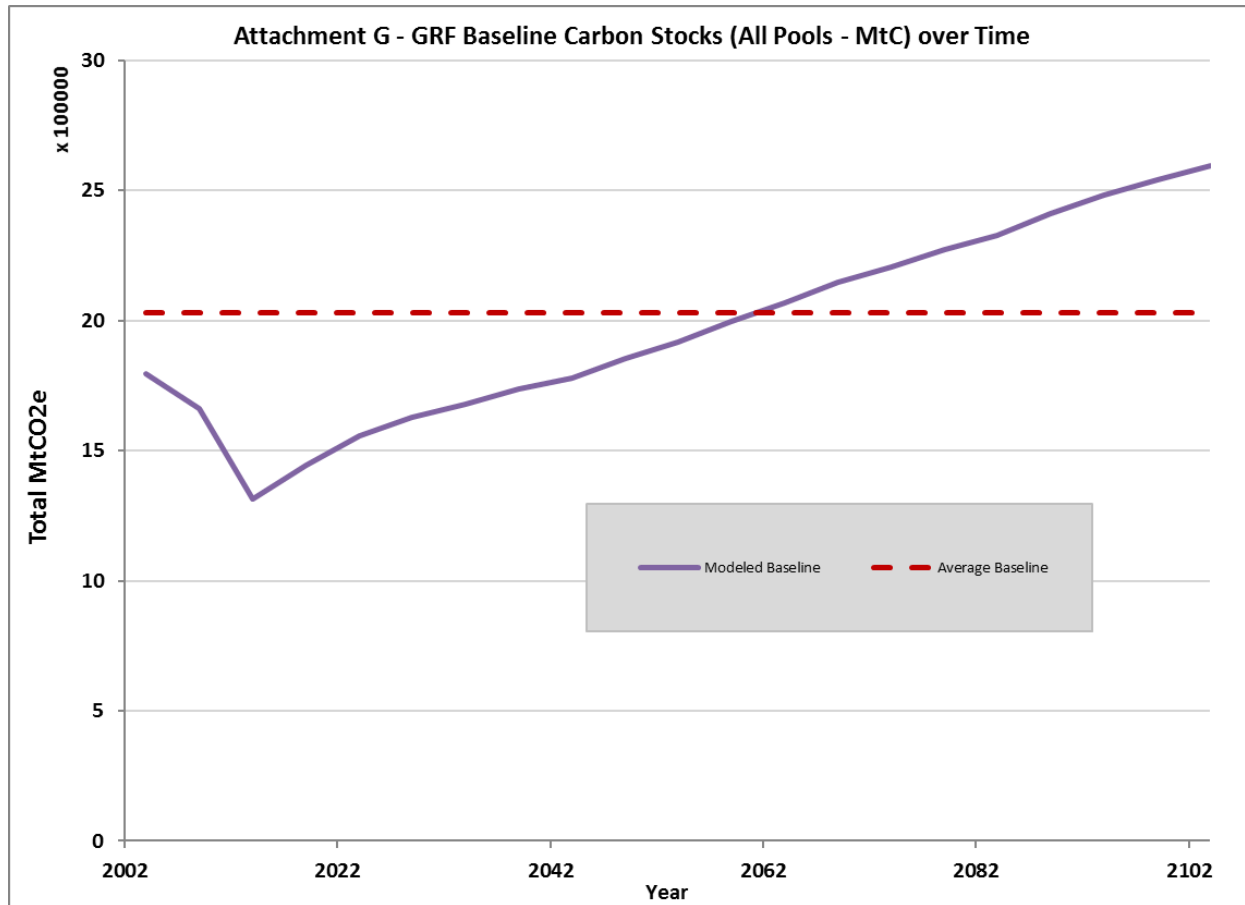
Key components of the calculated baseline are as follows:

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

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

Elapsed Time	Standing Live Carbon Pool IFM-1	Standing Live Above Ground	Standing Live Below Ground	Standing Dead Carbon Pool IFM-3	Baseline
0	133.60	106.63	26.97	4.41	151.08
5	123.52	98.60	24.92	4.41	151.08
10	97.85	77.49	20.37	4.41	151.08
15	107.46	85.33	22.13	4.41	151.08
20	115.72	91.98	23.74	4.41	151.08
25	121.16	96.48	24.68	4.41	151.08
30	124.85	99.46	25.39	4.41	151.08
35	129.10	102.98	26.12	4.41	151.08
40	132.38	105.62	26.76	4.41	151.08
45	138.03	110.29	27.74	4.41	151.08
50	142.48	113.90	28.58	4.41	151.08
55	148.56	118.92	29.64	4.41	151.08
60	153.83	123.21	30.62	4.41	151.08
65	159.66	128.06	31.61	4.41	151.08
70	164.05	131.66	32.39	4.41	151.08
75	168.87	135.61	33.26	4.41	151.08
80	173.07	138.99	34.08	4.41	151.08
85	179.24	144.10	35.14	4.41	151.08
90	184.45	148.37	36.08	4.41	151.08
95	189.03	152.17	36.86	4.41	151.08
100	193.02	155.42	37.60	4.41	151.08
Average	146.66	117.39	29.27	4.41	151.08

Figure 1: Baseline Carbon Stocks



Wood Products

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

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

Woods Products	Mg C/ acre	Total Mg CO ₂ e
Average Annual Carbon 100-year In-Use	0.167	8,020.67
Average Annual Carbon 100-year Landfill	0.108	5,181.90
Average Annual Carbon in Harvested Trees Prior to Delivery to the Mill	1.087	52,277.00

Literature Cited

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