Buckeye Forest Project
Initial Offset Project Data Report (version 1.6)
California Air Resources Board

Forest Owner and Offset Project Operator:

Sustainable Conservation Inc.

Authorized Project Designee: The Conservation Fund
Offset Project Name: Buckeye Forest Project
OPR Project ID#: CAR1013
ARB Project ID#: CAFR 5055
OPO CITSS ID#: CA 1591
APD CITSS ID#: CA 1597
Initial OPDR updated – 10/30/2016 (Reporting Period 2)

In signing this document, I certify under penalty of perjury under the laws of the State of California the GHG reductions and/or GHG removal enhancements for Buckeye Forest Project from 6/1/2014 to 5/31/2015 are measured in accordance with the Compliance Offset Protocol U.S. Forest Projects, October 20, 2011 and all information required to be submitted to ARB in the Offset Project Data Report is true, accurate, and complete. I further certify that I am an Account Representative of the Offset Project Operator (OPO).

Lauren Fety _____ 10/30/2016

Lauren Fety — Date

Forest Analyst, Primary Account Representative

Table of Contents:

1. Introduction *6*

2. General Project Information *6*

2.1. Project Information 6

3. Buckeye Forest Project Details *8*

3.1. Offset Project Operator Contact Details 8

3.2. Authorized Project Designee Contact Details 8

3.3. Ownership Type 8

3.4. Offset Project Type 8

3.5. Management Activities that Lead to Higher Carbon Stocks than Baseline 8

3.6. Project Commencement Date 8

3.7. Other Registries 8

3.8. Statutory Requirements 9

3.9. Broadcast Fertilization 9

3.10. Sustainable Long-Term Management 9

3.12. Detailed Project Area Description and Map 10

3.13. Assessment Areas 10

3.14. General Description of Forest Conditions 11

3.15. Conservation Easement 11

3.16. Inventory Methodology 11

3.17. Carbon Pool Calculation Methodology 11

3.18. Modeling Plan 11

3.19. Diagram and Description of Final Baseline 11

3.20. Summary of Carbon Stocks 12

3.21. Summary of Inventory Confidence Statistics 13

3.22. Summary of Long-Term Harvested Wood Product Carbon Storage 13

3.23. Calculation of Reversal Risk Rating 14

3.24. Tree Canopy Cover 15

3.25. Initial Carbon Stocks and Determination of Common Practice 16

3.26. Legal Constraints Affecting Forest Management 16

3.27. Financial Feasibility Analysis 16

3.28. Summary of Changes 16

3.29. Reversals 17

4. Inventory Methodology *17*

4.1. Offset Project Boundary 17
4.2. Field Measurement Procedures 17
4.3. Stratification 18
4.4. Inventory Analytical Methods 21
4.4.1. IFM 1: Primary Effect – Standing Live Carbon Pool 22
4.4.2. IFM 3: Primary Effect – Standing Dead Carbon Pool 23
4.4.3. IFM 6: Primary Effect – Soil Carbon Pool 24
4.4.4. IFM 7: Primary Effect – In-Use Forest Product Carbon Pool 24
4.4.5. IFM 8: Primary Effect – Forest Product Carbon in Landfills Pool 24
4.4.6. IFM 9: Secondary Effect – Site Preparation Emissions 24
4.4.7. IFM 14: Secondary Effect – Changes in Harvesting Outside of Project Area 25
4.4.8. IFM 17: Secondary Effect – Forest Product Decomposition Emissions 25
4.5. Quality Assurance and Quality Control Procedures 25
4.6. Data Management Systems and Procedures 25
4.7. Inventory Update Procedure 26
4.8. Change Log 27
5. Modeling Plan 28
5.1. Baseline Management Buffers 29
5.2. Baseline Management Setup and Assumptions 31
5.3. Legal Constraints 33
5.4. Management Description 34
5.5. Baseline Management Results 37
1. Introduction 57
2. Multi-stage Probability Proportional to Size Stratified Sampling 57
2.1. Calculations and Equations 57
2.2. Accuracy Assessment Process 60
3. Simple Random / Systematic Stratified Sampling (SRSS) 60
3.1. Calculations and Equations 60
3.2. Accuracy Assessment Process: 61
4. Combined MSPPS and SRSS Calculations 61
5. Accuracy Results 62

Figures:

Figure 1: General Overview Map of BFP (formerly Preservation Ranch) and surrounding region 7
Figure 2: Baseline Model 12
Figure 3: Map of Qualified Conservation Easement Coverage 15
Figure 4: BFP Stands and Strata 20

Figure 5: Example of post-disturbance stand layer update cut into the existing stratification and stand system on a different property. 26
Figure 6: Baseline Management Regime Results by Management Type. 38
Figure 7: Baseline graph 42

Tables:

Table 1: % BA by Species and species group (OH includes species such as true oaks, California Bay-Laurel, Giant Chinquapin, and others). 9
Table 2: Average forest age by watershed. 9
Table 3: Standing live carbon stocks (metric tons) at project start based on 12/31/2013 inventory and forward and backward modeled growth. 13*
Table 4: Harvested Wood Product Summary – Annual Addition by Product Class (see table 26 for coefficients used) 14
Table 5: Reversal Risk Rating and Buffer Pool Contribution Calculation 15
Table 7: Strata Summary 19
Table 8: Stratification system summary 21
Table 9: Volume, Biomass, and Density Equations and Coefficients by Species 22
Table 10: Volume basis for biomass calculation of snags. 23
Table 11: Coarse woody debris – Relative density factors (Mt/m^3) from Harmon et al (2008) 24
Table 12: Change Log Summary 28
Table 13: Baseline buffering description. 30
Table 14: CA FPR Constraint References 31
Table 15: Baseline management buffer areas. 31
Table 16: Site Index Estimates by Species and Site Class 32
Table 17: Regeneration percentages by species for four species strata bins. 33
Table 18: Regeneration by harvest type. 33
Table 19: CA Forest Practice Rule Section References for different Silviculture. 34
Table 20: Silvicultural systems descriptions. 36
Table 21: Pre-harvest stand conditions. 37
Table 22: Post-harvest stand targets[17] 37
Table 23: Average per acre conifer growth and yield (net BF/acre) over the project lifetime. 39
Table 24: Average per acre growth and yield of above and belowground stocks (MtCO_2e/acre) over the project lifetime. 39
Table 25: Percentage of total forested acre managed by silviculture. 40
Table 26: Baseline carbon stocks (MtCO_2e/acre). 41
Table 27: Wood product coefficients by product type. 42
Table 28: List of Tree Species and their Species Codes. 48
Table 29: Status Code Descriptions. 48
Table 30: Damage Codes 49
Table 31: Snag Decay Class Descriptions 50
Table 32: Lying Dead Wood Decay Class Descriptions. 52
Table 33: MSPPS variable definition from Shiver and Borders. 59
Table 34: SRSS Variable definition from Shiver and Borders. 61
Table 35: BFP 90% accuracy levels. 62
Table 36. Calculation of GHGs for Initial Stocks & Reporting Period Ending 5/31/3015 63

Appendices:

Appendix A – Inventory Methodologies – Buckeye Cruise Specifications (see end of this document)
Appendix B – US Fish and Wildlife Service – Suggestions for Placement of NSO Information in CAL FIRE Coast Forest District Plans/Amendments (see end of this document)
Appendix C – Statistical Methods for Stratified Sampling (see end of this document)
Appendix D – Calculation of GHG Reductions and GHG Removals Enhancements (see end of this document)
Appendix E – Inventory Methodologies – Fixed Radius Plots for Buckeye Forest Sampling (see end of this document)
Appendix F – Buckeye Forest Aerial Imagery Map (see SCI_BFP_AerialImageryMap_05272014.pdf)
Appendix G – Forest Age by HUC12 Watershed Map (see SCI_BFP_WatershedAgeMap_05282014.pdf)
Appendix H – Detailed Property Map (see SCI_BFP_PropertyMap_05272014.pdf)
Appendix I – CA Wildlife Habitat Relationship Classes Map (see SCI_BFP_WHRTypes_05272014.pdf)
Appendix J – Baseline Model Harvestable Acre Analysis Map (see SCI_BFP_HarvestConstraints_05272014.pdf)

1. Introduction

The Buckeye Forest was purchased by Sustainable Conservation Inc. (SCI) doing business in California as Buckeye Forest on May 31st, 2013. The first full day of ownership was June 1st, 2013 and this date serves as the start of the project as it was the first date SCI had management control of this property. The Buckeye Forest Project (BFP) carbon project is listed as an Improved Forest Management (IFM) project under the California Air Resources Board (CARB) Compliance Offset Protocol U.S. Forest Projects (COPUSFP) dated October 20, 2011.

The purpose of this document is to fully describe the Buckeye Forest Carbon Offset Project. This document will serve as the BFP Offset Project Data Report (OPDR). This will be a living document that is updated as new management and new policies are instituted on the BFP. This document will also serve as a change log for these updates and will contain a full history of the project's design since its inception.

2. General Project Information

2.1. Project Information

The BFP is a 19,552-acre forest located in Sonoma County, CA; it is east of Gualala, CA and west of Healdsburg, CA. At the time of the project commencement, the full ownership of SCI was 19,649 acres and included a 97 acre vineyard. This vineyard was sold in 2014 and is no longer owned by SCI and is not included in the carbon project. The BFP is located within the Gualala River watershed just east of the community of Annapolis. The property straddles three sub-basins including the Rock Pile Creek basin, the Buckeye Creek basin, and the Wheatfield Fork basin. The property is generally comprised of one large tract of land but also includes two smaller satellite parcels: one located just north of the main block, the other located southwest of the main block. The topography is generally moderate to very steep. The property is crossed by numerous tributaries of the Gualala River. These streams have created steeply incised canyons resulting in steep side slopes with varying aspect. Numerous small ridges are found throughout the property where topography is gentler. The property has been extensively logged in the past with tractors and skid trails established on many steep slopes.[1]

There are over 29 miles of fish bearing streams located in this primarily redwood / Douglas-fir / tanoak forest. In the 1980s and 1990s, the majority of the property was harvested using aggressive selection techniques, often resulting in young stands with heavy competition from tanoak. The forest conditions vary based on aspect, soils, and proximity to the coast, supporting both productive redwood forest and drier oak woodlands and grasslands. The figure below shows the general location of the BFP.

[1] This property description was adapted from a recent property appraisal written by R. Forsburg

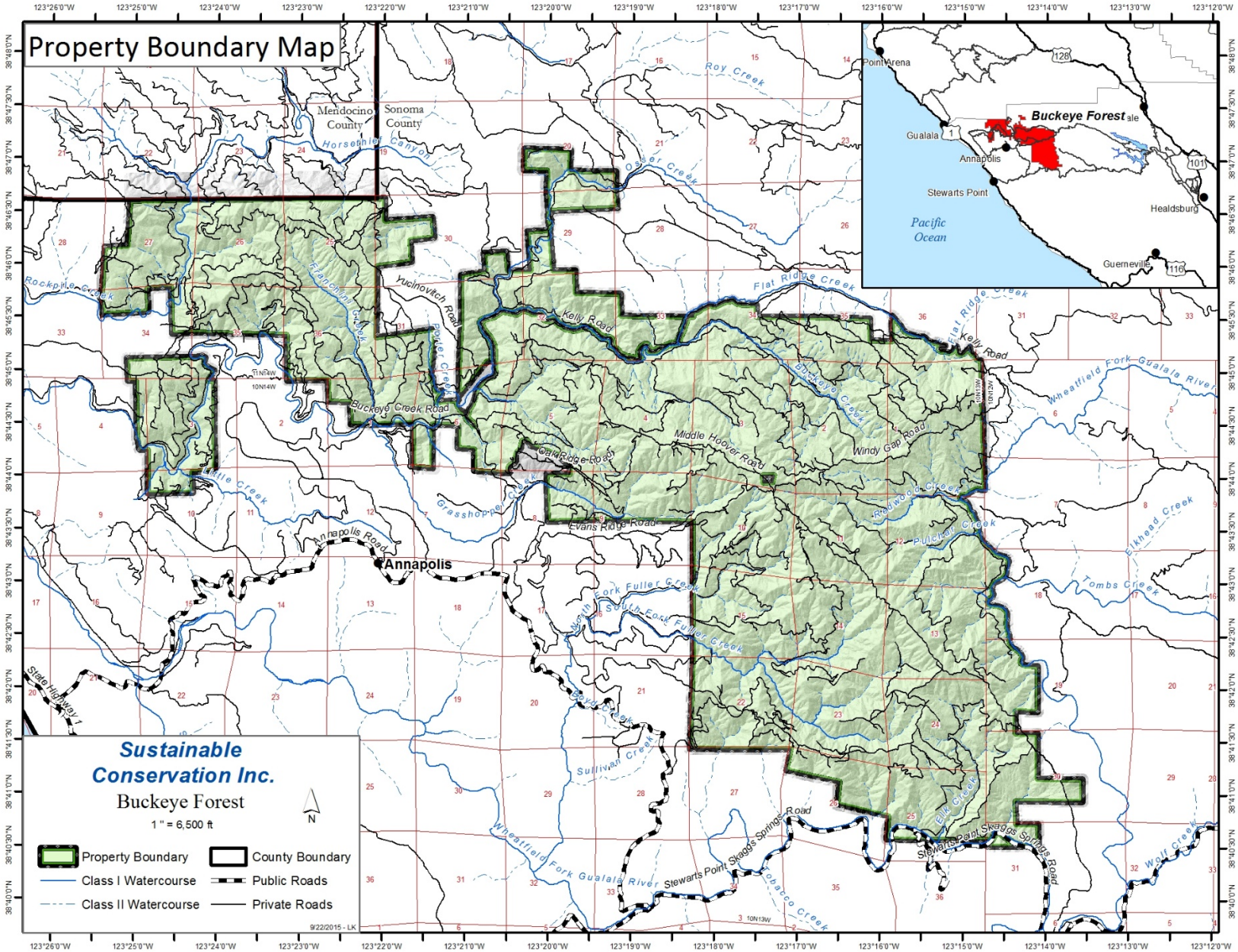

Figure 1: General Overview Map of BFP and surrounding region.

3. Buckeye Forest Project Details

3.1. Offset Project Operator Contact Details

Elizabeth Engle
Assistant Secretary
Sustainable Conservation Inc.
1655 N. Fort Myer Drive, Suite 1300
Arlington, VA 22209
lengle@conservationfund.org
703-525-6300

3.2. Authorized Project Designee Contact Details

Lauren Fety
Forest Analyst
The Conservation Fund
215 West Standley, Suite 11
Ukiah, CA 95482
Phone: 541-727-2094 Fax: (866) 426-4496
Email: lfety@conservationfund.org

3.3. Ownership Type

The BFP is privately owned in fee by SCI doing business in California as Buckeye Forest. There have been no changes in forest owner status during the reporting period (6/1/2014-5/31/2015). SCI and The Conservation Fund (TCF) have entered into an Agreement Regarding Real Property pursuant to which TCF assumes sole responsibility and liability for management and operation of the BFP.

3.4. Offset Project Type

The BFP is an Improved Forest Management (IFM) project. This project is listed under the CARB Compliance COPUSFP adopted on October 20th, 2011.

3.5. Management Activities that Lead to Higher Carbon Stocks than Baseline

Compared to the baseline, there are several changes in the management of Buckeye Forest that will lead to higher carbon stocks. SCI is not planning any timber harvesting at this time. In contrast, the baseline assumes that timber harvesting will begin at the project commencement date. For a more complete description of the baseline modeling, see the modeling plan in section 5.

3.6. Project Commencement Date

The Buckeye Forest was purchased by SCI doing business in California as Buckeye Forest on May 31st, 2013. The commencement date for this project is June 1st, 2013: the first full day SCI owned this property. This transfer of ownership serves as the start of the project as it was the first date SCI had management control of this property.

3.7. Other Registries

The BFP has only been listed with the CARB COPUSFP. It has not been listed or registered with any other registry or program. The Offset Project Registry (OPR) for the BFP is the Climate Action Reserve (CAR). CAR reviewed all offset project and verification documents.

3.8. Statutory Requirements

The BFP carbon project was not implemented as a result of any law, statute, regulation, court order, or legally binding mandate.

3.9. Broadcast Fertilization

No broadcast fertilization is used on the BFP property.

3.10. Sustainable Long-Term Management

SCI is not planning any timber harvests at this time; no Timber Harvest Plans have been submitted to CALFIRE.

3.11. Natural Forest Management

3.11.1. Native Species

Since the project start, more than 95% of the standing carbon on the BFP is found in native species.[2] Additionally, no individual species represents more than 60% of the total basal area (BA) across the project area.

Table 1: % BA by Species and species group (OH includes species such as true oaks, California Bay-Laurel, Giant Chinquapin, and others).

Species Code	Species Name	%BA
DF	Douglas-fir	27.8%
SP	Sugar pine	2.9%
OH	Other Hardwoods	21.7%
RW	Redwood	16.7%
TO	Tanoak	30.9%

3.11.2. Age Class Distribution / Sustainable Management

Within each sub-watershed (specified by the HUC12 CA Planning Watersheds) covered by the BFP, at least 40% of the area has trees at least 20 years old. This is based on the average age of the measured site trees within each watershed. The table below shows the average age of the trees measured by watershed within the BFP. Appendix F shows a map of the HUC12 planning watersheds colored by the average age of the site trees measured within these watersheds.

Table 2: Average forest age by watershed.

Watershed	Acreage	Average Age	Trees Measured
Buckeye Creek	9,816	43	40
Lower Wheatfield Fork Gualala River	5,519	46	9
Rockpile Creek	1,498	44	7
Upper Wheatfield Fork Gualala River	2,719	54	8

3.11.3. Structural Elements (lying and dead wood)

In 2013, the BFP had 9 $MtCO_2e$/acre of lying dead wood. This is more than 4% of the standing live carbon stocks. Before forest management occurs, structural elements will be retained and recruited as naturally occurs in forests. When timber removal begins in the future, this harvesting will retain standing dead wood in the form

[2] This criterion is based on the language found in Table 3.2 of CARB COPUSFP.

of snags for wildlife trees. Tops will be left in woods during harvesting to increase down wood recruitment, and no lying dead wood will be removed from the forest.

3.12. Detailed Project Area Description and Map

Appendix G is a map that shows the governing jurisdictions (county lines), latitude and longitude, public and private roads, nearby towns, all major watercourses, topography, townships, ranges, and sections. The forest vegetation types can be seen in the map in Figure 3 below as well as in the Wildlife Habitat Relationship Classes map in Appendix H. The full property is Douglas-fir site class 3 and redwood site class 4 so it was not necessary to show this information on a map. The existing land cover is forest for most of the property although there are some scattered grasslands. The existing land use is forestry for the full project area except grasslands.

The primary land pressures within Sonoma County are vineyard development and subdivision for second home development and hobby ranches. The BFP is part of a forested watershed with a coastally influenced climate in the lower half of the drainage. Located within the Oregonian Biotic Province, the watershed has a Mediterranean climate, characterized by a pattern of low-intensity rainfall in the winter and cool, dry summers with coastal fog. Mean annual precipitation is 30 inches at the coast and up to 100 inches per year on the inland peaks. 90% of this precipitation generally falls as rain between October and April with the highest average precipitation in January.

The property has a history of intensive forest management resulting in a forest now characterized as a young redwood Douglas-fir forest with a high component of tanoak. Compared to pre-settlement conditions, the forest is relatively young, structurally simple, and contains a relatively high density of hardwoods. Almost all of the old growth was logged in the 1960's with ground-based harvesting practices that were damaging to streams. Subsequent harvests removed all the residual old growth and most of the large second-growth.

The project is currently zoned as a Timber Production Zone (TPZ). Future land use in this forest area will continue to be forest management.

In the reporting period 2, no natural disturbances occurred on the Buckeye Forest Project. If natural disturbances do occur in the future, procedures in Section 4.7 will be followed.

3.13. Assessment Areas

The Buckeye Forest Project is located within the Northern California Coast Supersection per Appendix F of the Protocol. Within the larger Supersection, the Project is within both the Coast Redwood / Douglas-fir Mixed Conifer (CRDFMC) and the Northern California Coast Mixed Oak Woodland (NCCMOW) Assessment Areas. The CRDFMC is 13,379 acres of the total BFP (68% of the area) and the NCCMOW is 5,684 acres (29% of the area). These assessment area acreages were calculated based on the California Wildlife Habitat Relationship Types Life Form criterion. Conifer forest (WHR_CON) and Mixed Forest (WHR_MIX) were considered part of the CRDFMC assessment area. Hardwood forest (WHR_HDW) was considered part of the NCCMOW assessment area. Herbaceous (WHR_HEB), Shrubs (WHR_SHB), and non-forested areas (WHR_NFO) were 489 acres (3% of the area) and not considered as part of the common practice calculation.[3]

[3] Habitat Classification Rules. California Wildlife Habitat Relationships System. 2005. 46 pages. California Department of Fish and Game California Interagency Wildlife Task Group, Sacramento, CA.
Standards and Guidelines for CWHR Species Models. 2000. 43 pages. California Department of Fish and Game California Interagency Wildlife Task Group, Sacramento, CA.

3.14. General Description of Forest Conditions

The BFP is made up of primarily Tanoak, Douglas-fir, and Redwood trees. The property is dominated by trees between 30 and 60 years old in densely stocked stands. See section 3.12 for a description of the management history of the property.

3.15. Conservation Easement

The Sonoma County Agricultural and Open Space District (District) holds a conservation easement that restricts the management of the BFP and prevents future subdivision and development of this property. This easement is considered to be "qualified" according to the CARB COPUSFP. The conservation easement was granted to the District on May 31st, 2013 and encumbers approximately 18,119 acres, 94% of BFP. Any future forest management activities will require the preparation, submission and approval by CALFIRE of a Timber Harvest Plan and be consistent with an integrated resource management plan to be developed by SCI and approved the District. As stated in Section 3.5, no timber harvests have been initiated or are planned at this time, and no Timber Harvest Plans have been submitted to CALFIRE. Additionally, the entire Buckeye Forest is covered by an Offer to Dedicate, held by the California State Coastal Conservancy, a notice of which is publicly recorded.

