California Air Resources Board

Quantification Methodology
Technical Documentation

Forest Restoration & Management

California Climate Investments

Note:
The California Air Resources Board (CARB) is accepting public comments on the draft update to the Forest Restoration & Management Quantification Methodology until November 26, 2025, via ForestQM@arb.ca.gov. The Draft Quantification Methodology is subject to change pending stakeholder review. The Final Quantification Methodology will be available on the California Climate Investments resources webpage.

DRAFT

November 5, 2025

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I. Introduction

California Climate Investments is a statewide initiative that puts billions of Cap-and-Invest dollars to work facilitating greenhouse gas (GHG) emission reductions; strengthening the economy; improving public health and the environment; and providing benefits to residents of disadvantaged communities, low-income communities, and low-income households, collectively referred to as "priority populations." Where applicable and to the extent feasible, California Climate Investments ust maximize economic, environmental, and public health co-benefits to the State.

The California Air Resources Board (CARB) is responsible for providing guidance on estimating the net GHG benefit and co-benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). This guidance includes quantification methodologies, co-benefit assessment methodologies, and benefits calculator tools. CARB develops these methodologies and tools based on the activities eligible for funding by each administering agency, as reflected in the program expenditure records.

For California Climate Investments programs involving forest health and restoration activities, CARB staff developed this Quantification Methodology to provide guidance for estimating the net GHG benefit of each proposed activity. The QM is designed for use by the CAL FIRE programs Forest Health Grant Program, Wildfire Prevention Grant Program, Forest Legacy, and others. This methodology estimates carbon sequestration from reforestation, avoided losses from pest management, avoided wildfire emissions from fuel reduction treatments and wood utilization, and avoided conversion of forest land to alternative land uses.

The QM for Forest Restoration and Management requires geospatial analysis and specialized forest modeling software. This Technical Documentation describes the QM in detail. For California Climate Investment programs, typically State agency staff perform the QM utilizing information that project proponents submit according to the QM Guide for Project Proponents. Project applicants and grantees may not require the technical information provided here. This document provides the equations used, methodology, and the procedure for replicating the QM using standardized code and modeling steps. Please contact ForestQM@arb.ca.gov with questions.

Methodology Development

CARB and CAL FIRE developed this QM consistent with the guiding principles of California Climate Investments, including ensuring transparency and accountability, per the *California Climate Investments Funding Guidelines.* CARB and CAL FIRE developed this QM to be used to estimate the outcomes of proposed projects, inform project selection, and track results of funded projects. The implementing principles ensure that the methodology would:

- Apply at the project-level;
- Provide uniform methods to be applied statewide, and be accessible by all applicants;
- Use existing and proven tools and methods;
- Use project-level data, where available and appropriate; and
- Result in net GHG benefit estimates that are conservative and supported by empirical literature.

CARB assessed peer-reviewed literature and tools and consulted with experts, as needed, to determine methods appropriate for forest restoration and management project types. CARB also consulted with CAL FIRE to determine project-level inputs available. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level.

Project Activities

Activities included within the Forest Restoration and Management QM achieve a net GHG benefit through forest management actions and may include forest biomass utilization activities that store carbon in wood products and/or reduce GHG emissions by generating energy. Other project features may be eligible for funding; however, each project requesting GGRF funding must include at least one of the following project activity types:

1. Reforestation
2. Pest Management
3. Fuels Reduction
4. Forest Conservation (Avoided Conversion or Forest Management Easements)
5. Biomass Utilization

Limitations

The Forest Restoration and Management QM is aligned with the rigor required for California Climate Investment programs and includes detailed modeling of each project. However, the objective of the QM is to generate prospective estimates based on planned activities and publicly available data, not to determine empirical results of projects. This is different from CARB's compliance offset protocol, which involves project-level field measurements, ongoing monitoring, and verification.

This QM shares similarities with the Reduced Emissions from Megafire (REM) voluntary offset protocol from Climate Forward, with key differences. The REM protocol involves many forest growth simulations using the Forest Vegatation Simulator (FVS) per project in which wildfire is modeled at different years. The Forest Restoration and Management QM only involves one FVS simulation per scenario to reduce computational burden. Additionally, the REM protocol captures GHG fluxes, such as direct emissions from wildfire, whereas the Forest Restoration and Management QM is based on a stock-change approach, estimating GHG benefits by differencing end-state carbon stocks in each scenario.