3.16. Inventory Methodology

See section 4 for a complete description of the inventory methodology used following the requirements outlined in Appendix A of the CARB COPUSFP. A new inventory of the full BFP was completed in 2013 using a two-stage probability proportional to size stratified sampling design. Future sampling will use both simple stratified random sampling and two-stage probability proportional to size stratified sampling.

3.17. Carbon Pool Calculation Methodology

See section 4.4 for a complete discussion of the analytical methods used to convert field data into biomass and carbon estimates as well as a description of all of the carbon pools within the offset project boundary.

3.18. Modeling Plan

See section 5 for the modeling plan discussion following the requirements outlined in Appendix B of the CARB COPUSFP.

3.19. Diagram and Description of Final Baseline

The figure below shows the final baseline for aboveground standing live carbon stocks. This graph also shows the final 100 year average as well as the common practice stocks.[4] Because the starting stocks are above the common practice stocking for this assessment area (weighted average ARB Common Practice for CRDFMC and NCCMOW assessment areas = 148.07 Aboveground $MtCO_2e$/acre vs. BFP Starting Stocks = 156.5 Aboveground $MtCO_2e$/acre), a high-stocking reference calculation is not required.

The property has been broken into three separate areas for modeling purposes: no cut acres, watercourse and lake protection zones (WLPZ) and unconstrained harvest acres. To calculate the total baseline, all three areas are combined and the standing dead pool is added as well. In the figure below, the solid, thick purple line shows the final baseline model and the dashed horizontal orange line is the 100-year average of this model. The baseline model in the no harvest acres and the WLPZ acres steadily grows carbon stocks over time. The unconstrained harvest shows an initial rapid decline in stocks followed by more steady growth due to the initial harvest and hardwood management silviculture. Further description of the baseline management regimes can be found in section 5 – the Modeling Plan.

[4] See figures 5 and 6 for a breakdown of the components of the baseline model.

The shape of the graph below reflects that in the first 20 years of the unconstrained portion of the property, most of the management is transition silviculture that harvests to 50 ft^2 of conifer BA. After this period, stands are entered when they have 125 ft^2 of conifer BA and harvested to 75 ft^2 of conifer BA using selection silviculture. Stands are re-entered at a minimum of 10 years after they are harvested. In most cases, stands required more than 10 years to reach the required 125 ft^2 conifer BA required for a selection harvest so there is a period of stock growth after the first 20 years followed by an evening out of harvest rates as the forest reaches a sustainable yield stream as can be seen in the slow but steady increase towards the end of the 100 year period.

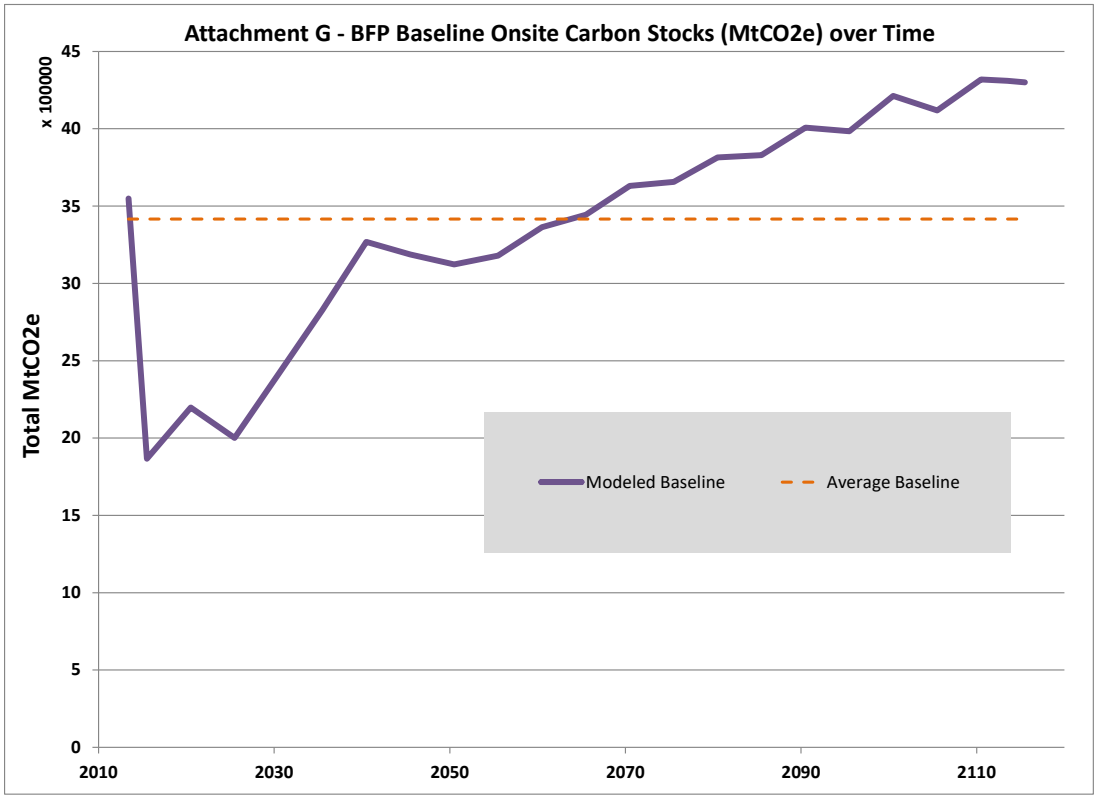

Figure 2: Attachment G - Baseline Model

Compared to the baseline, there are several changes in the management of Buckeye Forest that will lead to higher carbon stocks. In the first 5 years of the project, no harvest is planned. The baseline calculation assumes timber harvesting starting at the project start date. Future forest management will use single tree selection practices that are less intensive than the baseline harvesting regimes.

3.20. Summary of Carbon Stocks

Because the reporting period for the BFP runs from 6/1 to 5/31 each year, it is necessary to estimate the starting carbon stocks based on the end of year inventory estimate. The initial inventory was collected between 11/18/2013 and 3/26/2014. This inventory represents the carbon stocks as of 12/31/2013. The carbon stocks were grown backwards from the inventory date of 12/31/2013 to the reporting commencement date of 6/1/2013. This backward estimate of starting carbon stocks was calculated by first growing the full forest forward one year. This estimate of year one growth was then scaled by a factor of 0.5836 (213 days from 6/1 to 12/31 so 213/365= 0.5836). This partial year of growth was then deducted from the end of year 2013 estimate to find the 6/1/2013 stock estimate. This backwards estimate of starting stocks is only necessary for the initial reporting period; future reporting periods will only use forward projections to estimate carbon stocks. The table below details this calculation process. There were 3.3 $MtCO_2e$/acre of standing dead stocks at year end 2013, and these stocks were carried over with no change to the 6/1/2013 start date as well as the 5/31/2014 reporting period end date.

For the reporting period of 6/1/2014 to 5/31/2015, the forest inventory was grown forward two years from the 12/31/2013 inventory to 12/31/2015 in FORSEE using the update inventory function. FORSEE is known to not model small tree growth well. For Reporting Period 2 and in the future, until further guidance is provided or the model is updated, this will be addressed by using the most recent field measurement for diameter and height (e.g., zero annual height or diameter growth) for all trees subject to negative diameter growth. The carbon stocks for the 2015 calendar year were then scaled back to reflect the first half of the year, (1/1/15-5/31/15). This value was added to the second half (6/1/14-12/31/14) of the 2014 carbon stock values. There were 3.3 $MtCO_2e$/acre of standing dead stocks during the initial cruise; these stocks were carried over with no change for the 5/31/2015 reporting period.

Table 3: Standing live carbon stocks (metric tons) at project start based on 12/31/2013 inventory and forward and backward modeled growth.*

	Carbon Stocks: Project Start and Grown Forward to Reporting Period 2								
Year	**Date**	**AGC/ acre**	**TotC/ acre**	**AGC**	**TotC**	**AGCO2/ acre**	**TotCO2/ acre**	**AGCO2**	**TotCO2**
Initial Stocks	**6/1/2013**	42.7	53.0	767,986	952,608	156.5	194.1	2,813,902	3,490,355
2013	**12/31/2013**	43.8	54.4	787,098	977,590	160.4	199.2	2,883,926	3,581,891
RP1	**5/31/2014**	44.5	55.4	800,646	995,301	163.1	202.8	2,933,568	**3,646,783**
2014	**12/31/2014**	45.6	56.7	819,848	1,020,401	167.1	207.9	3,003,921	3,738,749
RP2	**5/31/2015**	**46.2**	**57.4**	**830,964**	**1,032,697**	**169.3**	**210.4**	**3,044,653**	**3,783,803**
2015	**12/31/2015**	47.1	58.4	846,536	1,049,921	172.5	213.9	3,101,709	3,846,910

*The light green 12/31/13 row represents the measured inventory results. The 12/31/14 row shows the modeled stocks grown 1 year into the future; the 12/31/2015 row is the measured inventory data grown 2 years into the future. The 6/1/13, 5/31/14, and 5/31/2015 rows deduct or add scaled portions of the calendar year for the reporting period.

3.21. Summary of Inventory Confidence Statistics

The 2013 BFP inventory resulted in an estimate of 202.5 $MtCO_2e$/acre of standing live and dead stocks. The estimate achieved an accuracy of 4.15% at the 90% confidence level. This calculation uses sampling estimators from a multistage probability proportional to size stratified sample that relies on 662 plots. For a complete discussion of how the inventory accuracy statistics are calculated, see Appendix C of this document. Since the initial inventory, there have been no additional inventory data collected and thus the inventory confidence statistics remain the same.

3.22. Summary of Long-Term Harvested Wood Product Carbon Storage

The table below summarizes the 100-year harvested wood product (HWP) carbon storage by product class. This table also shows the final annual addition of HWP storage after applying the 80% HWP production factor to adjust for market responses to HWP production.

Table 4: Harvested Wood Product Summary – Annual Addition by Product Class (see table 26 for coefficients used)

	Product Values (based on 100 year average) MtCO2e	IFM 7: 100 Year Product MtCO2	IFM 8: 100 Year Landfill MtCO2	100 Year Product and Landfill Total MtCO2	80% of HWP Totals
SW Lumber	15,166	7,022	4,519	11,541	9,233
HW lumber	0	0	0	0	0
SW Plywood	293	142	84	226	181
Oriented Strandboard	0	0	0	0	0
NonStruc Panels	38	15	13	28	22
Misc Prods	15	3	7	9	7
Paper	112	7	20	26	21
Total:	**15,624**	**7,187**	**4,643**	**11,831**	**9,464**

3.23. Calculation of Reversal Risk Rating

The calculation of reversal risk rating follows the rules laid out in Appendix D of the CARB COPUSFP. Applicable sources of risk were identified in Table D.10, and then the risk rating analysis formula in Appendix D was used to calculate the total buffer pool contribution. Because the full project is not covered by a QCE, the project uses the non-QCE option and the calculated risk of reversal / buffer pool contribution is 19.236%**.** The project's annual Forest Buffer account contribution for the first reporting period was 63,525 $MtCO_2e$ (19.236% of 330,236 $MtCO_2e$) (see Appendix D for GHG reduction calculation). The project's buffer account contribution was second reporting period 22,756 $MtCO_2e$ (19.236% of 118,295 $MtCO_2e$) for a total cumulative contribution of 86,281 $MtCO_2e$.

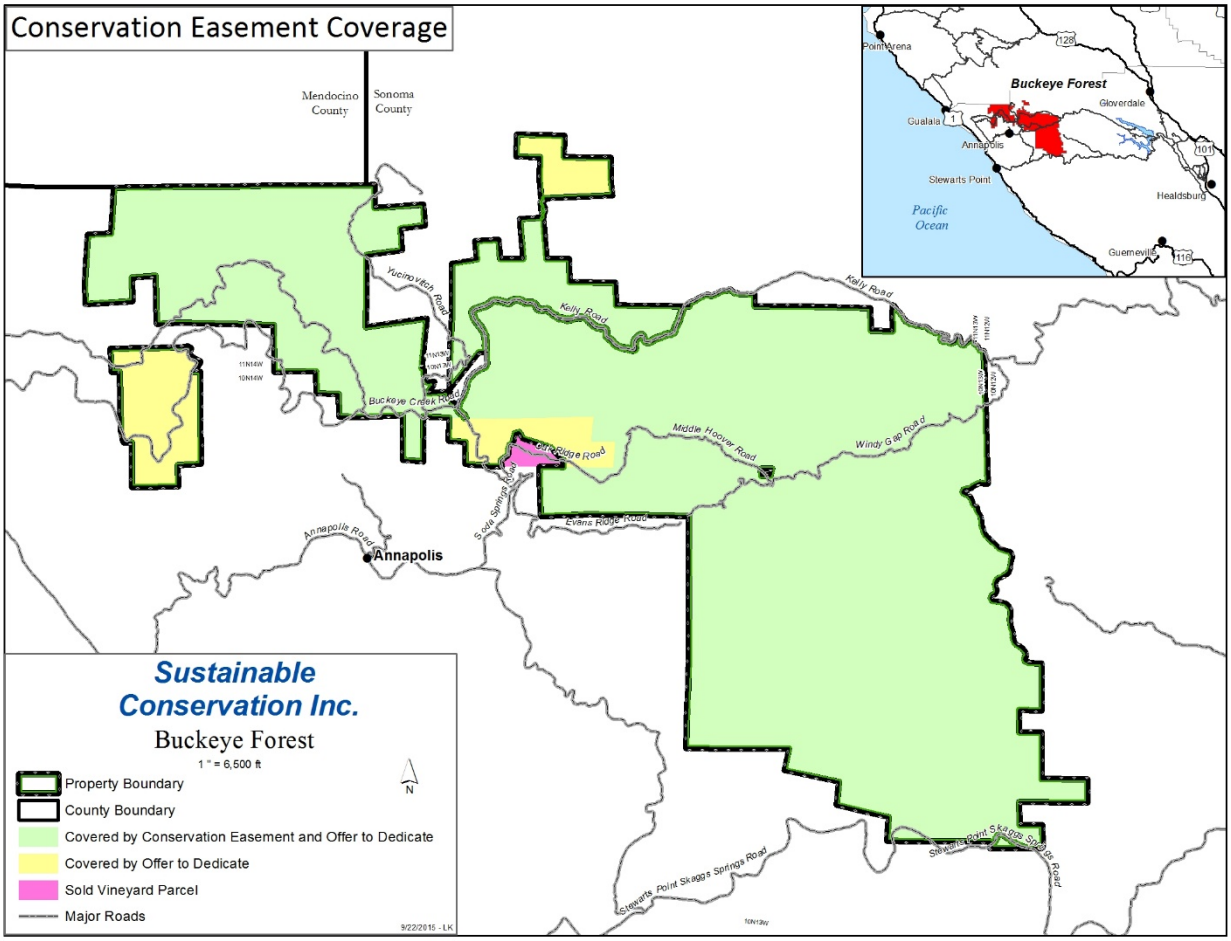

Figure 3: Map of Qualified Conservation Easement Coverage

Table 5: Reversal Risk Rating and Buffer Pool Contribution Calculation

	Risk Category	Risk Rating
	Financial Failure	5%
Management	Illegal Harvesting	0%
Management	Conversion	2%
Management	Over Harvesting	2%
	Social	2%
Natural Disturbance	Wildfire	4%
Natural Disturbance	Disease/Insect	3%
Natural Disturbance	Other Catastrophic Events	3%
	Total Buffer Pool Contribution*	19.236%

*Total Buffer Pool contribution was calculated with the risk rating analysis formula on page 107 of Appendix D.

3.24. Tree Canopy Cover

Based on visual analysis of high-resolution aerial imagery, it is clear the BFP is dominated by forest with greater than 10% tree canopy cover. The only areas with less than 10% canopy cover are grassland areas, as shown in Appendix E (SCI_BFP_CanopyCover_AerialPhoto_24x36_2014.pdf). Additionally, the CA Wildlife Habitat Relationship classes categorize the project as having only 3% of the area in non-forest habitat types.

3.25. Initial Carbon Stocks and Determination of Common Practice

As described in section 3.20 – Summary of Carbon Stocks, the initial carbon stocks on the BFP were found using the year-end inventory from 2013 and growing these stocks backwards to the project commencement date of 6/1/2013. The approximately half year of backwards growth is a fraction of a year of forward growth and was grown using the FORSEE growth and yield model. The initial stocks can be seen above in Table 3.

As described in section 3.13 – Assessment Areas, the Project is located within the Northern California Coast Supersection per Appendix F of the Protocol. Within the larger Supersection, the Project is within both the CRDFMC and the NCCMOW Assessment Areas. The Project Area is classified as Low Site class within these Assessment Areas.

The Common Practice Indicator for the CRDFMC Assessment Area is 165 Mt CO_2e/acre of above ground live trees per acre for Low Site and 188 MtCO_2e/acre for High Site. The project is located solely on low site soils so 165 MtCO_2e/acre is the common practice baseline used for this assessment area.[5] The Common Practice Indicator for the NCCMOW is 108 MtCO_2e/acre. Combining these two common practice values based on the area they represent on the property, the final Common Practice for the BFP area is 148.07 MtCO_2e/acre. The Project Area's starting above ground live carbon stocks are 156.5 MtCO_2e/acre, and as such, are above the Common Practice Indicator (CPI). Because the Project Area is above the CPI, the project area is not subject to the High Stocking Reference (HSR) test. Furthermore, because the initial stocks are higher than the CPI, the minimum baseline level (MBL) is equal to the CPI.[6]

3.26. Legal Constraints Affecting Forest Management

The BFP lands have been in compliance with all local, state and federal regulatory requirements for the reporting period from 6/1/2014 to 5/31/2015. Please see section 5.3 – Legal Constraints in the Modeling Plan – in this document for a complete list of the legal constraints that affect forest management.

3.27. Financial Feasibility Analysis

A test of the financial feasibility of the baseline model was run in accordance with section 6.2.1.3 of the CARB COPUSFP. This analysis showed there is a positive net present value (NPV) associated with the harvesting of timber under the baseline scenario. The baseline scenario already reflects all legal and regulatory constraints and the costs of logging and values of logs were conservatively estimated so these conclusions will likely hold even with significantly worse market conditions and/or harvesting costs. The result of this analysis showed a NPV of the full 100-year stream of net timber value of over $6 million.

3.28. Summary of Changes from Initial Listing

There are several changes to the BFP documentation since the project was initial listed. First, the initial listing stated that the project was 19,525 acres; however, this was a typo and the project area is actually 19,552 acres.

---

[5] SSURGO soil data was examined (see http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx). Of the BFP total 19,552 acres, only 773 acres had SSURGO site class or site index data and these acres were all low site class. The other acres without site class or site index data used the measured site index to estimate site class. See section 5.2.3 of this document for more discussion of the site index and site class values used.

[6] Equation 6.5 of the CARB COPUSFP specifies that the MBL = CP when the initial stocks are above common practice.

Furthermore, the first reporting period was expanded to be a full year (6/1/2013-5/31/2014) rather than ending the initial reporting period with the calendar year (6/1/2013-12/31/2013).

The Inventory methods and resulting calculations also have changes as a new inventory was installed in 2013. A total of 662 plots were measured with an accuracy of 4.15% at the 90% confidence level.

Finally, nearly all of the project is covered by a QCE; however, it is understood that the appropriate risk rating does not use a weighted average for the risk liability. The reversal risk rating was increased from 12.869% in the initial list document to a value of 19.236% used in subsequent documents.

During the second reporting period (6/1/2014 – 5/31/2015) there were two changes to the project from the initial OPDR. The first is the updated inventory methodology for future on-the-ground measurements. The new methodology is attached in Appendix E and is documented in the change log. It will be implemented in subsequent reporting periods, if approved. Additionally, the approach to address negative growth outputs in inventory updates in the growth and yield model, FORSEE, was revised. For this OPDR and in the future, until further guidance is provided or the model is updated, this will be addressed by using the most recent field measurement for diameter and height (e.g., zero annual height or diameter growth) for all trees subject to negative diameter growth. The contact for the APD changed during Reporting Period 2. Lauren Fety, Forest Analyst for the Conservation Fund is the new contact: 215 W Standley St Suite 11, Ukiah, California 95482. Email lfety@conservationfund.org; Telephone: 541-727-2094

3.29. Reversals

There have been no reversals of carbon stocks since the project commenced.

4. Inventory Methodology

The BFP inventory was designed and implemented in 2013. The BFP was sampled using a 2-stage probability proportional to size stratified random sampling design with the primary sample (stands) selected with probability proportional to size and the secondary samples (plots) placed in each stand on a systematic grid. The sampling design used was described by Borders et al. (2005) as 2-stage list sampling.[7]

4.1. Offset Project Boundary

The BFP measures carbon in standing live trees (both above and belowground carbon) and in standing dead trees.

4.2. Field Measurement Procedures

The original sample of standing live and dead trees used a basal area factor (BAF) prism to determine which trees to measure. BAF are chosen for each stand to count on average 6 trees greater than or equal to 5 inches DBH per plot. Trees less than 5 inches are measured in a 1/100th acre fixed area regeneration plot. Total height was measured on trees in each 3rd plot. Appendix A details the inventory collection procedures used at the project start. Future sampling will use fixed area circular plots; the methodology for fixed area plots is outlined in Appendix E. These fixed area plots will allow for easier re-verification.

[7] Borders, B. E., B. D. Shiver, and M. L. Clutter. 2005. Timber Inventory of Large Acreages Using Stratified Two-Stage List Sampling. Southern Journal of Applied Forestry 29:152–157.

Future sampling for inventory updates fixed area plots will be 1/10th acre in size and use the plot center from the initial forest inventory. Appendix E of the Initial OPDR v1.3 details the inventory methodology and the logistics associated with inventory update.

4.3.Stratification

The BFP uses a stratified sampling design to sample the forest. Generally, in stratified sampling, a population of interest is divided into strata that share certain attributes. By dividing the population into strata and then sampling within these strata, more accurate estimates of strata and population level variables can be accomplished with less sampling effort.

4.3.1. 2-Stage Probability Proportional to Size Stratified Sampling Design

Multi-stage sampling randomly selects stands within strata with probability proportional to their size to sample. This type of sampling is considered multi-stage in that the first stage of the sample is to select the stands within a stratum. In the second stage, a sample of each stand is conducted. Appendix C details the mathematical formulas used to calculate means and standard errors using this approach as well as the results of these calculations.

The stand boundaries were defined using high-density Light Detection and Ranging (LiDAR) data following the method described by Golinkoff (2013)[8]. Stands were assigned strata labels based on how their LiDAR derived attributes fell within four categories: mean tree height, percent canopy cover, variability of tree height, and percent conifer or hardwood. The table below shows the strata that were created, the area they cover, the number of stands within each stratum, and the number of plots sampled. A total of 34 strata were created and inventoried in the original inventory.

The BFP boundary is the full 19,552 acres and includes roads (818 acres based on an 18ft buffer on both sides of the linear road features), grasslands (750 acres) and bareground areas (2.4 acre). These strata were not sampled and were assumed to have 0 carbon stocks/acre. As the project changes over time, the acreage in these non-forest types (as well the forested strata) may change. However, road, grassland, and bareground types will always be assumed to have 0 $MtCO_2e$/acre for the full life of the project.

[8] Golinkoff, J. S. 2013. Area Dependent Region Merging: A Novel, User-Customizable Method to Create Forest Stands and Strata. European Journal of Remote Sensing 46:511–533.

Table 6: Strata Summary

Strata	Forest Acres	Stands	Plots
CHD1H	904	61	58
CHD1I	201	8	12
CHD1V	13	1	4
CHD2H	296	11	16
CHD2I	29	4	4
CHD2V	10	1	4
CHE1H	585	24	35
CHE1I	157	7	12
CHE2H	5,198	126	125
CHE2I	1,708	47	51
CHL1H	35	2	4
CHM1H	328	27	16
CHM1I	21	2	4
CHM2H	50	4	8
COND1H	54	5	8
COND2H	27	4	4
COND2I	57	4	8
CONE1H	34	3	4
CONE2H	5,052	150	109
CONE2I	1,872	59	69
CONE2V	62	3	8
CONE3H	165	10	14
CONE3I	33	2	4
CONE3V	9	1	4
CONL1H	5	1	4
CONM2H	9	1	4
HCD1H	363	23	16
HCD1I	9	1	4
HCE1H	332	11	17
HCE2H	48	1	4
HCL1H	91	7	8
HCL1I	38	4	4
HCM1H	178	16	12
HWM1H	7	1	4
Totals:	**17,982**	**633**	**662**

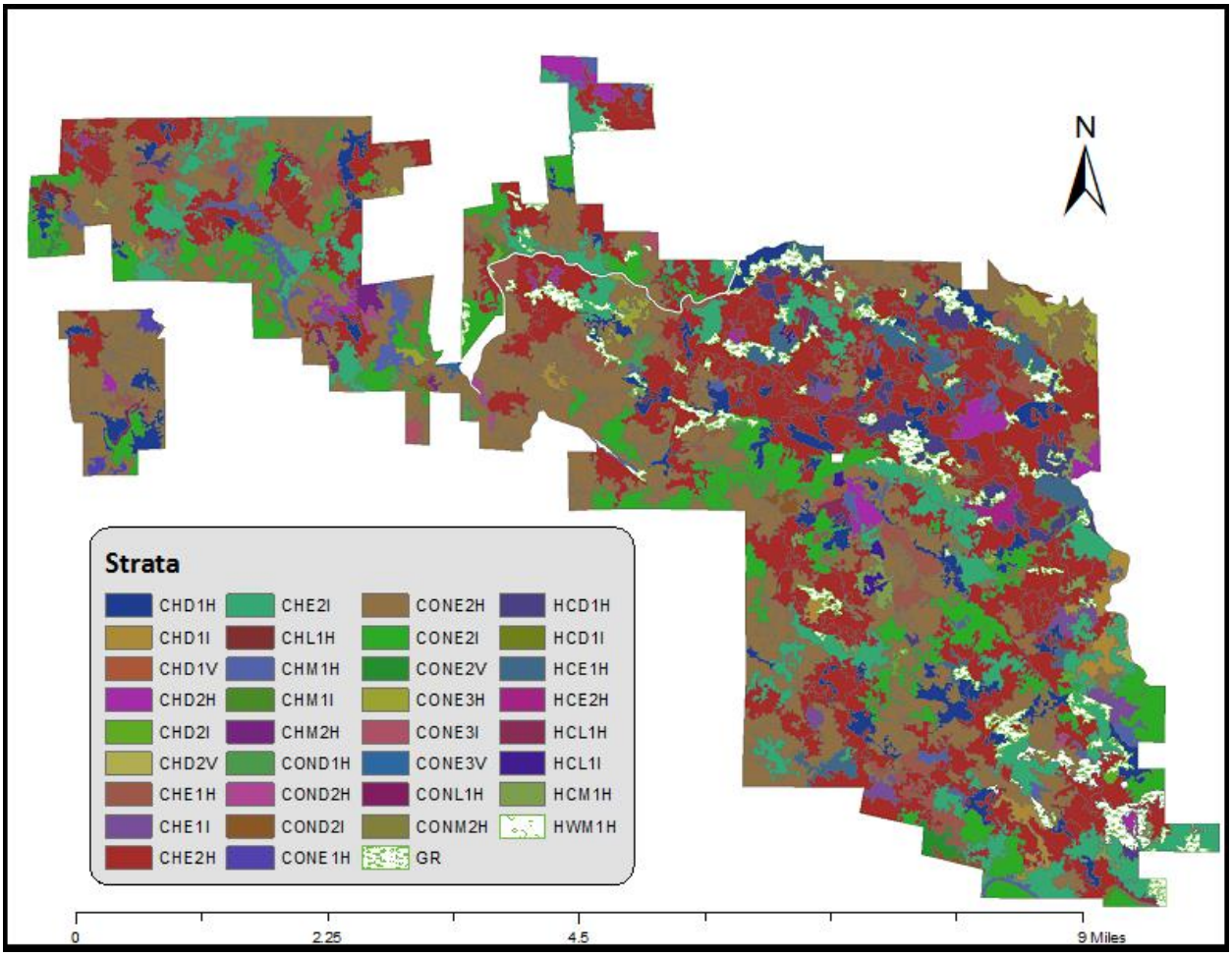

Figure 4: BFP Stands and Strata

Table 7: Stratification system summary

Category	Class Names	Class Breaks
Percent Conifer Canopy Cover	CON: more than 75% Conifer Crown Cover CH: between 50% and 75% Conifer Crown Cover HC: between 25% and 50% Conifer Crown Cover HW: less than 25% Conifer Crown Cover	25% conifer crown cover bins. The LiDAR-derived crown segmentation was assigned a conifer or hardwood call based on the crown shape.
Percent Canopy Cover over 25ft	O (Open): less than or equal to 20% Cover L (Low): between 20% and 40% cover M (Medium): between 40% and 60% cover D (Dense): between 60% and 80% cover E (Extremely Dense): over 80% cover	20% canopy cover bins where % cover is defined as the cover of crown elements above 25ft tall.
Mean Tree Height	1,2,3,4,5,6,7	25ft height bins of mean tree height.
Tree Height Variability (Coefficient of Variation of Tree Height)	H (Homogeneous) I (Intermediate) V (Variable)	Homogeneous stands are any stand with CV <. 23, Intermediate: .23 <= CV <.33, and Variable: CV >= .34

4.3.2. Future Stratification and Sampling Designs

Future stratification efforts will be conducted as the forest grows and disturbance occurs. The aim of any new stratification will be to reduce the variability of inventory that results as the existing strata become outdated due to changing forest conditions. When new stratifications are conducted, new inventory plots will be placed into the newly created strata using a random or probability proportional to size approach. The new stratification systems in the future may use LiDAR and/or high resolution imagery paired with past inventory data and professional judgment. New stratification systems will either use a multi-stage approach or a simple random stratification approach.

4.4.Inventory Analytical Methods

The sections below will outline the estimation methods used for each of the required IFM pools. The offset project boundary is defined in Table 5.2 of the COPUSFP and each required pool is outlined below (see Appendix D for values).

After inventory data is collected in the field following the forest inventory methodology outlined in Appendix E, it is transferred to an electronic format by the timber cruiser or by TCF staff. The inventory data is then entered into the inventory growth and yield database system. A series of Quality Assurance and Quality Control (QAQC) checks are then applied to this data as discussed below. Individual trees and their associated plots are then tracked through all growth and yield modeling.

The inventory design sub-samples tree height by measuring height on every 3rd plot starting with the first plot. Trees not measured for height are estimated using the equation forms outlined in Eng (2012).[9]

[9] 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.

4.4.1. IFM 1: Primary Effect – Standing Live Carbon Pool

Individual trees have the approved CARB COPUSFP biomass and carbon equations applied to them to calculate their biomass and carbon equivalents[10]. The biomass estimates are then summed and converted to metric tons of biomass per hectare at the plot level. These per hectare biomass estimates are the input variable in a regression developed by Cairns et al.[11] to estimate below ground biomass (BGB) from above ground biomass (AGB). All estimates of belowground biomass are applied at the plot level to metric tons of biomass/hectare of standing live trees. Standing live biomass (**SLB**) is the sum of AGB and BGB.

Table 8: Volume, Biomass, and Density Equations and Coefficients by Species

Species Code	Common Name	Latin Name	Bole Volume (ft3)	Bark Biomass (kg)	Live Branch Biomass (kg)	Specific Gravity	Wood Density
BM	**Big Leaf Maple**	*Acer macrophyllum*	Equation 37	None	None	0.44	27.46
BO	**Black Oak**	*Quercus kellogii*	Equation 38	None	None	0.56	34.94
CB	**CA Bay/Laurel**	*Umbellularia californica*	Equation 33	None	None	0.59	36.82
CO	**Canyon Live Oak**	*Quercus chrysolepis*	Equation 42	None	None	0.8	49.92
CU	**CA Buckeye**	*Aesculus californica*	Equation 43	None	None	0.38	23.71
DF	**Douglas fir**	*Pseudostugsa mensziesii*	Equation 3	Equation 8	Equation 6	0.46	28.7
GC	**Giant/Golden Chinquapin**	*Chrysolepis chrysophylla*	Equation 32	None	None	0.48	29.95
LO	**Interior Live Oak**	*Quercus wislizenii*	Equation 44	None	None	0.8	49.92
NM	**CA Nutmeg**	*Torreya californica*	Equation 8	Equation 13	Equation 10	0.51	31.82
PM	**Pacific Madrone**	*Arbutus mensziesii*	Equation 40	None	None	0.69	43.06
RA	**Red Alder**	*Alnus Rubra*	Equation 26	Equation 20	Equation 16	0.37	23.09
RW	**Redwood**	*Sequoia sempervirens*	Equation 24	Equation 17	Equation 10	0.34	21.22
SP	**Sugar Pine**	*Pinus lambatiana*	Equation 20	Equation 10	Equation 8	0.34	21.22
TO	**Tanoak**	*Lithocarpus densiflorus*	Equation 34	None	None	0.58	36.19
UK	**Unknown**	*Unknown*	Equation 41	None	None	0.45	28.08
WA	**White Alder**	*Alnus rhombifolia*	Equation 26	Equation 20	Equation 16	0.37	23.09
WM	**Wax Myrtle***	*Myrica californica*	Equation 41	None	None	0.44	27.46
WO	**OR While Oak**	*Quercus garryana*	Equation 41	None	None	0.6	37.44
XX	**Unknown**	*Unknown*	Equation 41	None	None	0.45	28.08

*Wax Myrtle does not have a volume equation so uses the Unknown species equations.

The recommended belowground biomass equation is used to calculate the belowground biomass using the aboveground biomass. This equation is applied at the plot level and is applied to the sum of all standing live wood. That equation is:

Equation 1: Belowground biomass – $BBD = \exp(-0.7747 + 0.8836 \times \ln(ABD))$

BBD – belowground biomass density

ABD – aboveground biomass density in kg/ha – this is a per plot value.

The total standing live carbon (above and below ground) per hectare is then converted to units of carbon per acre by dividing by 2.47 acres/ha and then dividing by 2 to convert from biomass to carbon as carbon is assumed to be half of the total biomass. All calculations occur in modules and queries called from a database system. The per acre carbon values are converted to CO_2e values by multiplying by 3.664 as specified by the COPUSFP. All per acre values are then scaled to the forest as a whole by multiplying by the strata area.

[10] The approved DBH to biomass regressions were all taken from the USFS Pacific Northwest Research Station documentation that can be found here: http://www.arb.ca.gov/cc/capandtrade/protocols/usforestprojects.htm#Documents_for_Projects_Located_in

[11] Cairns, M. A., S. Brown, et al. (1997). "Root biomass allocation in the world's upland forests." Oecologia 111(1): 1.

The aboveground biomass of standing live trees with missing tops is calculated by using the regressed estimate of total tree height. If a broken top tree was measured for height, its volume is scaled by the ratio of the measured to regressed height. For unmeasured broken top trees, a call is made in the field for the percentage of the height of the tree that is missing, and this is deducted from the resulting estimate of tree volume. This approach was used to better account for the taper of trees with broken and missing tops.

The SLB for the project activity is calculated each year based on any new inventory data collected and/or grown forward tree lists following methodology outlines in Appendix E. The SLB for the baseline is also calculated as described above for the full 100 year baseline timeframe.

4.4.2. IFM 3: Primary Effect – Standing Dead Carbon Pool

Standing dead wood biomass (**SDB**) and lying dead wood biomass (**LDB**)[12] is calculated in several steps. **LDB** is calculated based on the piece length and averaged piece diameter recorded in the field. The cylindrical volume of the piece is then calculated from these measurements and converted to biomass of a sound log. The sound log biomass is then converted to dead biomass using the relative density coefficients from Harmon et al (2008).[13]

SDB is calculated based on the DBH and height measured in the field (all dead trees are measured for height) following methodology described in Appendix E. For dead trees with only limited decay (recently dead trees – snags with decay class 1), the full volume and biomass is calculated in exactly the same fashion as for live trees, except that the belowground carbon is omitted. For snags with more advanced decay (decay classes 2 to 5), volume and biomass is calculated only for the portion of the tree remaining and discounted based on the missing volume due to broken tops. The percentage volume discount is equal to the measured height as a percentage of the regression based height estimate. Once the volume is calculated, the undecayed biomass is estimated using the density coefficients specified in the CARB COPUSFP biomass references. The biomass components included in the calculation depends on the state of decay of the dead tree and can be seen in the table below.

Table 9: Volume basis for biomass calculation of snags

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

Lastly, the decay adjusted biomass is calculated by applying the species specific relative density factors seen in the table below from Harmon et al. (2008). The decay classes used are those defined by the USFS for their Forest Inventory and Analysis (FIA) plots and this description can be seen in Appendix A. The biomass is converted to carbon assuming carbon is 50% of biomass. Carbon is converted to CO_2e for standing live and standing dead pools by multiplying by 3.664 as required in the COPUSFP.

[12] Lying dead wood biomass is calculated however it is **NOT** included within the GHG assessment boundary and is only used as an indicator for natural forest management and forest health purposes.

[13] Harmon, M. E., C. W. Woodall, B. Fasth, and J. Sexton. 2008. Woody detritus density and density reduction factors for tree species in the United States: a synthesis. Pages 90. General Technical Report NRS-29, United States Department of Agriculture, Forest Service, Northern Research Station.

Table 10: Coarse woody debris – Relative density factors (Mt/m³) from Harmon et al (2008)

Species Code	Common Name	Latin Name	Decay Class 0: No Decay (same density as live trees)	Decay Class 1	Decay Class 2	Decay Class 3	Decay Class 4	Decay Class 5
BM	**Big Leaf Maple**	Acer macrophyllum	0.44	0.941	0.709	0.533	0.317	0.241
BO	**Black Oak**	Quercus kellogii	0.56	0.981	0.779	0.665	0.416	0.428
CB	**CA Bay/Laurel**	Umbellularia californica	0.59	0.944	0.734	0.583	0.37	0.282
CO	**Canyon Live Oak**	Quercus chrysolepis	0.8	0.981	0.779	0.665	0.416	0.428
CU	**CA Buckeye**	Aesculus californica	0.38	0.944	0.734	0.583	0.37	0.282
DF	**Douglas fir**	Pseudostugsa mensziesii	0.46	0.858	0.723	0.444	0.305	0.329
GC*	**Giant/Golden Chinquapin**	Chrysolepis chrysophylla	0.48	0	0	0	0	0
LO	**Live Oak**	Quercus wislizenii	0.8	0.981	0.779	0.665	0.416	0.428
NM	**CA Nutmeg**	Torreya californica	0.51	0.956	0.827	0.678	0.426	0.366
PM	**Pacific Madrone**	Arbutus mensziesii	0.69	0.944	0.734	0.583	0.37	0.282
RA	**Red Alder**	Alnus Rubra	0.37	0.99	0.836	0.505	0.277	0.3
RW	**Redwood**	Sequoia sempervirens	0.34	0.956	0.827	0.678	0.426	0.366
SP	**Sugar Pine**	Pinus lambatiana	0.34	1	0.788	0.553	0.364	0.407
TO	**Tanoak**	Lithocarpus densiflorus	0.58	0.944	0.734	0.583	0.37	0.282
UK*	**Unknown**	Unknown	0.45	0.944	0.734	0.583	0.37	0.282
WA	**White Alder**	Alnus rhombifolia	0.37	0.99	0.836	0.505	0.277	0.3
WM*	**Wax Myrtle**	Myrica californica	0.44	0	0	0	0	0
WO	**OR While Oak**	Quercus garryana	0.6	0.981	0.779	0.665	0.416	0.428
XX*	**Unknown**	Unknown	0.45	0	0	0	0	0

* Chinquapin, Wax Myrtle, and unknown species all have 0 standing dead carbon since these species are not found in the Harmon et al. (2008) publication. This only effects Chinquapin as there were no standing dead unknown or Wax Myrtle trees measured.

4.4.3. IFM 6: Primary Effect – Soil Carbon Pool

The soil carbon pool is excluded since no site preparation activities are used.

4.4.4. IFM 7: Primary Effect – In-Use Forest Product Carbon Pool

The in-use forest product carbon pool is calculated each year when a harvest occurs. The baseline forest product carbon pool is also calculated for all harvest events. In use forest product carbon is calculated following the instructions described in Appendix C of the COPUSFP. The mill efficiency used is based on conifer only milling for the Pacific Coast Southwest region. Table 26 shows the coefficients used to convert the milled material (after the efficiency deduction is applied) into product classes. These coefficients are taken from Appendix F Assessment Area data of the COPUSFP. The total in-use forest product carbon pool calculation follows table C.2 in the COPUSFP. The final CO_2e estimate is converted from carbon by multiplying by 3.67. Table 4 shows the final results by product type.

4.4.5. IFM 8: Primary Effect – Forest Product Carbon in Landfills Pool

The forest product in landfill carbon pool is calculated each year when a harvest occurs. The baseline forest product carbon pool is also calculated for all harvest events. Landfill forest product carbon is calculated following the instructions described in Appendix C of the COPUSFP. The mill efficiency used is based on conifer only milling for the Pacific Coast Southwest region. Table 26 shows the coefficients used to convert the milled material (after the efficiency deduction is applied) into product classes. These coefficients are taken from Appendix F Assessment Area data of the COPUSFP. The total landfill forest product carbon pool calculation follows table C.3 in the COPUSFP. The final CO_2e estimate is converted from carbon by multiplying by 3.67. Table 4 shows the final results by product type.

4.4.6. IFM 9: Secondary Effect – Site Preparation Emissions

Site Preparation Emissions are excluded since no site preparation activities are used.

4.4.7. IFM 14: Secondary Effect – Changes in Harvesting Outside of Project Area

The market leakage effects are estimated using a default 20% "leakage" factor applied to the difference in the actual yearly harvest volume relative to modeled baseline harvest levels.

4.4.8. IFM 17: Secondary Effect – Forest Product Decomposition Emissions

Forest product decomposition emissions are quantified as a component of the 100 year in-use forest products and landfill forest products calculations.

4.5. Quality Assurance and Quality Control Procedures

All inventory data is check-cruised for accuracy. Check cruising was done to identify and correct errors found in the field. Plots were check cruised on a cruiser-by-cruiser basis. A cruiser was considered to have passed the check cruise if their total merchantable BF/acre and metric tons of C/acre were within 10% of the check cruiser's estimate and if these estimates were not statistically different using a paired t-test at the 90% confidence level. Once the data is entered into the database, a suite of QA/QC tests are then run on the data to determine any irregularities or problems. These tests throw warnings for individual trees that fail the following tests:

- outside the existing range of max and min DBH data
- outside the existing range of max and min HT data
- outside the existing range of max and min DBH/HT data
- species codes cannot be found either in existing data or SPECIES table
- greater than one tree counted for trees greater than BAF_DBH
- incorrect or inappropriate group codes
- incorrect plot location
- incorrect or missing defect codes or defect percentages

If any questions arise during this phase, the inventory database manager contacts the field technicians to clarify or collect new data.

4.6. Data Management Systems and Procedures

SCI uses a forest growth and yield model as well as computer code written by Jordan Golinkoff to manage the forest inventory and make projections of future forest conditions. Currently, TCF uses the FORest and Stand Evaluation Environment (FORSEE) Software developed by the California Growth and Yield Modeling (CAGYM) cooperative (http://www.cagym.com/). As new versions of FORSEE become available they will be tested and potentially incorporated into the project. FORSEE is an approved growth model found in the CARB COPUSFP. FORSEE is used to grow the forest forward in years when data is not collected on the ground; for more details see Appendix E.