There are several ongoing efforts to conduct new scientific analyses that will improve the Forest Restoration and Management QM. Future updates will reflect these efforts:

1. Contract with University of California Davis and Cal Poly San Luis Obispo to analyze the carbon effects of delayed forest reestablishment (DFR) following wildfire. The likelihood of DFR will be estimated from historic data and remote sensing analyses and the carbon density of post-fire shrub fields will be estimated from original field measurements. The primary research objective is to understand to what extent DFR impacts the carbon benefits or costs of forest fuel reduction treatments.
2. Contract with Spatial Informatics Group to improve the fuelbed and forest structure data inputs used in the QM. The contract will quantitatively compare multiple data sources to field measurements of fuel loads and recommend modifications to the QM workflow that improve fuelbed and forest structure accuracy.
3. Collaboration with California State University, Fresno to add shrubland and grassland modeling to the QM. The Rangeland Vegetation Simulator (RVS), a vegetation forecasting method specific to shrublands and grasslands, will be used to improve QMs for projects impacting non-forested ecosystems.

Updates

CARB staff periodically review each quantification methodology to evaluate their effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified. CARB updated the Forest Restoration and Management QM from the previous version to enhance the analysis and provide additional clarity (e-mail ForestQM@arb.ca.gov to request a copy of previous versions). The changes include:

- The methods have been standardized to ensure that each planned project yields a deterministic estimate of GHG benefits. In previous versions of the QM, users were able to choose from multiple simulation models and make other subjective choices. This flexibility allowed applicants and grantees with varying technical expertise to perform the QM independently. Since the QM is now typically performed by State staff rather than applicants/grantees, the current version of the QM establishes a single, standardized methodology, enabling more consistent and comparable evaluations across projects.
- Previous QM versions allowed users to choose between several imputed forest structure datasets to initiate FVS. Recently, a high-quality nationally imputed dataset called TreeMap has become available from the U.S. Forest Service. There are three vintages of TreeMap currently available (2016, 2020, and 2022). The 2022 vintage of TreeMap is used, unless the QM applies retroactively to past treatments, in which case the 2016 or 2020 vintage may be used.
- The wildfire probability map used for Fuels Reduction activities has been replaced by FSim a national simulation-based map of wildfire likelihood produced by the US Forest Service.
- In the most recent version of the QM, it was optional to include ingrowth of natural regeneration in forest growth simulations. In this update, natural regeneration is included in the Reforestation and Fuels Reduction scenario modeling using the tool REGIMPUTE, a publicly available FVS add-on.
- FVS wildfire modeling parameters were standardized to values that reflect modern wildfire patterns. For example, wind speed is now set to 20 mph and season of burn is set to Fall.
- The Cycle Length in FVS modeling was previously set to 10 years to reduce computing time but is 5 years in this QM version to increase modeling precision.

- Reforestation modeling was adjusted from 100% assumed survival of planted seedlings to 70% survival to more conservatively estimate GHG benefits. Since FVS incorporates density-dependent tree mortality, this adjustment did not reduce GHG benefits proportionally to the reduction in survival rate.
- The calculations to estimate the benefit of fuels treatments on the surrounding landscape, called Impact Area, have been transferred from the IFTDSS platform to a custom R shiny app called TRIAADS, developed for the QM by a researcher at California State University, Fresno.
- The NIDRM pest risk map was updated to reflect disturbances between 2012 and 2018, according to NIDRM data.
- The previous QM asked applicants and grantees for Forest Conservation projects to provide information about the quantities of biomass that will be removed throughout the 50-80-year project duration under each scenario, as well as the end fate of that biomass. This information is difficult to predict for hypothetical counterfactual scenarios, especially over long time spans into the future. The current update asks grantees and applicants to optionally provide percentages for each biomass utilization pathway. Total quantities of biomass removal are estimated from FVS modeling results.
- The baseline (counterfactual) scenario for reforestation transitioned from look-up tables to FVS modeling. The FVS runs for baseline scenario are initiated with seedling densities based on the PostCRPT model of natural regeneration success. Growth modifiers are applied to reflect suppression of conifer growth by post-fire shrubs.
- The equations for Fuels Reduction were updated to more intuitively reflect fuel treatment benefits to wildfire severity and spread.

How to use this document

To understand the calculations and assumptions embedded within the QM, see Section II. To run the QM for a project, use Section III.

II. Methods

QM calculations account for on-site forest carbon stocks, carbon stored in wood products, the displacement of fossil fuels that results from biomass energy generation, and GHG emissions associated with the implementation of forest health projects. For all activity types except Biomass Utilization, forest growth modeling is performed using the Forest Vegetation Simulator, a growth-and-yield model developed and maintained by the United States Forest Service. The net GHG benefit is estimated using the approaches described below.