TCF has also developed a suite of in-house computer code written in several languages that aid in the processing and analysis of the data stored within the Microsoft Access inventory database. All computer code used in this project is also stored on a server using the SVN version control software. This code resides within the individual inventory databases as well as in the SVN repository located on a remote server.

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 that is used for registration forms (databases and Excel spreadsheets) is archived and saved with each registration. Any future work on these data sources is done on copies and the originals are saved for future reference.

4.7.Inventory Update Procedure

Post-Disturbance or Harvest: After any disturbance event (either planned or unplanned), new inventory plots are installed to measure the impact of the disturbance. The first step of this inventory update is to create polygons that describe the area impacted by the disturbance. A 10-by-10 chain grid of points with a random start has been overlaid across the full ownership. A subset of the plots will be measured for heights on all trees and in some cases LiDAR data will be used to estimate tree heights. If a stand has fewer than four 10-by-10 chain plot points in it, a 5-by-5 chain grid is used such that all stands have at least four plots. If there still are not enough plots using a 5-by-5 chain grid, a 2.5-by-2.5 chain grid is used. Data collection for post-disturbance events follows the forest inventory methodology outlined in Appendix E.

To track disturbance areas spatially and in the growth and yield database, each disturbance polygon receives a unique stand ID of the form Year-Disturbance Number. For example, if there are 3 harvested areas in 2011, these would receive stand number 20111, 20112, and 20113. Contiguous disturbance areas usually form one polygon but may be split if conditions are deemed to be distinct in different areas. Each distinct area also receives a strata label that identifies the disturbance (e.g.: CG1 is one strata resulting from the Coombs Gulch THP). Each polygon has its area calculated and this area is removed from whatever stands the polygon was originally in prior to the disturbance event. The figure below shows an example of the how this approach works on a different forest.

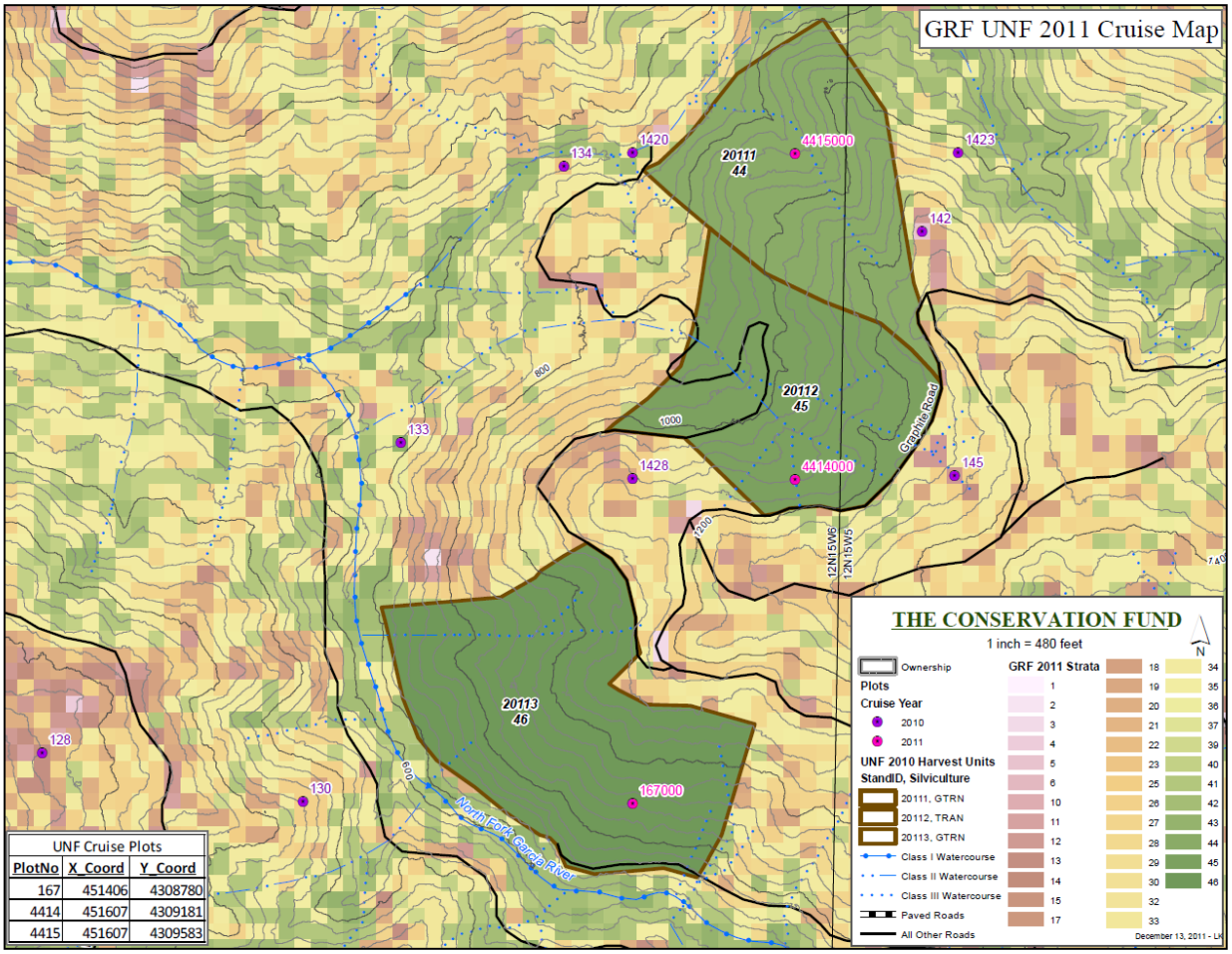

Figure 5: Example of post-disturbance stand layer update cut into the existing stratification and stand system on a different property.

In addition to sampling disturbance areas, some areas of the forest may be resampled from time to time to insure all plots are less than 12 years old and inventory accuracy targets are met. This re-inventory process may use the existing stand layer or may define new stand boundaries similar to the method described above. All future sampling will use the fixed radius methodology outlined in Appendix E.

Harvest or disturbance removals or carbon stock reductions are estimated by differencing pre- and post-disturbance inventory estimates at the stand polygon level. Disturbance impacts are then reported on a stand (polygon) basis. Inventory data is added to the master inventory database as it is collected. When full, property wide inventory data is collected, a new database is used to store this data and old inventory databases are archived for record-keeping purposes.

Growth: Growth is applied on a yearly basis to stands or strata that have not been disturbed in a given year. All plot data at the project start was grown to the year of the project start (if necessary) so that in subsequent years growth is only for one year at a time. TCF uses FORSEE (as discussed above) and grows each stand or stratum's tree list using the most recent inventory data. For a more complete discussion of growth and site index, see the modeling plan.

Incorporating New Plots and Retiring Old Plots: As discussed in the disturbance section above, new plots are added in disturbed areas and these disturbed areas become new strata. For un-disturbed areas, strata may be entered periodically to be completely re-inventoried or may be re-inventoried at the point of a complete property-wide re-inventory process. Regardless of the scale of new inventory efforts, no plot data older than 12 years old is used in the inventory database. New plot data replaces old data in all cases (all old plot data is saved for archival purposes).

Modeling: Modeling is only used to grow the DBHCLASS tables for stands or strata that have not been disturbed.

Calculation and Application of Confidence Deduction: All accuracy statistics are calculated based on the plot level total carbon per acre values. Appendix C details the equations used to calculate accuracy at the 90% confidence level. Any confidence deductions are applied as per CARB COPUSFP rules. Accuracy calculations are based on un-grown plot data. The accuracy calculations and confidence deductions are calculated each year.

4.8.Change Log

The table below notes the date and nature of changes to the inventory procedures that have occurred since the project start.

Table 11: Change Log Summary

#	Rpt Year	Change
1	**2014**	Corrected cubic volume calculations.
2	**2014**	Corrected DF and RW site index calculation equations.
3	**2014**	Modeled all growth and yield at the plot level. Past modeling was all done at the stand level.
4	**2014**	Only calculated belowground biomass on standing live trees. Past modeling also calculated belowground biomass on recently dead trees. As part of this updated, the distinction between recently dead trees and snags was removed and instead recently dead trees are given a decay code of 1 and are considered snags.
5	**2015**	Fixed radius plot sampling methodology was incorporated into the OPDR for future sampling.
6	**2015**	Revised method for addressing trees with negative growth output from FORSEE
7		
8		
9		
10		
11		
12		

5. Modeling Plan

The CARB COPUSFP requires that all forest projects model the baseline business as usual carbon stored over a 100-year period. To estimate the project additionality, a baseline management regime that conforms to the California Forest Practice Rules (CA FPR) Option C language is modeled and is subtracted from the measured project activity on a yearly basis. The difference between these two regimes is an estimate of the additional carbon that can be claimed as a result of the forest owner's management actions.

Before modeling the management activities in a given area, an accurate representation of the size of buffers based on the laws governing forest management is needed. The CA FPR define the buffer area (linear distance from objects) requirements in terms of silvicultural limitations, which may be based on retention standards defined by either basal area or canopy cover retention, or disallowing any harvest. The CA FPR mandates streams, certain rare and endangered species, and areas highly sensitive to erosion be buffered to reduce the potential impact of forest management activities on riparian areas and sensitive species.

The baseline model was constructed to be a financially feasible approach to management legal under all relevant laws, rules, and regulations. The growth and yield modeling was done using the approved FORSEE growth and yield model (see section 5.2 below for details).

The computation of carbon stocks for inventory, growth, and harvest in the baseline is all done based on the tree list outputs from FORSEE. There are 4 regimes (outlined below) and each harvesting regime outputs to two separate databases. The first database contains the pre-harvest tree list. The second database contains the post-harvest tree list. The calculation of stocks at each reporting period are based on the end of period output tree list. This reflects the harvest removals simulated for all stands. The harvest volumes are estimated on a stand level by differencing the pre-harvest and post-harvest tree lists. Each individual tree has its total aboveground carbon as well as only its bole carbon estimated and summed at the stand level for each year.

5.1. Baseline Management Buffers

Appendix I shows the management buffers on a map of the property. The tables below summarize the area within each type of forest area. Geospatial data is analyzed using ArcMap 10.3.

5.1.1. Forest Area

The first calculation applied to the gross property acreage is to remove non-forest areas. This involves removing rock pits, bare ground, grassland, and shrub-land areas that do not support forest. The next step is to remove all road surfaces from the forest land area using an 18 foot linear buffer on each side of all mapped truck roads. The forest area (17,982 acres) is then the basis for all future modeling steps.

5.1.2. No Harvest Area

No harvest areas are defined in the CA FPR for certain sensitive species and to provide watershed protection for anadromous fisheries. The primary species of concern that have mandated protection zones in the coastal northern California region are Northern Spotted Owls (NSO) (14 CCR 919.9, and the regulations described in USFWS attachment A, scenario 4 included with this document as Appendix B.) and Coho Salmon (14 CCR 916.9). The forest non-harvestable area is calculated by removing non-harvestable NSO areas, non-harvestable stream riparian areas, and other non-harvestable sensitive species areas if any exist.

The non-harvestable NSO areas consist of a 100-acre core area in which no harvesting is allowed around known nesting or roosting sites. The non-harvestable stream areas (watercourse and lake protection zones – WLPZ) are the inner 30 feet of class 1 and large class 2 streams and the inner 15 feet for standard class 2 streams. There were no other sensitive species on the BFP that required no harvest areas. The non-harvestable acres were then subtracted from the full forest acres and grown forward with no management applied.

5.1.3. Constrained Harvest Area

Some degree of harvesting is allowed outside of the inner stream zones according to the CA FPR (all references to the CA FPR sections to find these constraints can be found in the table below). At the time of baseline modeling, the CA FPR requires that class 1 and large class II watercourses have a 30ft inner no harvest area but allowed limited harvest to occur in an outer 70 foot buffer area on class 1 and large class 2 streams. Similarly, no harvest is allowed within an inner 15 foot area on standard class 2 streams but limited harvest is allowed in an outer 85 foot buffer area. Class 1 and large class 2 streams (WLPZ1) require that harvest within the constrained area retain at least 80% canopy cover and the largest 13 trees per acre (TPA). Class 2 streams (WLPZ2) require that at least 50% canopy cover is retained at all times. Lastly, for stands managed with variable retention harvest or commercial thinning, there is an additional 50 foot buffer (from 100 to 150 feet) on Class 1 streams that is added to the WLPZ2 buffer area to retain 50% canopy cover. These two separate classes of constrained acres (WLPZ1 and WLPZ2) were then modeled and tracked separately for the full 100-year baseline modeling.

5.1.4. Unconstrained Harvest Area

After removing the non-forest acres, the non-harvestable acres, and the constrained harvested acres from the gross project acreage, the remaining acreage is then available to be modeled without the NSO and WLPZ constraints. The table below summarizes the different forest areas.

Table 12: Baseline buffering description

Final Manageable Areas	Description	Variable Name	Equation	Acres
Net Acres	***Net Acres removing road acres.***	NA	***NA = GA - RD***	***18,734***
Forest Acres	***Total Forested Acres***	FA	***FA = GA - RD - NonF***	***17,982***
Just Grow Acres	***Acres where no harvesting is allowed***	JGA	***JGA = NH_O + NH_C1 + NH_LC2 + NH_C2***	***896***
WLPZ Class 1 and Large Class 2 Management Acres	***Manageable acres along class 1 and large class 2 streams***	WLPZ1	***WLPZ1 = HR_C1 + HR_LC2***	***519***
WLPZ Class 1 Management Acres	***Manageable acres along Mainstem and Class 1 streams***	HR_C1	***HR_C1***	***424***
WLPZ Large Class 2 Management Acres	***Manageable acres Large Class II Streams***	HR_LC2	***HR_LC2***	***95***
WLPZ Class 1 Outer Zone Acres	***Manageable acres for the outer zone of Class I streams in stands with Variable Retention or Commercial Thinning Management***	HR_VRCT	***HR_VRCT***	***9***
WLPZ Class 2 Management Acres	***Manageable acres along class 2 streams (or outer zone Class 1)***	WLPZ2	***WLPZ2 = HR_C2 + HR_VRCT***	***1,250***
Unconstrained Acres	***Total acres whose management is not constrained by streams, owls, or easements.***	UA	***UA = FA -JGA - WLPZ1 - WLPZ2***	***15,316***

Table 13: CA FPR Constraint References

Category	Variable Name	Sub-Category	Linear Distance	Legal or Rule Refernce	Explanation
No Harvest Stream Acres	*NH_C1*	Class I	30'	916.9 Table 1 Core Zone	
	NH_LC2	Large Class II	30'	916.9 Table 4, Class II-L Core Zone	
	NH_C2	Class II	15'	916.9 Table 4, Class II-S Core Zone	
Harvestable Stream Acres	*HR_C1*	Class I	70'	916.9 Table 1 Inner Zone	
	HR_LC2	Large Class II	70'	916.9 Table 4, Class II-L Inner Zone	
	HR_VRCT	Class I	50'	916.9 Even Age Outer Zone	The outer zone buffering of class 1 streams was added to the WLPZ2 acreage to retain 50% canopy cover only for stands managed with Variable Retention or Commercial Thinning.
	HR_C2	Class II	85'	916.9 Table 4, Class II-S Inner Zone	Most areas on the Buckeye have > 50% slope so the largest buffer distance was used.

Table 14: Baseline management buffer areas.

Class	Acres
Gross	19,552
Net	18,734
Forest	17,982
No Harvest	896
WLPZ1	519
WLPZ2	1,250
WLPZ total	1,770
Unconstrained	15,316

5.2.Baseline Management Setup and Assumptions

The BFP baseline was modeled to reduce the average standing live aboveground carbon stocks in a way that was financially feasible. The section below outlines how this modeling was performed.

5.2.1. Growth Model

TCF uses the FORSEE growth and yield model to manage and model the BFP forest inventory data. FORSEE is an approved growth and yield model under the CARB COPUSFP. FORSEE was developed by the CAGYM cooperative. FORSEE provides a graphical user interface and database interface that allows users to enter plot and stand data. FORSEE also has a batch processing mode that allows for the processing of multiple stands at once using user-defined logic written in visual basic scripts and run by FORSEE. FORSEE's growth libraries are based on the CRYPTOS model for the California Redwood Region.

The FORSEE model was not calibrated in any way beyond specifying the local site indices for DF, RW, and SP and supplying the property specific regeneration rates. The FORSEE model is the primary tool used to model the

baseline case. Each stand is simulated based on the tree list for a given stand and a set of management regimes are applied to that stand to estimate the impacts of growth and harvest. After the initial harvest entry, most stands eventually enter a 10 year selection harvest cycle.

5.2.2. Tree List Inputs

A tree list for each plot was generated and these plot estimates were converted to per acre values. Uncruised stands were given the plot list of the cruised stands within the same stratum. All plots' tree lists are then the basis for all future growth and yield modeling.

5.2.3. Productivity Estimates (Site Index)

The BFP is comprised primarily of site class III lands. Accurate estimates of site class based on USGS or SSURGO spatial layers could not be found for the BFP. As a result, the site class was estimated based on the measured site index and the site class ranges defined by Shih (2002).[14] Site index trees were cored across the full forest. The site indices for individual trees were calculated using the recommended equations found in the Krumland and Eng (2005) publication.[15] Based on the measured site index, the BFP is composed of site class 3 lands for DF and site class 4 for RW (Krumland and Eng also have a site classification table on page 128 and the breaks in this table also results in DF SC = 3 and RW SC = 4). The resulting site class estimates can be seen in the table below for redwood, Douglas-fir, and sugar pine trees. FORSEE expands these site index estimates to other species. The site tree selection methodology is detailed in Appendix A.

Table 15: Site Index Estimates by Species and Site Class

Species	50yr SI	100yr SI	Shih Site Class
DF	97.6	147.2	III
RW	81.4	124.4	IV

5.2.4. Regeneration Assumptions

The FORSEE model only applies regeneration after harvest events. The regeneration tree counts are defined as the number of viable trees surviving for five years after the harvest event. Based on the trees found across the BFP property, four tree lists were used when simulating regeneration post-harvest. These regeneration tree lists were based on the four conifer / hardwood classes defined in the timber stratification. The percentage regeneration by species is based on the measured basal area within each of the 4 strata bins. Any species with less than 2.5% of the BA was not included in the regeneration list. The table below shows the percentage of regeneration stems that will be added by species strata group based on the measured BA in these groups.

[14] Shih, T.-T. 2002. Timberland Site Class on Private Lands Zoned for Timber Production. Page 10. Technical Working Paper, California Department of Forestry and Fire Protection, Fire and Resource Assessment Program.

[15] Krumland, B., and H. Eng. 2005. Site Index Systems for Major Young-Growth Forest and Woodland Species in Northern California. Page 220. State of California, The Resources Agency, Department of Forestry and Fire Protection, California.

Table 16: Regeneration percentages by species for four species strata bins.

Spcs Code	Common Name	Latin Name	CH	CON	HC	HW
BO	Black Oak	*Quercus kellogii*	0%	0%	10%	0%
CB	CA Bay/Laurel	*Umbellularia californica*	6%	0%	14%	14%
CO	Canyon Live Oak	*Quercus chrysolepis*	0%	0%	6%	0%
DF	Douglas fir	*Pseudostugsa mensziesii*	23%	27%	23%	0%
LO	Live Oak	*Quercus wislizenii*	3%	0%	8%	55%
PM	Pacific Madrone	*Arbutus mensziesii*	6%	6%	8%	0%
RA	Red Alder	*Alnus Rubra*	0%	0%	0%	0%
RW	Redwood	*Sequoia sempervirens*	19%	26%	4%	0%
SP	Sugar Pine	*Pinus lambatiana*	3%	3%	0%	0%
TO	Tanoak	*Lithocarpus densiflorus*	39%	38%	9%	0%
WO	OR While Oak	*Quercus garryana*	0%	0%	18%	32%
		Total:	**100%**	**100%**	**100%**	**100%**
		Acres:	9,535	7,380	1,060	7

The number of seedlings planted post-harvest is seen in the table below and represents the number of seedlings that are viable 5 years after the harvest event. Seedlings are added after silviculture where planting does not occur to simulate the natural regeneration that would take place.

Table 17: Regeneration by harvest type.

		TPA	
Silviculture	**Description**	**Conifer Regen**	**HW Regen**
WLPZ Silviculture	Natural regeneration only.	15	5
Single Tree Selection	Natural regeneration only	25	10
Transition	Natural regeneration only	50	10
Variable retention	Natural regeneration and planted seedlings are used for this treatment.	270	10
Commercial Thin	Natural regeneration only.	30	10
Rehabilitation	Natural regeneration and planted seedlings are used for this treatment.	270	10
Conifer Release (HW Treatment)	Natural regeneration only.	15	5

5.3.Legal Constraints

The following legal constraints apply to the project area and were incorporated into all modeling activities.

- Z'Berg-Nejedly Forest Practice Act of 1973 (California Public Resources Code –Division 4, Chapter 8): Designed to protect, enhance & restore California's timberland.
- California Forest Practice Rules (Title 14, California Code of Regulations, Chapter 4): Regulations used to implement the Forest Practice Act that govern timber operations.
- California Timberland Productivity Act of 1982 (Gov.C. 51100 et seq.): The intent of this Act is to "encourage investment in timberlands based on reasonable expectation of harvest", and to "discourage premature or unnecessary conversion of timberland to urban and other uses".

- California Environmental Quality Act (CEQA) (Pub.Res.C. 21000 et seq.): statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.
- Porter-Cologne Water Quality Control Act (California Water Code, Division 7. Water Quality): This is the primary vehicle for implementation of California's responsibilities under the federal 1972 Clean Water Act.
- Clean Water Act of 1972 (33 U.S.C. §1251 et seq.): The Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.
- California Endangered Species Act (Fish & G.C. 2050 et seq.): Protects and Preserves all native species of fishes, amphibians, reptiles, birds, mammals, invertebrates, and plants, and their habitats, that are threatened with extinction.
- Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884): The Act provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend.

5.4. Management Description

The baseline BFP forest model considers four distinct management areas when modeling forest growth and yield. As described in the management buffer section above, the modeling separately projects no-harvest forest areas, class 1 and large class 2 (WLPZ1) forest areas, class 2 forest areas (WLPZ2), and unconstrained forest areas. The management of unconstrained areas uses both even and uneven-aged forest management approaches to harvest timber but the vast majority (>99%) of the management used is uneven-aged selection or transition harvests. A description of the sections of the CA FPR can be seen in the table below. These rules are the legal constraints that must be met when managing a forest using these silvicultural techniques, and therefore they inform how the management approaches were designed.

Table 18: CA Forest Practice Rule Section References for different Silviculture.

Prescription	CA FPR Sections
WLPZ1	916.9
WLPZ2	916.9, 916.5
Single Tree Selection	913.2
Transition	913.2
Variable Retention	913.4
Commercial Thinning	913.3
Rehabilitation	913.4, 912.7
Conifer Release	913.4

The BFP growth and yield modeling is done using 5-year planning periods and stand re-entry occurs no more frequently than once every 10 years and depends on stand conditions.

5.4.1. No Harvest Acres

The non-harvestable acres were grown forward with no harvest for the full 100-year baseline period. These areas consist of the non-harvestable inner gorges of streams as well as the non-harvestable NSO habitat areas.

5.4.2. WLPZ Constrained Harvestable Acres

The WLPZ acres were harvested according to the CA FPR which states that for class 1 and large class 2 streams at least 80% canopy cover and the largest 13 TPA must be retained. For class 2 streams at least 50%

canopy cover is retained at all times.[16] To model these constraints, a FORSEE batch script was developed to leave the 13 largest TPA for WLPZ1 areas and to calculate the canopy cover for all WLPZ areas so as to meet the canopy cover constraints. The canopy cover was calculated using a modified version of the Beer-Lambert law that scales the overlapping individual tree crown area to non-overlapping canopy cover. The individual tree crown area is calculated by FORSEE based on equations from the literature. The non-overlapping canopy is then calculated using the following formula[17]:

Equation 2: Non-Overlapping Canopy Cover

$$CCnon = (1 - Exp(-CCoverlapping))$$

In this formula, CCoverlapping is the overlapping canopy cover as a percentage of the ground area based on FORSEE's crown width models. WLPZ stands are entered if they have more than 125 ft^2 of basal area (BA) and more than the required amount of canopy cover. They are harvested to 75 ft^2 of BA at least or to the lowest BA possible given the canopy cover and largest TPA requirements. WLPZ areas are entered every 10 years at most but often less frequently.

5.4.3. Unconstrained Harvestable Acres

The forest area unconstrained by streams or owls is managed using a tiered system of stand structure metrics. There were six potential different management approaches used when modeling the baseline for the BFP. Single tree selection and transition silviculture are uneven-aged approaches. Variable retention, commercial thinning, rehabilitation, and conifer release all are considered even-aged silvicultural approaches. All hardwoods are reduced to 10 ft^2 BA if a stand is entered. The 10 ft^2 of hardwood BA are retained for wildlife habitat (the exception to this rule is for the conifer release silviculture which removes all hardwood BA). Uneven-age management is only performed if at least 10ft^2 of BA is available for harvest. Each harvesting approach is briefly described in the table below. The next table outlines the decision framework used to determine which silviculture to apply when entering a stand.

[16] CA FPR Section 916.9 - See page 80 for table 1 describing Class 1 WLPZ rules. See page 93 diagram for Class 2 large WLPZ rules. See page 72 for Class 2 small WLPZ rules.

[17] The Beer-Lambert law can be seen in Waring, R. H., and S. W. Running. 2007. Forest Ecosystems: Analysis at Multiple Scales. Elsevier Academic Press, San Francisco, CA. The conversion of this relationship to calculate non-overlapping canopy can be seen in Crookston, N. L., and A. R. Stage. 1999. Percent Canopy Cover and Stand Structure Statistics from the Forest Vegetation Simulator. Pages 16. General Technical Report, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Rocky Mountain Research Station.

Table 19: Silvicultural systems descriptions.

Prescription	Description
Single Tree Selection or Group Selection	The goal of this prescription is to create and maintain multistoried, uneven-aged stands with varied diameter classes. Trees are harvested individually or in small groups up to 1/4 acre in size. For Group Selection, trees are harvested individually or in groups up to 2.5 acres in size.
Transition	The goal of this prescription is to develop uneven-aged stands from stands that have an even-aged or irregular stand structure. Trees are harvested individually or in small groups up to 2.5 acres in size.
Variable Retention	Variable retention is a harvesting approach based on the retention of structural elements or biological legacies (trees, snags, logs, etc.) from the pre-harvest stand for integration into the post-harvest stand to achieve various ecological, social and geomorphic objectives. Retained trees may be intended to become part of future stands managed by the Selection regeneration method. Retained trees are often designated as decadent tree or snag recruitment and therefore not ever intended for harvest.[18] Variable retention only occurs if more than 50% of the pre-harvest conifer BA is in trees at least 18in DBH.
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 co-dominant trees from the pre-harvest stand.[14]
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. No Rehabilitation harvests were used in the final baseline model.
Conifer 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. Conifer release only occurs if there are at least 125 conifer seedlings between 0 and 6in DBH.

[18] Description taken from the CA FPR.

Table 20: Pre-harvest stand conditions[19]

Prescription	Miscellaneous	Conifer BA Lower Limit	Conifer BA Upper Limit
Single Tree Selection or Group Selection	NA	126	None
Transition	This harvest type only occurs twice per stand.	55	125
Variable retention (<= 40 acre stand)	Greater than 50% of conifer basal area in trees larger than 18" DBH (this is a surrogate for tree age >60 yrs)	30	75
Commercial Thin	50% of con BA < 14in DBH and at least 100 con TPA > 4in	15	75
Rehabilitation	Less than 300 point count conifer	0	75
Conifer Release (HW treatment)	At least 125 TPA of conifer stems <= 6in DBH.	0	75

The table below shows the post-harvest stand conditions as well as the constraints for re-entry and the type of management during re-entry.

Table 21: Post-harvest stand targets[17]

Prescription	Conifer BA Retention (ft2/acre)	HW BA Retention (ft2/acre)	Time to Next Treatment
Single Tree Selection	75	10	Selection when BA > 125 and at least 10 years
Transition	50	10	Transition when BA >= 55 (at least 10 years) followed by Selection
Variable retention	7.5	10	Transition after at least 30 years
Commercial Thin	8.72	10	Transition after at least 30 years
Rehabilitation	0	10	Selection when BA > 125
Conifer Release (HW treatment)	No Con Harvest	0	Transition after at least 30 years

5.5. Baseline Management Results

5.5.1. Standing Carbon Stocks

The results of the management of the BFP can be seen below. The figure below shows a graph of the final baseline and the components of the baseline outlined above. The common practice minimum baseline level, based on the CA Wildlife Habitat Relationship analysis was 148.07 $MtCO_2e$/acre in standing live trees (the solid black line below – see sections 3.13 and 3.19). The modeled baseline following the description outlined above is 148.09 $MtCO_2e$/acre in standing live trees (the horizontal dashed line below).

[19] Rule language can be found on p. 44 to 54 of the CA FPR

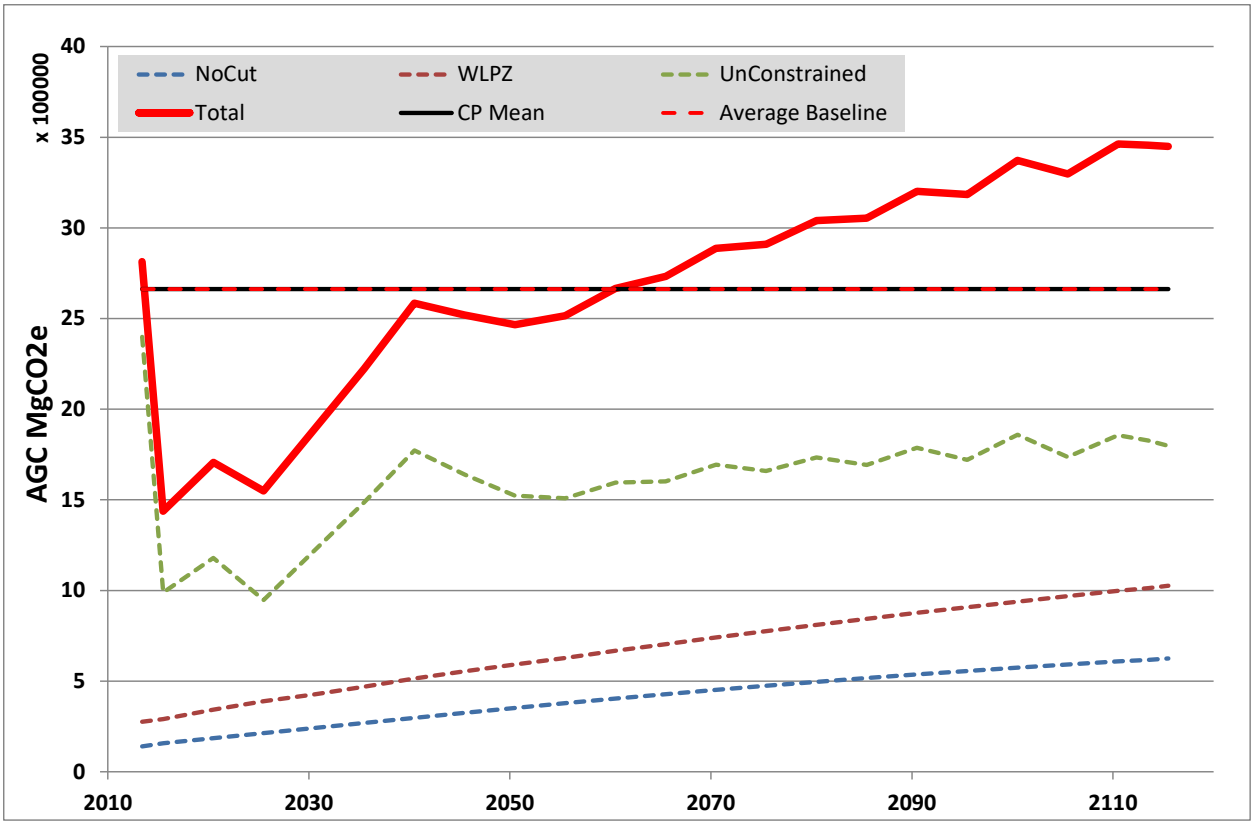

Figure 6: Baseline Management Regime Results by Management Type.

The tables below show the board foot volume/acre and metric tons of CO_2/acre for the full 100-year project lifetime.

Table 22: Average per acre conifer growth and yield (net BF/acre) over the project lifetime.

Year	BF/acre	Annual Growth	Annual Harvest
2013.4	8,109	start	start
2015.5	9,043	467	781
2020.5	6,696	311	53
2025.5	8,291	372	484
2030.5	7,885	402	26
2035.5	10,207	491	129
2040.5	12,272	542	91
2045.5	14,849	606	406
2050.5	15,627	562	583
2055.5	15,342	525	276
2060.5	16,631	534	298
2065.5	17,797	531	236
2075.5	19,231	523	301
2080.5	20,310	517	292
2085.5	21,429	515	334
2090.5	22,277	504	277
2095.5	23,389	499	305
2100.5	24,312	490	287
2105.5	25,301	485	256
2110.5	26,450	486	341
2115.5	25,927	236	NA

Table 23: Average per acre growth and yield of above and belowground stocks ($MtCO_2e$/acre) over the project lifetime.

Year	AG Live	Annual Growth	Annual Harvest
2013.4	156.5	start	start
2015.5	79.9	3.0	6.9
2020.5	94.9	4.1	0.3
2025.5	86.1	4.3	5.3
2030.5	104.9	4.0	0.2
2035.5	123.7	4.4	0.5
2040.5	143.7	4.5	0.4
2045.5	140.1	4.6	4.7
2050.5	137.2	4.2	4.2
2055.5	139.9	3.9	3.2
2060.5	148.3	3.8	1.9
2065.5	152.0	3.8	2.9
2070.5	160.5	3.7	1.8
2075.5	161.8	3.7	3.2
2080.5	169.1	3.5	1.9
2085.5	169.9	3.5	3.1
2090.5	178.0	3.3	1.6
2095.5	177.1	3.3	3.3
2100.5	187.5	3.2	1.0
2105.5	183.4	3.2	3.8
2110.5	192.6	3.1	1.2
2115.5	192.2	3.2	3.1

The table below shows the percentage of the total BFP acreage managed using each of the different potential silvicultural regimes.

Table 24: Percentage of total forested acre managed by silviculture.

Year	Commercial Thin	Conifer Release	Rehab	Standard Selection	Transition	Variable Retention	No Entry	Total Managed
2016	0.2%	4.8%	1.9%	5.2%	79.3%	1.3%	7.5%	**92.5%**
2020	0.0%	1.6%	0.5%	0.0%	0.7%	2.3%	95.0%	**5.0%**
2026	0.0%	0.0%	0.3%	5.2%	79.9%	0.0%	14.7%	**85.3%**
2030	0.0%	0.0%	0.1%	0.2%	1.2%	0.0%	98.5%	**1.5%**
2036	0.0%	0.0%	0.0%	5.9%	1.0%	0.0%	93.1%	**6.9%**
2040	0.0%	0.0%	0.0%	6.2%	0.5%	0.0%	93.3%	**6.7%**
2046	0.0%	0.0%	0.5%	42.5%	8.0%	0.0%	49.0%	**51.0%**
2050	0.0%	0.0%	0.0%	41.4%	8.1%	0.0%	50.5%	**49.5%**
2056	0.0%	0.0%	0.0%	44.4%	7.1%	0.0%	48.5%	**51.5%**
2060	0.0%	0.0%	0.0%	41.6%	2.0%	0.0%	56.4%	**43.6%**
2066	0.0%	0.0%	0.0%	46.3%	0.2%	0.0%	53.6%	**46.4%**
2070	0.0%	0.0%	0.0%	44.2%	0.0%	0.0%	55.8%	**44.2%**
2076	0.0%	0.0%	0.0%	50.6%	0.5%	0.0%	48.9%	**51.1%**
2080	0.0%	0.0%	0.0%	46.6%	0.5%	0.0%	52.9%	**47.1%**
2086	0.0%	0.0%	0.0%	50.8%	0.0%	0.0%	49.2%	**50.8%**
2090	0.0%	0.0%	0.0%	39.4%	0.0%	0.0%	60.6%	**39.4%**
2096	0.0%	0.0%	0.0%	57.5%	0.0%	0.0%	42.5%	**57.5%**
2100	0.0%	0.0%	0.0%	17.6%	0.0%	0.0%	82.4%	**17.6%**
2106	0.0%	0.0%	0.0%	72.1%	0.0%	0.0%	27.9%	**72.1%**
2110	0.0%	0.0%	0.0%	23.3%	0.0%	0.0%	76.7%	**23.3%**
2116	0.0%	0.0%	0.0%	50.7%	0.0%	0.0%	49.3%	**50.7%**

The table below shows the final baseline model accounting for all legal constraints. This final baseline model did not need to be adjusted for the high-stocking reference or weighted for other lands under the same management control.

Table 25: Baseline carbon stocks ($MtCO_2e$/acre)

	$MtCO_2e$/acre					$MtCO_2e$ for BFP				
Elapsed Time	**Standing Live**	**Standing Dead**	**In Use and Landfill**	**Total**	**Baseline**	**Standing Live**	**Standing Dead**	**In Use and Landfill**	**Total**	**Baseline**
0	194.1	3.3	0.5	197.9	187.2	3,490,355	58,770	9,464	3,558,590	3,366,057
5	111.6	3.3	0.5	115.4	187.2	2,004,138	58,770	9,464	2,072,373	3,366,057
10	112.4	3.3	0.5	116.2	187.2	2,018,503	58,770	9,464	2,086,738	3,366,057
15	121.8	3.3	0.5	125.6	187.2	2,188,242	58,770	9,464	2,256,477	3,366,057
20	144.8	3.3	0.5	148.6	187.2	2,603,654	58,770	9,464	2,671,889	3,366,057
25	168.7	3.3	0.5	172.5	187.2	3,033,839	58,770	9,464	3,102,074	3,366,057
30	175.8	3.3	0.5	179.6	187.2	3,160,817	58,770	9,464	3,229,052	3,366,057
35	171.8	3.3	0.5	175.6	187.2	3,089,412	58,770	9,464	3,157,647	3,366,057
40	172.3	3.3	0.5	176.1	187.2	3,098,193	58,770	9,464	3,166,428	3,366,057
45	179.7	3.3	0.5	183.5	187.2	3,231,784	58,770	9,464	3,300,019	3,366,057
50	186.5	3.3	0.5	190.3	187.2	3,353,463	58,770	9,464	3,421,698	3,366,057
55	194.5	3.3	0.5	198.3	187.2	3,497,313	58,770	9,464	3,565,548	3,366,057
60	199.5	3.3	0.5	203.3	187.2	3,587,427	58,770	9,464	3,655,662	3,366,057
65	205.3	3.3	0.5	209.1	187.2	3,692,480	58,770	9,464	3,760,715	3,366,057
70	209.4	3.3	0.5	213.2	187.2	3,764,663	58,770	9,464	3,832,898	3,366,057
75	215.6	3.3	0.5	219.4	187.2	3,877,461	58,770	9,464	3,945,696	3,366,057
80	218.8	3.3	0.5	222.6	187.2	3,934,415	58,770	9,464	4,002,650	3,366,057
85	225.9	3.3	0.5	229.7	187.2	4,061,894	58,770	9,464	4,130,129	3,366,057
90	227.8	3.3	0.5	231.6	187.2	4,097,097	58,770	9,464	4,165,332	3,366,057
95	232.5	3.3	0.5	236.3	187.2	4,180,057	58,770	9,464	4,248,292	3,366,057
100	236.4	3.3	0.5	240.2	187.2	4,250,971	58,770	9,464	4,319,206	3,366,057
AVG	**183.4**	**3.3**	**0.5**	**187.2**		**3,297,822.0**	**58,770.5**	**9,464.5**	**3,366,056.9**	

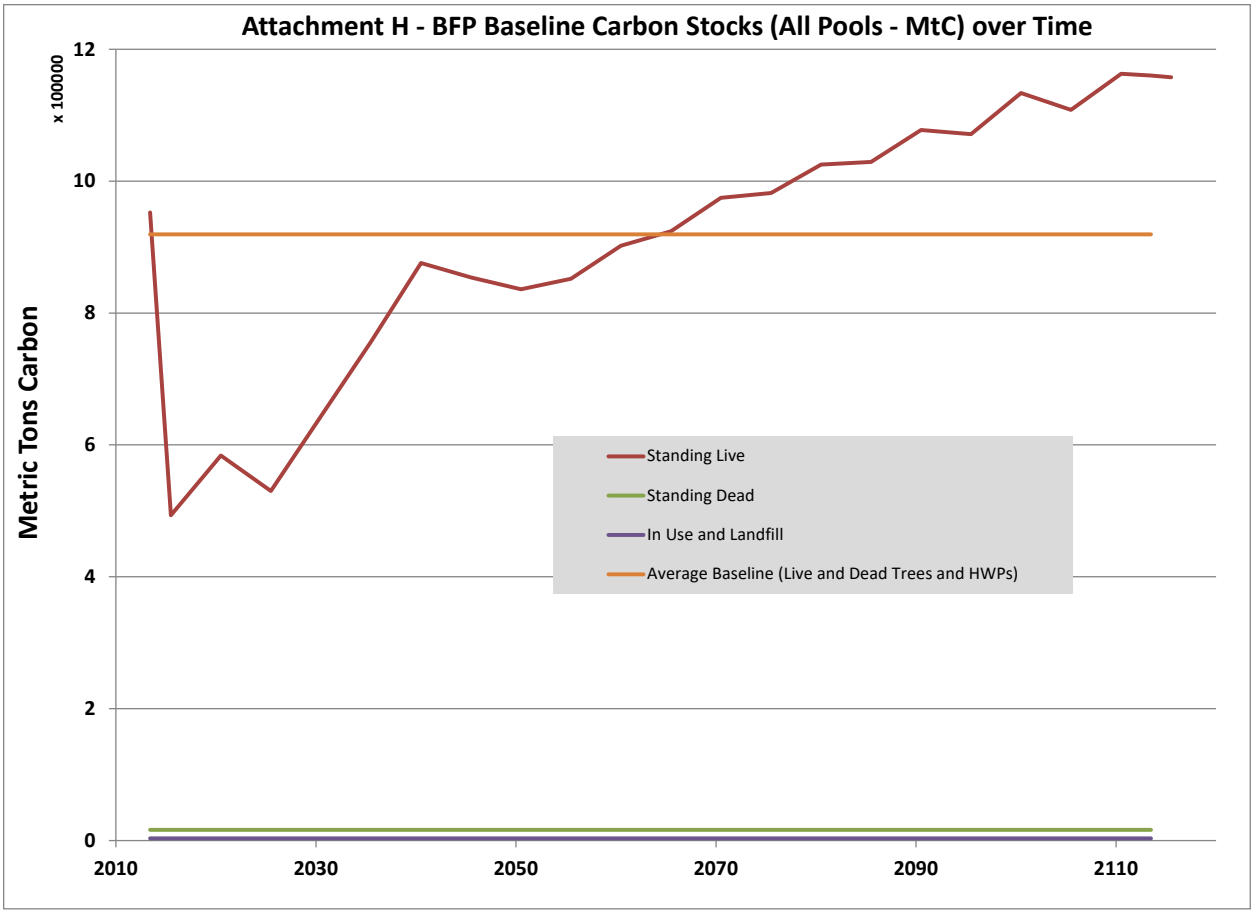

Figure 7: Attachment H - Baseline graph

5.5.2. Harvested Wood Product Carbon

The harvested wood product (HWP) carbon was calculated following the guidance in Appendix C of the CARB COPUSFP. For the BFP assessment area, a mill efficiency of 0.675 was applied to the bole portion of harvested conifers. This total was then broken into product classes and 100-year carbon pools by applying the specified coefficients in the table below.

Table 26: Wood product coefficients by product type.

		Product Breakdown (Appendix F)	100 year Product Coeffs (Table C.2)	100 year landfill Coeffs (Table C.3)
Product Breakdown from Appendix f. 100 year factors from Tables C.2 and C.3 in COP	SW Lumber	97.067%	0.463	0.298
	HW lumber	0.002%	0.25	0.414
	SW Plywood	1.874%	0.484	0.287
	Oriented Strandboard	0.000%	0.582	0.233
	NonStruc Panels	0.244%	0.38	0.344
	Misc Prods	0.095%	0.176	0.454
	Paper	0.717%	0.058	0.178

These coefficients were applied to the wood delivered to the mill (only bole carbon) and the resulting 100-year product and landfill storage was then averaged to calculate the HWP carbon. 80% of this total was calculated for the final HWP carbon pool. The secondary effects were calculated as 20% of the prior to mill

delivery carbon stocks to estimate market leakage. The results of these calculations can be seen in the table in section 3.22 above.

Appendix A: Inventory Methodologies – Buckeye Cruise Specifications

Sustainable Conservation Doing Business in California As Buckeye Forest
Inventory Collection Manual and Specifications
February 25th, 2015[20]

1. **Sampling Design**
   a. **Plot Location (This section describes how plots are located across the property):**

   Stands were selected to sample with probability proportional to size. The set of plots to sample within a stand was a random selection of all plots on a 5 by 5 chain grid within that stand. If the stand was selected twice, plots were randomly selected from 2 different 5 by 5 chain grids within the stand. All stratum should have at least 4 plots selected. Every 3rd plot, starting with the first plot, will have heights measured on all trees. Cruisers will receive a list of the randomly chosen plots with the corresponding latitudes and longitudes within each stand. This list will also note which plots should have tree heights measured.

   b. **Plot Design – Overview and Description of Measurements:**
   The plot design consists of a variable radius plot, a fixed radius plot for regeneration, and a 100 foot transect for down dead material.

   Variable Radius Plot Measurements (standing live trees and snags >=5 inches DBH):
   - species
   - diameter at breast height (DBH)
   - height to the nearest foot (on every 3rd plot starting with the first plot)
   - and height to crown base (on every 3rd plot starting with the first plot)
   - % defect (on every 3rd plot starting with the first plot)
   - Limiting distances are calculated to the face of the tree.

   Fixed Radius Regeneration Plot Measurements (1/100th of an acre = 11.8 ft radius):
   - Species
   - Count of Trees < 5 inches DBH within 2 size classes by species (0 to 3 inches DBH, and 3 to 5 inches DBH)

   Down Dead Transect Measurements (Two 50ft Transects starting at Plot Center):
   - Ocular estimate of average diameter and length of piece
   - Soundness of Piece (Decay Class 1 through 5)

   The map in Appendix C shows the plots that have been placed across the ownership. Maps and shapefiles with the location of the plots will be provided.

   c. **Plot Access and Road Point Procedures:**
   Each plot will be accessed from the nearest road entry point or the prior plot. The cruiser shall navigate via GPS to the plot center.

   d. **Plot Monumenting and Plot Navigation Procedures:**
   The following monumenting should occur at all plots:

[20] Future versions of this cruise specification will use fixed area plots to aid in verification activities. Plots will be 1/10th acre in size with a 1/100th acre regeneration subplot.

1. Plot centers should be marked with a plastic stakes painted orange, ½" PVC pipe is recommended. The stakes should extend at least 18" above the ground and be driven securely into the soil.
2. The plot number and the distance and bearing to the next plot measured should be clearly written on an aluminum tag affixed to the plot center stake.
3. Additionally all plots shall be labeled on the white and pink flagging hung near plot center for visibility and attached to the permanent plot center marker (plastic stake).
4. The flagging and tag shall include the initials or the cruiser, the plot number, the date, and the distance and bearing to the next plot, if applicable.
5. GPS coordinates taken at plot centers and should be recorded on the plot sheet. Distance and bearing to the next plot should also be noted on the plot sheet.

e. Plots Falling on Roads:

Plots that fall on unmapped roads are sampled. Plots that fall on mapped truck roads shall be offset 1 chain to the west, and if still on truck road offset 1 chain north. The offset shall be in a cardinal direction moving clockwise on the compass until a bearing is found that will lead to a vegetated plot. Landings are included as part of the truck road and not sampled. New plot centers will be mapped and the GPS coordinates provided to the Owner.

2. Sampling Procedure and Data Collection at Plots:

a. BAF and/or Fixed Area Plot Sizes Used:

The basal area should be chosen such that most plots within a strata count 6 to 8 trees. Once a BAF is chosen for a stand, all plots must have the same BAF within that stand.

Each plot also has a 1/100th acre subplot for regeneration and two 50ft transects for down dead logs.

b. Variable Radius Plot Data:

Live Trees, and Snags >15 ft tall of any species (conifer and hardwood). All live or standing dead trees (snags) greater than or equal to 5 inches are measured if they fall in the variable radius plot.[21] Trees will be tallied and measured in a clockwise direction beginning at a North line. The following data should be collected for each tree measured:

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

- **Group** – Each tree in the variable radius plot has a group assigned to it. Trees can be live (..), site trees (A), snags (SN), or damaged (C). See Table 2 below for a complete description of the group codes. **All snags (SN) must be measured for height on all plots** and have a decay class from 1 to 5 assigned to them. The decay class descriptions for snags can be seen in table 4 below.

[21] Snags include recently dead trees with intact branches, bark, and leaves and older trees with a more advanced stage of decomposition. See table 2 for a more complete description of these types. Snags and live trees are measured in the variable radius plot whenever they are greater than 5 inches at DBH and >= 15ft tall.

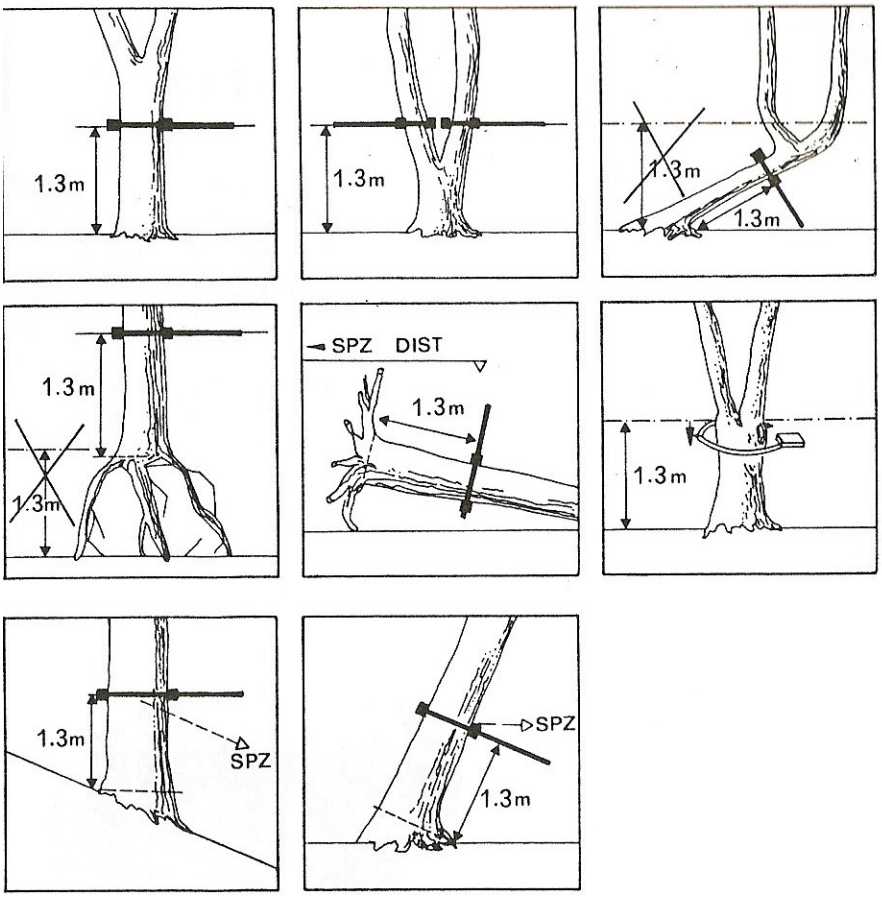

Figure 8: Point of measurement of diameter at breast height (from Pancel , 1993).[22] The top right figure and the bottom middle figure incorrectly show the measurement location of DBH. On flat ground (this is exceedingly rare), the DBH is taken 4.5ft from the ground on the higher side of the lean. On slopes, the DBH is taken on the uphill side of the tree even if this is on the bottom side of the bole. DBH is measured in a straight line from the ground not along the bole (as is shown in this figure).

- **<u>Diameter at Breast Height</u> (DBH) see figure above** – 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 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. For redwood stump sprouts the ground level should be considered the lowest point that a tree could possibly be cut down.
    - <u>Forked trees</u> – 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, (the cruiser shall note on the field form every DBH estimated). If the fork originates above DBH then the tree is measured and counted as a single tree.

- **<u>Height</u>** – Total height is measured on trees >= 5 inches DBH (This includes **live and snag classes**).[23] Height is measured and recorded to the nearest foot. Height on live trees should only be measured in the specified plots (provided by The Conservation Fund).
    - <u>Leaning Trees</u> – Trees with lean are measured for height perpendicular to the lean if they are less than 45 degrees from vertical when considering the entire tree. Estimate the length of the bole for trees that are more than 45 degrees from vertical, or severely bent in the middle. Estimated heights are to be noted on the cruiser data sheet.

[22] Pancel, L., ed. 1993. Tropical forestry handbook. Berlin, Germany, Springer-Verlag. Volume 1, 738 pp.
[23] Every 3rd plot has height and height to crown based measured starting with the first plot measured in a stand.

- Snags – All dead trees >= 5 inches DBH should be measured for total height **ON ALL PLOTS.**

- **Height to Crown Base (HTCB)** – This measurement provides an estimate of the total crown area. The measurement is taken on every tree >= 5 inches DBH (**only live trees**).[1] The measurement is taken from the base of the tree 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. HTCB should be measured only in the height plots specified by The Conservation Fund.

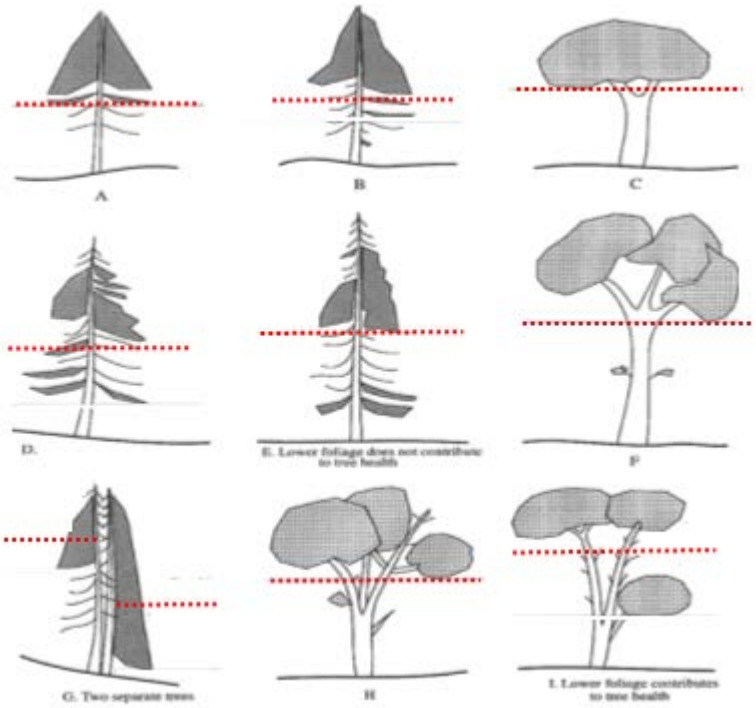

Figure 9: Height to Crown Base Diagram

- **Damage/Defect –** A damage code is assigned to damaged trees. See codes in Table 29 below for descriptions of these codes. On height measure plots, 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. Only record rot for visible defect. In height measure plots, **% missing volume** should be recorded on trees with broken tops and is an estimate of the percentage of total volume missing in the top.

Table 27: List of Tree Species and their Species Codes

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

Table 28: Status Code Descriptions

Status Code	Code Definition	Description	Data Source
..	Live	Default code for trees with normal form. *All regeneration also should have this code.*	**Variable Radius Plot**
A	Site Tree	Site trees are dominant trees used to estimate forest growth rates.	
SN	Snag	Standing trees that are dead. Recently dead snags may have branches or leaves. All Snags must be greater than 15 ft tall.	
C	Damaged Trees	Tree damage codes are shown in the table below and should be noted on the plot card. Any tree given a "C" code must have a damage code associated with it.	
DD	Lying Dead Wood	Down woody debris that is hard. See description below.	**Transect**

Table 29: 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		
6 - Animal	1 - Deer & Elk	0 - Unspecified		
	2 - Bear	1 - Light Damage		
	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			

c. **1/100th Acre Fixed Area Plot Data (Regeneration):**

Trees less than 5 inches DBH are tallied on every plot **only if they are at least 4.5in tall**. The sample area measured for regeneration is a fixed 1/100th acre plot (11.8 ft radius). Individuals of common tree species are recorded as trees if they have a clear leader and tree form. Hardwoods which do not show a clear tree form and can occur in brush or tree (e.g. tanoak and madrone) are counted as lesser vegetation.

- **Species** – Record all trees by species
- **Count** – Tally seedlings and saplings in two size classes: **0-3.0 inches DBH and 3-5 inches DBH**. Record a count of all seedlings by species in the plot.
- **Height** – Estimate the average height of trees in the regeneration plot within each DBH class by species.

Table 30: Snag Decay Class Descriptions[24]

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.

d. **100 ft Transect (Down Dead Material) – OCULAR ESTIMATE ONLY:**

Down logs are measured at every plot. Down dead logs are measured using a 100 ft transect (slope distance). The 100 ft transect should be composed of **two 50 ft long transects that are 90° apart from one another**. Both of the 50 ft transect start at plot center. One extends towards the north. The other 50ft transect extends to the east. The transects shall be measured with a logger's tape or similar device (note: hip chain is not allowed). Transects have no width and logs must intersect the transects to be measured. **If either transect intersects a mapped road, the intersecting transect should be rotated 90° until no road intersection occurs.** Deviations from the North or East transect shall be recorded on your form or data entry device.

Down logs must meet the following criteria to be sampled:

[24] 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.

- To be counted the log or log segment must have a minimum **diameter of 6 inches outside bark** and a minimum length of 6 feet.
- Where logs taper to a point less than six inches in diameter, the log length is measured to the six inch diameter.
- For a log to be counted, the transect must intersect the log at a point where the diameter is greater than 6 inches.
- In some cases there may be broken pieces or decayed pieces where questions may arise about whether it represents one or two pieces. Pieces are defined based on points of abrupt physical change based on breakage, forks, or advanced decay. Forks should be considered separate pieces when they meet the diameter and length requirements for individual pieces as defined above. Broken pieces which were obviously part of a single larger piece and are separated by less than 6 inches of space are counted as 1 piece of LWD (see Figure 10 below– these are considered separate pieces if they have more than 6 inches between them.)
- Down logs should be assigned a decay class of 1 to 5. The description of the lying dead decay classes can be seen in table 8.

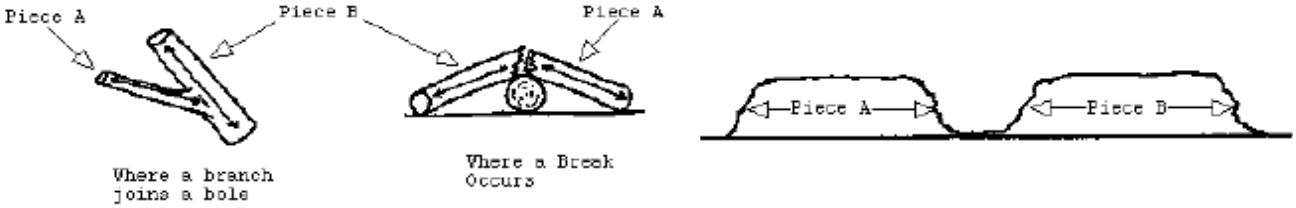

Figure 10: Down Dead Material Diagram

Table 31: Lying Dead Wood Decay Class Descriptions[25]

Decay Class	Structural Integrity	Texture of Rotten Portions	Color of Wood	Invading Roots	Branches and Twigs
1	Sound, freshly fallen, intact logs	Intact, no rot; conks of stem decay absent	Original color	Absent	If branches are present, fine twigs are still attached and have tight bark
2	Sound	Mostly intact; sapwood partly soft (starting to decay) but can't be pulled apart by hand	Original color	Absent	If branches are present, many fine twigs are gone and remaining fine twigs have peeling bark
3	Heartwood sound; piece supports its own weight	Hard, large pieces; sapwood can be pulled apart by hand or sapwood absent	Reddish- brown or original color	Sapwood only	Branch stubs will not pull out
4	Heartwood rotten; piece does not support its own weight, but maintains its shape	Soft, small blocky pieces; a metal pin can be pushed into heartwood	Reddish or light brown	Through-out	Branch stubs pull out
5	None, piece no longer maintains its shape, it spreads out on ground	Soft; powdery when dry	Red-brown to dark brown	Through-out	Branch stubs and pitch pockets have usually rotted down

e. **Additional Plot Information Recorded:**

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

- **GPS coordinates should be recorded at each plot center.**
- Items that should be noted are the location of skid trails, springs, watercourses and historical artifacts when they assist in relocating the plot.
- Wildlife observed should be noted including raptor nests, hawks, owls, mountain lions, bears, feral pigs 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**.**
- Notes should also include the distance and bearing to the next plot.
- 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 0, and tree count equal to 0.

f. **Site Class Sampling:**

A minimum of **3 trees** per stratum should be selected, record species and measure DBH (to the nearest 10th inch), height to nearest 1 foot, HTCB (height to crown base), and age. The trees should be **redwood, Douglas-fir, Grand Fir or Sugar Pine species.** Each plot should be evaluated for the presence of potential site trees.

To be considered eligible for site tree measurement, a tree must have the following qualities:

[25] 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.

- be a conifer located within or near the plot (preferably within),
- have a dominant or co-dominant crown class, and
- demonstrate good phenotype and vigor, e.g. straight bole clear of defect, crooks and forks, full even crown and healthy top growth
- Free of defect and disease.

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). Tree selected for site tree measurement shall be marked with orange flagging with writing on the flag stating that it is selected as a site tree.

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.

Example of Plot Form

See below for the data form that should be used.

Data transfer: Initial data reports to facilitate check cruising will be provided weekly to The Conservation Fund, by email to lfety@conservationfund.org and skelly@conservationfund.org. Following completion of the cruise all plot measurements and GPS coordinates shall be compiled by the contractor and provided in an excel spreadsheet. Deliveries should use the template excel spreadsheet provided by the Conservation Fund. Before submitting the excel spreadsheet, please check for common data transcription errors including:

1. Do all trees have species codes that make sense?
2. Do all dead trees have status codes?
3. Do all trees have a species code? (even for plots with no trees there should be a tree record with species XX and a DBH of 12 inches **with tree count = 0**)
4. Are all DBHs and HTs reasonable? (General Rules of Thumb: DBH > 0, DBH < 70in, and HT > 4.5, HT < 250ft)
5. Do dead trees (both SN and DD) have measured heights?
6. Do all regeneration trees have heights? (all heights should be > 4.5 ft)

		Date: _____
Stand # _____	Cruiser: _____	Slope: _____
Plot # _____	BAF: _____	Aspect: _____

Road Point GPS Coordinates					Plot Center GPS Coordiantes				
UTM NAD 83 zone 10N					UTM NAD 83 zone 10N				
UTM N:					UTM N:				
UTM E:					UTM E:				

Tree #	Species	DBH	Status	Crown Class	Height	HTCB	Damage or Decay	Age / Defect %	% Missing Volume
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									

Down Dead Wood Transect Bearing: _____						Regeneration			
Log #	Avg. Diam	Species	Length	Decay Class		Species	0 - 3 In DBH	3 - 5.4 in DBH	

Distance and Bearing to the Next Plot:_____

Notes:

Appendix B: US Fish and Wildlife Service – Suggestions for Placement of NSO Information in CAL FIRE Coast Forest District Plans/Amendments

Suggestions for Placement of NSO Information in CAL FIRE Coast Forest District Plans/Amendments
14 CCR 919.9(e), USFWS Scenario 4, Attachment A, version 3/15/11

Section II – Item 32 NSO Information

- [State that] the plan is within the coast range of the northern spotted owl.
- [State that] the plan will comply with 14 CCR 919.9(e), USFWS Programmatic Technical Assistance Scenario 4, Attachment A dated 3/15/11.
- [State that] no timber operations shall occur until all surveys which follow the most current approved USFWS survey protocol for the current, or immediately preceding, survey period are complete; the results have been provided to CAL FIRE to be evaluated for consistency with the plan and protocol; and the results amended into the plan.
- Provide any other plan specific operational NSO information required to be in the plan.
- Provide an operational map showing areas where operational restrictions may occur as a result of NSO protection measures.
- [State whether] survey information is included in the plan. [If so, state whether the] surveys are to be reviewed in order to operate prior to February 1 of the year following plan approval. State the type of survey e.g. Year 1 of 2 complete surveys, Year 3 spot checks with AC Search, etc.
- [State] the NSO habitat and operational protection measures for any known, or future Activity Centers within 0.7-mile of the project as follows:

  Activity Center (AC) Habitat Protection – Core Area

  - A 100-acre Core Area polygon must be identified that contains the highest quality habitat (typically Nesting/Roosting (N/R)) located contiguous with the AC.
  - When an AC is closer than 500 feet to the outside edge of the N/R polygon, the acres of non-N/R habitat within 500 feet of the AC are included, but should be augmented with additional N/R habitat elsewhere in the Core Area polygon to make a total of 100 acres of the highest quality habitat.
  - When the AC is closer than 1,000 feet to, but not within 500 of, the outside edge of the N/R polygon, the protected Core Area should extend to that most distant edge of the N/R habitat but shall not be less than a 500-foot radius.

- Operations conducted outside the Core Area, but within 1,000 feet of an AC should retain the functionality of any NSO habitat present pre-harvest within this area, i.e., operations do not downgrade habitat.

- If a contiguous N/R polygon is 200 acres or greater, and operations in the N/R polygon outside the Core Area have retained functional N/R habitat (i.e., no more than 33% of the basal area removed retaining a minimum of 100 sq. ft. of basal area per acre of trees greater than 11" DBH), then the 100-acre core area can be redrawn in subsequent entries. However, the 500-foot radius should remain unchanged, and the redrawn core area should not include any acres harvested within the previous 5 years.

Activity Center Habitat Protection - 0.7 Mile Radius (985 acres)

- Retain habitat to maximize attributes desirable for NSO.
- Retain at least 500 acres of suitable (N/R/Foraging) NSO habitat, post-harvest, as follows:
  - ➢ Retain 200 acres of N/R Habitat within a 0.7 mile radius of the AC consisting of:
    - ✓ 100 acres of the 200 acres of N/R habitat retained should be contiguous, or contiguous as possible with the AC.
    - ✓ An additional 100 acres of N/R with in the 0.7 mile radius:
      - ▪ If the second 100 acres of N/R habitat is also contiguous with the AC, or within the same drainage, operations should retain a minimum of 66% of the pre-harvest basal area per acre of trees at least 11" DBH.
      - ▪ If the remaining 100 acres of N/R habitat is not contiguous with the AC, retain at least N/R habitat.
  - ➢ Retain at least 300 acres of Suitable NSO habitat, post-harvest, of at least Foraging quality.
- Remove no more than 1/3 of the remaining suitable habitat in excess of 500 acres within 0.7 mile of an AC during the life of the timber operations.

Activity Center Protection - Road Use

- Road Use within 0.25 mile (1,320 feet) of a NSO AC during the breeding season is prohibited until July 10, unless:
  - ➢ Non-nesting, or nesting failure at the AC has been determined by a AC Search (2011 NSO Protocol) conducted on or after May 15th, or
  - ➢ The AC is within 165 feet of major highway that typically has continuous traffic year around (Hwy 1, 36, 101,128, 299, etc.) and the appurtenant road is not within 165 feet of the AC.
  - ➢ After July 9th until the end of the breeding season road use within the 100-acre core is restricted to existing road use, maintenance and map point work.

Activity Center Protection - Timber Harvest Operations

- Except for road use after July 9th, a 0.25 mile seasonal restriction on timber operations applies to ACs during the breeding season, unless an AC Search shows non-nesting or nesting. If that cannot be determined, the 0.25 mile seasonal restriction stays in effect for timber operations until after July 31st.

- For all known ACs, timber operations should adhere to the following recommendations:
  1) Within the 100-acre Core Area polygon of an NSO AC:
     a. Outside the breeding season, limited timber operations (i.e., road use and maintenance, map point work, tail-hold placements, use of existing skid roads, and loading) may be conducted, provided no trees >11 inches DBH are cut or removed by the operations, and no logs are yarded through the Core Area.

b. During the NSO breeding season, timber operations (including use of roads before July 9th), are not allowed within the 100-acre Core Area polygon, except as allowed in subsections 4 and 5, below.

2) Timber Operations outside the 100-acre Core Area polygon, but within 0.25 mile of an NSO AC:
   a. Outside the breeding season, timber operations may be conducted.
   b. During the breeding season, no timber operations should proceed unless protocol surveys do not detect nesting NSOs.

3) For all NSO ACs, prior to May 15th (until the required May 15 or later survey is completed):
   a. Timber operations (except helicopter yarding or staging) may be conducted only on those THP areas >0.25 mile from the AC.
   b. Helicopter yarding and staging may occur only on those THP areas >0.5 mile from the AC.

4) For NSO ACs where reproductive status has been determined to be non-nesting or failed nesting:
   a. Limited timber operations (road use, maintenance, map point work, use of existing skid roads, tail-hold placements, loading) within the 100-acre Core Area polygon of the AC provided no trees >11 inches DBH are cut or removed, and no logs are yarded through the Core Area.
   b. Full timber operations, including helicopter yarding/staging, may be conducted within 0.25 mile but not within the 100-acre core polygon of the AC. No Helicopter fly-overs within 1000 ft.

5) For NSO ACs, where reproductive status has been determined to be nesting:
   a. For ACs where fledging status has not been determined, timber operations may be conducted only on those THP areas that are >0.25 mile from the AC until the end of the breeding season.
   b. Helicopter yarding and staging may occur only on those THP areas >0.5 mile from the AC.

6) For NSO ACs, where fledging status has been determined (either nest failure or fledglings have left the Core Area):
   a. Full timber operations, including helicopter yarding and staging, may be conducted within 0.25 mile but not within the 100-acre core polygon of the AC. Helicopter fly-overs shall not occur within 1000 feet of the AC.
   b. Limited timber operations (road use and maintenance, map point work, use of existing skid roads, tail-hold placements and loading) may be conducted within the 100-acre core polygon of the AC, provided no trees >11 inches DBH are removed by the operations, and no logs are yarded through the Core Area.

7) For any NSO AC, regardless of reproductive status:
   a. If NSO move to a new location (>1000 feet from the historical AC) and reproductive behavior is confirmed at the new site, request technical assistance to evaluate the status of the historical AC.

- Definitions

Core Area: 100 acres of the 200 acres of N/R habitat retained within a 0.7 mile radius contiguous with the AC. If 100 acres of contiguous N/R is not available, then the highest quality habitat available shall be included.
Foraging Habitat: Habitat that contains ≥40% canopy cover of trees that are ≥ 11" DBH (diameter at breast height), and have a basal area ≥75 square feet per acre of trees ≥11" DBH. Trees may be conifer or hardwood.
N/R Habitat: Forested habitat that supports successful nesting and associated roosting behavior by NSO. Habitat with ≥60% canopy cover of trees that are ≥11" DBH, and have a basal area ≥100 square feet per acre of trees ≥11" DBH. Trees may be conifer or hardwood.
N/R Polygon: All N/R habitat which is contiguous with an NSO AC.
NSO Breeding Season: Defined as February 1 to July 31 within the coast redwood ecotype found in the Coast District of California.

Section IV Information

- Describe the NSO assessment area. Provide a discussion of the potential for cumulative impacts relative to NSO.

Section V Information

- CNDDB NSO database
  - Provide a copy of the most recent NSO database inquiry and results, including the run date. Provide all of Reports 1 and 2 and provide the portions of Report 3 which pertain to the NSO ACs within 0.7 miles of the plan area.
  - Explain any AC center location differences between the database and the plan. (Any abandonment requires USFWS TA.).

- Provide the USFWS NSO habitat definitions used for typing Nesting/Roosting, and Foraging if not provided in Section II. Indicate how size and shape of habitat patches were considered in habitat typing and/or habitat mapping.

- A map showing N/R, foraging, and non-habitat within the plan and surrounding area (0.7 miles from the plan boundary) in order to evaluate survey area coverage. Clearly identify the plan boundary. Habitat maps should reflect past, present or reasonably known future habitat altering activities such as other harvesting plans in the NSO AC territory. In the unlikely circumstance that surveys are not required, the habitat map is still required to verify typing.

- A map showing all known (from NSO database and surveys) NSO ACs within 0.7 miles of the plan. Identify the plan boundary. Describe efforts to obtain AC locations from nearby landowners or recent surveys.

- Pre-Post Harvest Habitat Maps and Tables for each ACs
  - Maps of pre and post harvest habitat typically within 0.7 of all known/historic NSO ACs. Clearly identify the plan boundary on the map. Post harvest maps should identify the location of the core area habitat retention polygon if proximate to timber operations.

  - Tables indicating the acres of pre and post harvest N/R and foraging habitat within 0.7 mile radius circles for each known NSO AC. In addition to the individual acreages, provide the sum of suitable habitat acreage; i.e. total of nesting/roosting plus foraging, for each AC.

- Pre-Post Harvest Habitat maps should reflect past, present or reasonably known future habitat altering activities such as other harvesting plans in the NSO AC territory.

➢ Aerial Photos: Provide 2 color copies of aerial photos which cover 0.7 from the plan boundary and cover 0.7 miles from each of the ACs in the assessment area. Each photo should identify the plan boundary.

➢ Survey Information: In order to operate after January 31 of any year, survey information should be provided to CAL FIRE in the plan or in the form of an amendment to demonstrate consistency with the USFWS survey protocols or appropriate USFWS agreement.

- Identify the survey protocol used for the NSO evaluation and where the surveys are in a survey cycle, e.g. 1st year of 2 year complete surveys; 3rd year of surveys for spot check/AC search, etc. Deviations from the survey protocol or survey agreements may trigger additional review by the Department.

- A map of the survey stations and call route, including 0.7 mi. buffer to verify survey coverage of suitable habitat. If possible, provide notations on the map that show why portions of the 0.7 were not covered (e.g., no access, safety issues, occupied ACs, topographic anomalies which change expected calling reach, etc.)

- Survey summary sheets or survey forms which include at least the survey date, weather, the calling station start and end times, calling method (digital, vocal), survey results, spot checks, etc. Also include pertinent maps . If other landowner surveys are used, provide calling records.

- If NSOs are detected during surveys, provide detection follow-up forms and maps of detection and response locations.

- If Monitoring or Activity Center Searches, provide forms and maps.

- Identify any variation from or exception to the USFWS survey protocol as modified or survey agreement and provide biological explanation and justification. Examples include but are not limited to:

  ✓ Areas within the required survey area not actually covered by the survey.
  ✓ Using off ownership survey data.
  ✓ Dropped calling stations.
  ✓ Calling started prior to the protocol start date, or stopped prior to the latest protocol stop date.
  ✓ Deviations from calling schedules.
  ✓ Attributing detections to distant ACs w/o follow-up confirmation.

  ✓ NOTE: Variations could negate the use of USFWS programmatic scenarios.

NOTE: Map quality should be as good as or better than those provided in the harvesting plan. Maps should be clear and provide sufficient information for review. This includes a legend with map title, scale, north arrow, and symbol identification. Topographic maps are preferred to clarify adequacy of calling.

Appendix C: Statistical Methods for Stratified Sampling

1. Introduction

The BFP project uses a two-stage random/systematic stratified sampling design (TSRSS) to measure the forest carbon stocks. Stands within strata were selected randomly without replacement. Selected stands were then systematically sampled using a grid of plots. Future samples may use a two-stage probability proportional to size sampling design (TSPPS) or a simple random/systematic stratified sampling design (SRSS).

The ARB requires that all project developers calculate the accuracy of their forest inventory. The ARB then requires that projects whose inventory exceeds certain accuracy thresholds deduct a portion of their claimed reductions due to uncertainties associated with their inventories. The ARB defines the measure of variability of the carbon estimate as the 90% confidence limit of the mean in metric tons of carbon per ha (Mt C/acre). The accuracy calculations must be calculated for the total of all sampled carbon pools: standing live and standing dead carbon.

2. Multi-stage Probability Proportional to Size Stratified Sampling

The overall mean and SE equations are the end result of the MSPPS sampling but intermediate results can describe within stand or within strata means and SEs.

2.1. Calculations and Equations

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

Equation 3: MSPPS Overall Mean $\bar{y}_{2SL} = \sum_{s=1}^{l} w_s \left(\frac{1}{n_s} \sum_{i=1}^{n_s} \bar{y}_{si} \right)$ **where** $\sum_{s=1}^{l} w_s = 1$

Equation 4: MSPPS Overall SE $SE_{\bar{y}_{2SL}} = \sqrt{\sum_{s=1}^{l} \frac{w_s^2 * S_{WB_s}^2}{n_s}} = \sqrt{\sum_{s=1}^{l} \frac{w_s^2}{n_s} * \frac{\sum_{i=1}^{n_s} \bar{y}_{si}^2 - \frac{\left(\sum_{i=1}^{n_s} \bar{y}_{si} \right)^2}{n_s}}{n_s - 1}}$

The table below defines the variables seen in the equations above as explained in Shiver and Borders (1996)[26]. The 90% sampling error is defined by multiplying the overall SE ($SE_{\bar{y}_{2SL}}$) by the z-statistic that corresponds to 90% of the area under a z-distribution – 1.645. To calculate the accuracy, the 90% sampling error is divided by the overall mean ($\bar{y}_{2SL}$) and the accuracy is the resulting percentage.

[26] The method described here is taken from: Borders, B. E., B. D. Shiver, and M. L. Clutter. 2005. Timber Inventory of Large Acreages Using Stratified Two-Stage List Sampling. Southern Journal of Applied Forestry 29:152–157.

Table 32: MSPPS variable definition from Shiver and Borders

Variables	Definition
$\bar{y}_{si} = \frac{1}{m_{si}} \sum_{j=1}^{m_{si}} y_{sij}$	Mean MtC of the plots in stand i within strata s
n_s	The number of sampled stands in strata s
N_s	Total number of stands in strata s
y_{sij}	MtC / acre found at plot j within stand i within strata s
m_{si}	The number of plots within stand i within strata s
M_s	Total area within strata s
M	Total area of all strata = $\sum_{s=1}^{l} M_s$ = total forested acres
w_s = strata area weight = $\frac{M_s}{M}$	The strata area weight. The sum of all strata area weights equals 1.
Variance Within and Between Stands $S^2_{WB_S} = \frac{\sum_{i=1}^{n_s} \bar{y}_{si}^2 - \frac{\left(\sum_{i=1}^{n_s} \bar{y}_{si}\right)^2}{n_s}}{n_s - 1}$	The variance within and between stands is basically a modified sum of squared differences. $S^2_{WB_S}$ is the variance calculated within each strata s.
Variance of the Mean within Strata s $S^2_{\bar{y}_{s2SL}} = \frac{S^2_{WB_S}}{n_s}$	The variance of the mean of strata s ($\bar{y}_{s2SL}$) given the number of plots n_s in strata s and the variance within and between stands of strata s.
Mean within Strata s $\bar{y}_{s2SL} = \frac{1}{n_s} \sum_{i=1}^{n_s} \bar{y}_{si}$	The mean of strata s given each stand mean $\bar{y}_{si}$
Variance of the Mean Across Strata $S^2_{\bar{y}_{2SL}} = \sum_{s=1}^{l} w_s^2 S^2_{\bar{y}_{s2SL}}$	The variance of the mean across all strata is the property wide variance of the property wide mean - $\bar{y}_{2SL}$ - weighted by the area of each stratum.
Mean Across Strata $\bar{y}_{2SL} = \sum_{s=1}^{l} w_s \bar{y}_{s2SL}$	The mean across all strata is the sum of the area weighted mean of each stratum.

The description above is adapted from Shiver and Borders but extends their method to variable radius plots and across multiple strata of different sizes. This approach is applied across the full ownership to generate a property wide mean, SE, and accuracy percentage of the inventory. One clarification to note is that all plots are considered to be part of the same population although they may be up to 12 years different. This means that plot data is not grown forward (for the purpose of accuracy calculations) but is taken as is and used in the equations above.

2.2. Accuracy Assessment Process

The first step in calculating the accuracy based on the method outlined above is to calculate each plots total carbon per acre. This calculation is done using the Reserve approved equations for biomass and carbon for both live and dead material and then calculating the below ground carbon and summing to find the total carbon per acre for each plot. The variance is then calculated for each strata based on the individual plot results. At this point, the process follows the equations defined above.

3. Simple Random / Systematic Stratified Sampling (SRSS)

At the project start, a two-stage random stratified sampling design was used to inventory the property. Future full property-wide inventory updates may use a stratified random sampling design and inventory updates post-disturbance will be done using an SRSS approach. Therefore, the estimators for this design are described below. The overall mean and SE equations are the end result of the SRSS sampling but intermediate results can describe within strata means and SEs. As opposed to two-stage sampling designs, SRSS sampling does not sample based on stands but rather only based on strata. This eliminates a level in the sampling design and simplifies the calculations of mean and SE.

3.1. Calculations and Equations

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

Equation 5: SRSS Overall Mean $$\bar{y}_O = \frac{1}{N}\sum_{h=1}^{L} N_h \bar{y}_h$$

Equation 6: SRSS Overall SE $$SE_O = \sqrt{S^2_{\bar{y}_O}} = \sqrt{\sum_{h=1}^{L}\left(\frac{N_h}{N}\right)^2\left(\frac{S^2_{y_h}}{n_h}\right)\left(\frac{N_h - n_h}{N_h}\right)}$$

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.

When variable radius plots are used, the potential sample size (N and N_h) is considered to be infinite. 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 acres * 5 plots/acre = 500 plots.

Table 33: SRSS Variable definition from Shiver and Borders

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.
$\bar{y}_h = \frac{1}{n_h}\sum_{i}^{n_h} y_{h,i}$	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.
$S_{y_h}^2 = \frac{1}{n_h - 1}\left[\sum_{i=1}^{n_h} y_{h,i}^2 - \frac{\left(\sum_{i=1}^{n_h} y_{h,i}\right)^2}{n_h}\right]$	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.

For variable radius plots however, an infinite number of plots could be installed in any given area as these plots technically have no area associated with them. Therefore, the FPC factor can be ignored (set to 1) in most cases.

3.2.Accuracy Assessment Process:

The accuracy assessment process is the same as described in section 2.2 of this appendix.

4. Combined MSPPS and SRSS Calculations

In some cases, both SRSS and two-stage sampling designs may be used. In these cases, the strata level estimates of the mean and SE are calculated using the appropriate approach. To find the final property level estimators, the means are multiplied by the area weights and summed. The variances are multiplied by the square of the area weights and summed. The standard error is the square root of the summed weighted variances. The total property accuracy at the 90% confidence level is calculated by multiplying 1.645 by the SE of the mean, dividing by the mean of the total carbon stocks and converting this to a percentage.

5. Accuracy Results

The table below shows the 90% accuracy of the BFP inventory.

Table 34: BFP 90% accuracy levels

Year	$MtCO_2$/acre	BA/acre	BF/acre
2013.5	4.2%	4.1%	9.5%

Appendix D: Calculation of GHG Reductions and GHG Removals Enhancements

Table 35. Calculation of GHGs for Initial Stocks & Reporting Period Ending 5/31/3015

	Initial Stocks	Reporting Period Ending 5/31/2014	Reporting Period Ending 5/31/2015
Calculating GHG Reductions/Removals for Onsite Carbon Stocks			
Standing Live Stocks	3,490,355	3,646,783	3,783,803
Standing Dead Stocks	58,770	58,770	58,770
Actual Onsite Carbon Stocks (tonnes CO2e)	3,549,125	3,705,553	3,842,573
Standing Live Stocks (MgCO2/Acre)	194	203	210
Standing Dead Stocks (MgCO2/Acre)	3	3	3
Actual Onsite CO2/acre (Standing Only)	197	206	214
Confidence Deduction	0	-	-
Adjusted Actual Onsite Carbon Stocks (adjusted for confidence deduction) (tonnes CO2e)	3,549,125	3,705,553	3,842,573
Increment in Actual Onsite Carbon Stocks (tonnes CO2e)	NA	156,428	137,020
Baseline Onsite Carbon Stocks (tonnes CO2e)	3,356,592	3,356,592	3,356,592
Increment in Baseline Onsite Carbon Stocks (tonnes CO2e)	NA	-	-
Quantified GHG Reductions / Removals for Onsite Carbon Stocks (tonnes CO2e)	192,533	156,428	137,020
Cumulative Gross GHG Reductions/Removals	192,533	348,961	485,981
Reporting Period Gross GHG Reductions/Removals	192,533	156,428	137,020
Calculating Carbon Stored in Wood Products Including Market Effects and Leakage			
Actual Carbon in Trees Harvested for Wood Products in (tonnes CO2e)	NA	0	0
Baseline Carbon in Trees Harvested for Wood Products (tonnes CO2e)	NA	46,301	46,301
Actual Carbon in Harvested Wood Delivered to Mills (tonnes CO2e)	NA	0	0
Baseline Carbon in Harvested Wood Delivered to Mills (tonnes CO2e)	NA	23,147	23,147
Actual Carbon Stored Long-term in Wood Products (tonnes CO2e) - Excl Landfill	NA	0	0
Actual Carbon Stored Long-term in Wood Products (tonnes CO2e) - Incl Landfill	NA	0	0
Baseline Carbon Stored Long-term in Wood Products (tonnes CO2e) - Excl Landfill	NA	7,187	7,187

	Initial Stocks	Reporting Period Ending 5/31/2014	Reporting Period Ending 5/31/2015
Baseline Carbon Stored Long-term in Wood Products (tonnes CO2e) - Incl Landfill	NA	11,831	11,831
Diff Between Actual and Baseline Carbon in Harvested Wood (tonnes CO2e) - Excl Landfill	NA	-7,187	-7,187
Difference Between Actual and Baseline Carbon in Harvested Wood (tonnes CO2e) - Incl Landfill	NA	-11,831	-11,831
Difference in Actual and Baseline Carbon Stored in Wood Products (tonnes CO2e) - Landfill Adj	NA	-11,831	-11,831
GHG Reductions / Removals for Carbon Stored in Wood Products (tonnes CO2e) w/ mkt response	NA	-9,464	-9,464
Calculating Other Secondary Effects - Improved Forest Management Projects			
Difference Between Actual and Baseline Carbon in Harvested Wood (tonnes CO2e)	NA	-46,301	-46,301
Other Secondary Effects Emissions (shifting activities/materials) IFM Projects (tonnes CO2e)	NA	-9,260	-9,260
Quantified GHG Reductions and Removals			
Annual GHG Reductions/Removals Net of Discounts and Secondary Effects (tonnes CO2e)	NA	330,236	118,295
Cumulative GHG Reductions/Removals; not incl.neg. carryover or reversals (tonnes CO2e)	NA	330,236	448,531
Cumulative Negative Carryover from Prior Year (tonnes CO2e)	NA	0	0
ARBOCs Issued - Net of Negative Carryover, bef. Buffer or adjust for Reversals (tonnes CO2e) **Qry**	NA	330,236	118,295
Cumulative ARBOCs Issued Net Neg Carryover	NA	330,236	448,531
Calculation of Buffer Pool Contribution			
Project Specific Reversal Risk Rating	0	19.24%	19.24%
Annual Buffer Pool Contributions (ARBOCs)	NA	63,525	22,756
Cumulative Buffer Pool Contribution (ARBOCs)	NA	63,525	86,281
Accounting for Reversals			
Annual Reversals (tonnes CO2e)	NA	0	0
Total "Avoidable Reversals" to be compensated by the Forest Owner (tonnes CO2e)	NA	0	0
"Unavoidable Reversals" compensated by the Reserve from the Buffer Pool (tonnes CO2e)	NA	0	0
Compensating for Avoidable Reversals			
"Avoidable Reversals" compensated by retirement of ARBOCs in the Forest Owners Reserve Account (tonnes CO2e)	NA	0	0

	Initial Stocks	Reporting Period Ending 5/31/2014	Reporting Period Ending 5/31/2015
"Avoidable Reversals" compensated by retirement of ARBOCs issued to other Forest Projects Registered with the Reserve (tonnes CO2e)	NA	0	0
Carryover "Avoidable Reversals" which need to be compensated by Forest Owner (tonnes CO2e)	NA	0	0
ARBOCs Issued to Account Holder			
Annual ARBOCs Issued to Account Holder	NA	266,711	95,539
Cumulative ARBOCs Issued to Account Holder	NA	266,711	362,250

Appendix E: Inventory Methodologies – Fixed Radius Plots for Buckeye Forest Sampling

Introduction to Fixed Radius Plot Methodology

To improve the reverification process of the Buckeye Forest Project (BFP) CAFR5055, Sustainable Conservation, Inc. (SCI) is planning to transition the inventory design from variable radius plots to fixed radius plots, while keeping the same plot locations and stratification design. Approximately 1/10th of the established plots will be re-measured annually, thus providing a complete re-inventory over the course of each 10-12 year period. To change to fixed radius plots, SCI will establish a fixed radius plot center at the plot center of existing variable radius plots. Plot placement and forest stratification will remain the same as in the initial cruise and as described in the Initial Offset Project Data Report (OPDR). The current inventory accuracy and confidence limits are expected to be maintained with the fixed radius plots.

The transition towards fixed radius plots is driven in large part by ARB sequential sampling protocol and the desire to have an inventory collection system that is durable, repeatable, and will satisfy the accuracy requirements of the ARB. Fixed radius plots are considered simpler, more repeatable and are recommended by ARB. In the Initial Buckeye OPDR submitted to the ARB, SCI states that future sampling will use fixed area plots. The method for transitioning to fixed area plots, or the size of the plots were not described in the Initial OPDR.

The Compliance Offset Protocol (COP) states that: *Specific methods used to update the forest inventory must follow the inventory methodologies approved at the time the project is initially verified*. ***Modifications to inventory methodologies must be approved in advance by a third-party verification body and by ARB, and documented in the change log*** (emphasis added*).* To comply with this requirement, SCI is including this Appendix to clarify the change in inventory methodologies documented in the Change Log. The current approved Inventory Methodology (Appendix A) will remain part of the OPDR until considered no longer necessary by the third-party verification body and ARB.

Additional logistics:

- Data from variable radius plots (original inventory) will continue to be grown forward with FORSEE for annual reporting
- Data from annual inventory updates and from disturbance events will be collected with a fixed radius inventory design.
- As plots are reinventoried, the old plot data will be removed from the database (and archived) and the new data will be incorporated and grown forward as needed.

Summary of Methodology Changes:

- Plots will be 1/10th acre fixed radius plots for conifers and 1/20th acre plots for hardwoods instead of variable radius plots
- Down wood will no longer be sampled
- The inventory now states that TCF will provide maps and GPS coordinates
- Plot GPS points will now be recorded twice per plot: once at establishment and once at plot completion
- Tree numbers will be painted on the trees; a line at DBH will also be painted on each measured tree
- Procedure for measuring lean trees replaces estimation of bole length
- Lesser vegetation sampling is now described in the inventory methodology
- It is now explicit that site trees will not be collected in cruise updates
- Continuous forest inventory design which will result in a complete forest re-inventory every 12 years will be used

  Additionally, the approach to address negative growth outputs in inventory updates in the growth and yield model, FORSEE, is revised. For this OPDR and in the future, until further guidance is provided or the model is updated, his will be addressed by using the most recent field measurement for diameter and height (e.g., zero annual height or diameter growth) for all trees subject to negative diameter growth.

1. Sampling Design and Overview

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

In the initial forest inventory, stands were selected to be sampled with probability proportional to size. The set of plots to sample within a stand was a random selection of all plots on a 5 by 5 chain grid within that stand. If the stand was selected twice, plots were randomly selected from 2 different 5 by 5 chain grids within the stand. All stratum have at least 4 plots selected. Every 3rd plot, starting with the first plot, will have heights measured on all trees. Cruisers receive a list of the randomly chosen plots with the corresponding latitudes and longitudes within each stand. This list also notes which plots should have tree heights measured.

1.2. Plot Design – Summary of Measurements

The plot design consists of a circular 1/10th acre plot (37.2 ft radius) for all conifer tree species, a circular 1/20th acre (26.3 ft radius) plot for all hardwood tree species, and a 1/100th acre circular fixed radius plot for regeneration (11.8 ft radius). All plots are concentric with the same center.

1.2.1. Circular 1/10th Acre (37.2 ft radius) Fixed-Area Plot Measurements (standing live and dead *conifer* trees >=5.0 inches DBH)

- species
- diameter at breast height (DBH)
- height to the nearest foot
- height to crown base
- % defect, % missing height, and defect code where needed
- height and decay class for all conifer snags greater than 15 feet tall.

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

- species
- diameter at breast height (DBH)
- height to nearest foot
- % defect, % missing height, and defect code where needed
  - 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 greater than 15 feet tall.

1.2.3. Circular 1/100 acre Regeneration Plot Measurements (11.8 ft radius): (standing live <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)
- lesser vegetation – dominant lesser vegetation type (shrubs and grasses) and average

height.

1.2.4. Down Dead Transect Measurements

- *The dead and down transect has been removed from the revised sampling procedure as it is not used in the calculation of GHG emissions per the OPDR page 22 version 2014 and 2015. References to the Laying down wood will be removed from future OPDR documents.*

1.3. Plot Access and Road Point Procedures

Each plot will be accessed from the nearest road entry point or the prior plot. The cruiser will navigate via GPS to the plot center. A map will be provided to cruisers which shows where plots that have been placed and their corresponding GPS locations will be provided on a separate spreadsheet; shapefiles will also be provided to the cruisers.

1.4. Plot Monumenting and Plot Navigation Procedures

The following monumenting procedure should occur at all plots:

1. Plot centers should be marked with a plastic stakes painted orange, ½" PVC pipe is recommended. The stakes should extend at least 18" above the ground and be driven securely into the soil.
2. **The plot number and the distance and bearing to the next plot measured should be clearly written on an aluminum tag affixed to the plot center stake.**
3. Additionally, all plots shall be labeled on the white and pink flagging hung near plot center for visibility and attached to the permanent plot center marker (plastic stake).
4. The flagging and tag shall include the initials or the cruiser, the plot number, the date, and the distance and bearing to the next plot, if applicable.
5. GPS coordinates taken at plot centers and should be recorded on the plot sheet. Distance and bearing to the next plot should also be noted on the plot sheet.
6. GPS coordinates taken at plot centers and should be recorded on the plot sheet. **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
7. 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 facing plot center, 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.
8. Trees in the 1/20th and 1/10th acre plots are numbered consecutively starting from the north and moving in a clockwise direction until the plots are completed.
9. Trees shall be numbered consecutively starting from "1" on each plot.

1.5. 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 unmapped truck roads are sampled. Plots that have *any portion* of the 37.2 ft radius land

on mapped truck roads are offset 1 chain to the west, and if still on truck road the cruiser returns to the original point and offsets 1 chain north. The offset shall be in a cardinal direction moving 90 degrees clockwise on the compass until a bearing is found that will lead to a vegetated plot. Landings are treated as part of the truck road and not sampled. New plot centers will be mapped and the GPS coordinates will be provided to the data manager.

2. Sampling Procedure and Data Collection at Plots

2.1. 1/10th Acre (37.2 ft Radius) Plot for conifer trees and 1/20th Acre (26.3 ft Radius) plot for hardwood trees

2.1.1.Borderline Trees

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—the center of the tree needs to be within the plot radius. 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 covert 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 12" dbh tree which is 37 feet horizontal distance from plot center to the face would be measured as 37.5 feet to the center of the tree or "out".

2.1.2.Live Trees

All live conifer trees greater than or equal to 5 inches DBH are measured if the **CENTER** of the stem at DBH is within 37.2 horizontal feet of plot center. All live hardwood trees greater than or equal to 5 inches DBH are measured if the **CENTER** of the stem at DBH is within 26.3 horizontal feet of plot center. 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 <u>at the location where DBH was measured</u> and the tree number above this line. The tree number should be recorded.**

The following data should be collected for each tree measured:

- **<u>Species</u>** – The species and species codes of trees can be found in Table 1 below.
- **<u>Group</u>** – 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 3 below.
- **<u>Diameter at Breast Height</u> (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. For redwood stump sprouts the ground level should be considered to be the top pf the parent stump.

- **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. If the fork originates above DBH then the tree is measured and counted as a single tree. DBH should be measured above or below the fork at the most reasonable point without swell.
- **DBH for Extreme Lean Trees** – Trees with extreme leans should be measured 4.5 feet from the point where they leave the ground. In some cases, this may be on the downhill side of the tree.

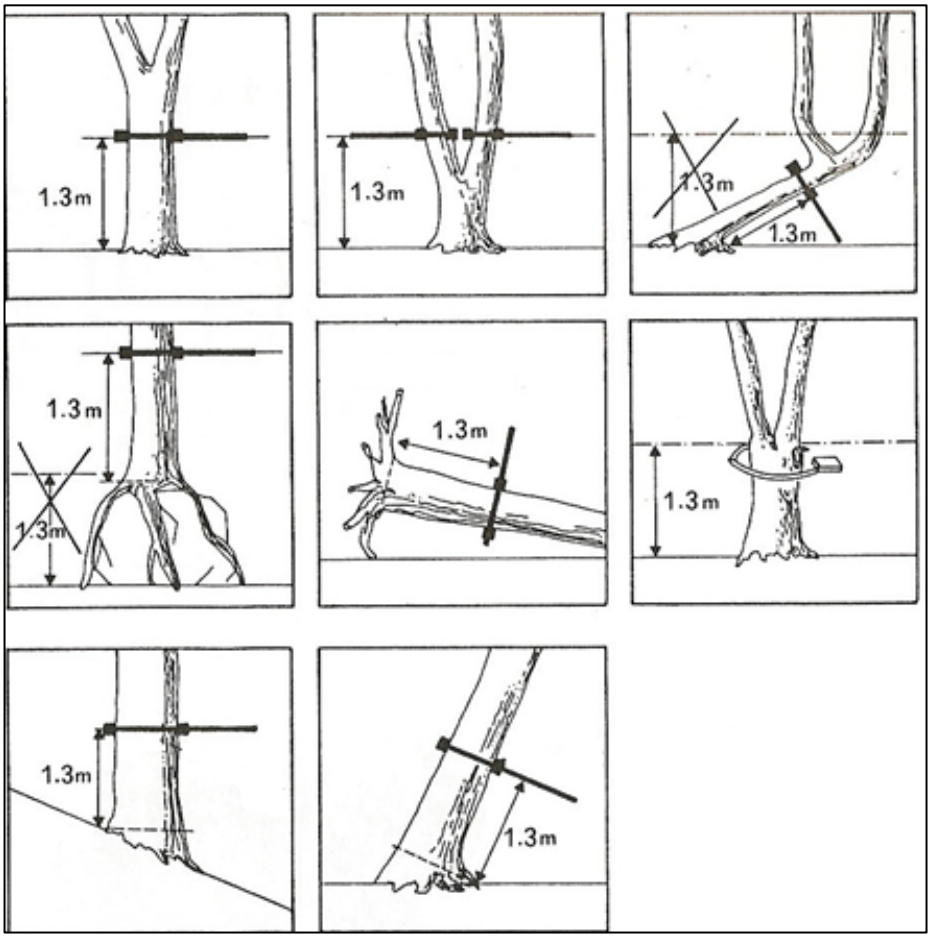

Figure 2. Point of measurement of diameter at breast height (from Pancel, 1993)[27] On slopes, the DBH is taken on the uphill side of the tree even if this is on the "bottom side" of the bole. DBH is a point on the tree 4.5 feet from the ground as measured along the bole.

- **Height** – Total height is measured on trees >= 5 inches DBH (This includes **live trees and**

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

snags greater than 15 feet tall).[28] Height is measured and recorded to the nearest foot. Height on live trees should only be measured in the specified plots (provided by The Conservation Fund).

- **Leaning or Sweep/Crook Trees** – Trees with lean and/or crook or sweep are measured for total vertical 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 provides an estimate of the total vertical crown area. The measurement is taken on every height measure tree. The 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. HTCB should be measured only in the height plots specified by The Conservation Fund.

- **Damage/Defect –** A damage code is assigned to damaged trees. See codes in Table 4 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. Only record rot for visible defect. **% missing volume** should be recorded on trees with broken tops or voids in the bole and is an estimate of the percentage of total volume missing in the top. Large hollows or other defect that impact the gross volume of the tree should be noted and a % missing volume estimated. Defect deductions are only taken for trees ≥ 8 inches in DBH.

[28] Every 3rd plot has height and height to crown based measured starting with the first plot measured in a stand.

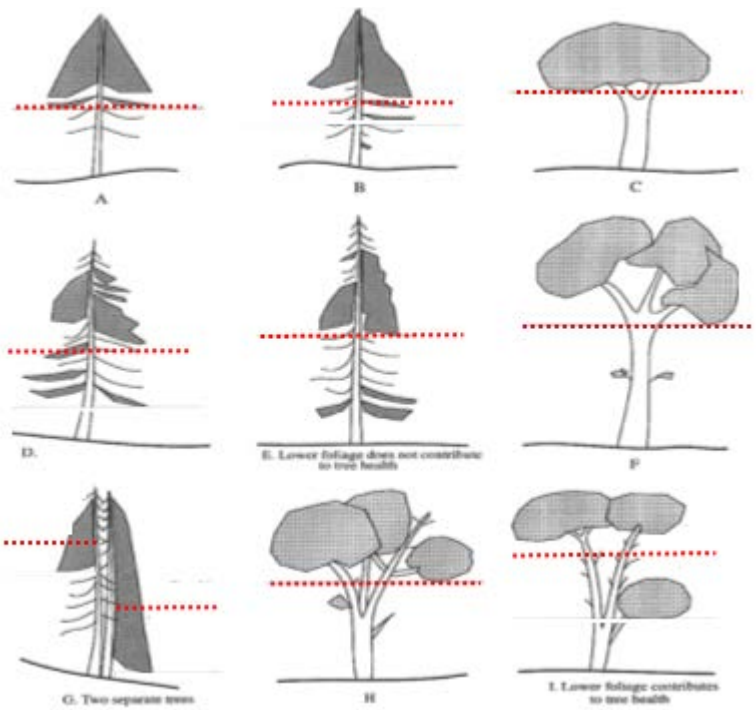

Figure 3. Height to Crown Base Measurement Examples (use the dotted line)

2.1.3.Snags (Standing Dead Trees[29]) > 15ft Tall

All snags over 15ft tall should be measured for **DBH** and **height** and should have their species noted. All conifer snags and Hardwood snags with the 1/10 and 1/20th acres plot respectively are recorded. All snags must have their **decay class** noted in the defect column (see Table 3 for Decay Classes). 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. Residual (old growth) stumps are not measured as snags unless they are at least 15' high as measured from the uphill side of the tree.

[29] Standing dead trees and snags are synonyms, and are used interchangeably in this document.

Table 1: List of Tree Species and their Species Codes

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

Table 2: Group Code Descriptions

Status Code	Code Definition	Description	Data Source
..	Live	Default code for trees with normal form. *All regeneration also should have this code.*	**1/10th acre plot**
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 1/100th acre regen plot.	**1/100th acre plot**

Table 3: [30]. 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.

[30] 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 4: Damage Codes

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		
6 - Animal	1 - Deer & Elk	0 - Unspecified		
	2 - Bear	1 - Light Damage		
	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. 1/100 Acre (11.8 ft radius) Plot

2.2.1.Regeneration – Trees < 5in DBH

The sample area measured for regeneration is a fixed 1/100th acre plot (11.8 ft radius). All trees less than 5.0 inches DBH are measured on every plot. 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. Hardwoods which do not show a clear tree form and can occur in brush or tree (e.g. tanoak and madrone) are counted as lesser vegetation.

- **Species** -Record species for all trees
- **Count** - Tally and seedlings and saplings by size class: 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 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

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.
- 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.

2.4. Site Class Sampling

Site tree sampling was completed in 2013 and no additional site tree data is required. This section is to remain in the OPDR for reference.

A minimum of **3 trees** per stratum should be selected, record species and measure DBH (to the nearest 10th inch), height to nearest 1 foot, HTCB (height to crown base), and age. The trees should be **redwood, Douglas-fir, Grand Fir or Sugar Pine species.** Each plot should be evaluated for the presence of potential site trees.

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),
- have a dominant or co-dominant crown class, and
- demonstrate good phenotype and vigor, eg straight bole clear of defect, crooks and forks, full even crown and healthy top growth
- Free of defect and disease.

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). Tree selected for site tree measurement shall be marked with orange flagging with writing on the flag stating that it is selected as a site tree.

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.

3. Data Entry and Transfer

Data will be collected using iPad tablets or other data logger provided by the cruising contractor. Cruisers shall email completed data to TCF at the end of each work day or as agreed. 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.

5. Example Plot Card

Strata _____	Cruiser(s): _____	Slope %: _____
Plot # _____	Date: _____	Aspect (deg): _____

Plot Center GPS Coordiantes: (leave GPS unit on)	Start of Plot GPS	GPS at Plot Completion	Road Point GPS Coordinates
	UTM N:_____	UTM N:_____	UTM N:_____
	UTM E:_____	UTM E:_____	UTM E:_____

Tree #	Species	DBH (.1 in)	Status (.., SN, LV)	Height (1 ft)	HTCB (1 ft)	3-Digit Damage Code OR Decay	Age OR Defect %	Missing Height %	Missing Volume %	Notes or Distance and Bearing to Bearing Trees

Regeneration (check one DBH category)

Species	0-2.4" DBH	2.5-4.9" DBH	Count	Est Ht

Notes:

Lesser Vegetation (type, density) & <DBH trees (count, species)

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	**37.2**	**33.0**	**50.0**	**66.0**	**100.0**	ratio
% slope :	degrees	SIN(degrees)	**(1/20th)**	**(1/10th)**	**ft**	**ft**	**ft**	**ft**	
10.0	5.71	0.10	26.4	37.4	33.2	50.2	66.3	100.5	0.9950
15.0	8.53	0.15	26.6	37.6	33.4	50.6	66.7	101.1	0.9889
20.0	11.31	0.20	26.8	37.9	33.7	51.0	67.3	102.0	0.9806
25.0	14.04	0.24	27.1	38.3	34.0	51.5	68.0	103.1	0.9701
30.0	16.70	0.29	27.5	38.8	34.5	52.2	68.9	104.4	0.9578
35.0	19.29	0.33	27.9	39.4	35.0	53.0	69.9	105.9	0.9439
40.0	21.80	0.37	28.3	40.1	35.5	53.9	71.1	107.7	0.9285
45.0	24.23	0.41	28.8	40.8	36.2	54.8	72.4	109.7	0.9119
50.0	26.57	0.45	29.4	41.6	36.9	55.9	73.8	111.8	0.8944
55.0	28.81	0.48	30.0	42.5	37.7	57.1	75.3	114.1	0.8762
60.0	30.96	0.51	30.7	43.4	38.5	58.3	77.0	116.6	0.8575
65.0	33.02	0.54	31.4	44.4	39.4	59.6	78.7	119.3	0.8384
70.0	34.99	0.57	32.1	45.4	40.3	61.0	80.6	122.1	0.8192
75.0	36.87	0.60	32.9	46.5	41.3	62.5	82.5	125.0	0.8000
80.0	38.66	0.62	33.7	47.6	42.3	64.0	84.5	128.1	0.7809
85.0	40.36	0.65	34.5	48.8	43.3	65.6	86.6	131.2	0.7619
90.0	41.99	0.67	35.4	50.0	44.4	67.3	88.8	134.5	0.7433
95.0	43.53	0.69	36.3	51.3	45.5	69.0	91.0	137.9	0.7250
100.0	45.00	0.71	37.2	52.6	46.7	70.7	93.3	141.4	0.7071
			% slope :	HD = COS(ARCTAN(</100)0*SD					
			slope in degrees :	HD = COS(<)* SD					
			ratio method :	HD =ratio*SD ex					
			leaning trees :	bole length = tree height/[SIN(lean degrees)]					

6.0 Inventory Update with FORSEE

Plots are re-measured approximately every 12 years. Approximately 1/10th of the established plots are re-measured annually, providing a complete forest re-inventory over the course of continuous forest inventory period. In the intervening years, when plots are not measured, the growth of trees is calculated in the approved growth and yield model, FORSEE. In FORSEE, the 'update inventory' function is used to grow the tree list forward to the current year.

Small trees sometimes show negative growth when grown forward in FORSEE. This will be addressed by using the most recent field measurement for diameter and height (e.g., zero annual height or diameter growth) for all trees subject to negative diameter growth.

After being forward grown, tree biomass is calculated as described in section 4.4 of the OPDR.