Reforestation

A. General Approach

Reforestation
Net GHG Benefit = Δ in standing live and dead tree carbon stocks (above and belowground) in the treatment boundary – carbon in shrubs and herbaceous understory removed from treatment boundary – emissions from site preparation and herbicide treatments

The GHG benefits from reforestation are calculated as the difference between the baseline (counterfactual) and project scenarios. Emissions and benefits of site preparation are included in the calculations. The process can be summarized in these steps:

1. FVS is used to simulate the growth of planted seedlings over the lifespan of the project, using planned trees per acre for each species.
2. The counterfactual carbon densities are estimated using FVS modeling of natural regrowth in a post-fire landscape. Regenerating conifer densities are estimated using the Postfire Conifer Reforestation Planning Tool (PostCRPT). The species of these seedlings are assigned based on a nationally imputed forest map called TreeMap. The growth rates of regenerating seedlings are modified in FVS to account for competition with post-fire shrubs.
3. The results of Steps 1 and 2 are entered into the Calculator Tool, which also incorporates the effects of shrub removal and site preparation on GHG benefit.

B. Detailed Methods & Equations

The GHG benefit from reforestation activities is calculated as the difference between the baseline and project scenarios using Equation 1. Equation 2 is used to determine carbon storage and project emissions in the project scenario. Equation 3 is used to determine the carbon storage in the baseline scenario.

For both the baseline and project scenarios, carbon is modeled over time in FVS. The default growth parameters in FVS are well-suited for modeling the growth of planted trees. However, FVS modeling alone cannot capture naturally regenerating seedlings and their competition with shrubs in the baseline scenario. We used a combination of the Postfire Conifer Reforestation Planning Tool (PostCRPT) and information from the scientific literature to modify FVS for the baseline scenario.

The PostCRPT tool is used to predict the density of naturally occurring regenerating conifers that would establish at the project site. The species of those trees is assigned based on conifer species composition of nearby areas according to TreeMap. Naturally regenerating seedlings are modeled in FVS starting at 20 years post-fire, which reflects the approximate average time at which trees will emerge above the shrub canopy (Tubbesing et al. 2021). Trees are assumed to be three feet tall at the time they emerge. Since trees are still subject to shrub competition at that point, height and diameter growth are adjusted for small trees to 70% of default FVS rates and the survival rate is set to 80% (Tubbesing et al. 2021).

Natural post-fire regeneration was not included in the project scenario because site preparation for planting usually occurs a few years after wildfire. Site preparation would likely kill the naturally occurring seedlings predicted by PostCRPT, which is based on data gathered ~5-8 years post-fire.

In the planting scenario, seedling survival rate refers to the percentage of planted seedlings that will survive to the end of the FVS modeling cycle, which is five years.

Equation 1: GHG Benefit from Reforestation Activities

$$GHG_R = GHG_{RP} - GHG_{RB}$$

Where			Units
GHG_R	=	GHG benefit of reforestation activities	MT CO_2e

Equation 1: GHG Benefit from Reforestation Activities

$$GHG_R = GHG_{RP} - GHG_{RB}$$

GHG_{RP}	=	On-site carbon storage and project emissions in reforestation project scenario (from Equation 2)	MT CO_2e
GHG_{RB}	=	On-site carbon storage in reforestation baseline scenario (from Equation 3)	MT CO_2e

In Equation 2, total carbon storage and emissions in the project scenario are determined by adding FVS outputs to emissions from herbicide and site preparation. Herbicide emissions are determined using a single emissions factor of 0.0607 MT CO_2e/Acre (Sonne 2006), while site preparation emission factors vary according to understory cover as shown in Table 1 (CARB Compliance Offset Protocol U.S. Forest Projects, 2015). Site preparation emission factors represent only the mobile source emissions from machinery. Carbon in understory vegetation that is lost during site preparation is reflected in Equation 3.

Equation 2: On-Site Carbon Storage and Project Emissions in Reforestation Project Scenario

$$GHG_{RP} = CT_{RP} \times 3.67 - MC_{RP} \times ASP_{RP} - AHT_{RP} \times 0.0607$$

Where			Units
GHG_{RP}	=	On-site carbon storage and project emissions in reforestation project scenario	MT CO_2e
CT_{RP}	=	Carbon within the treatment boundary at the end of the project with reforestation (from FVS)	MT C
3.67	=	Conversion factor from C to CO_2e	CO_2e/C
MC_{RP}	=	Mobile combustion emission factor if site preparation takes place in reforestation project scenario (based on level of brush cover)	MT CO_2e/ Acre
ASP_{RP}	=	Area subject to site preparation	Acres
AHT_{RP}	=	Area subject to herbicide treatment	Acres
0.0607	=	Herbicide treatment emission factor	MT CO_2e/ Acre

Table 1. Site preparation emission factors for reforestation

Brush cover	Brush cover definition	Site preparation emission factor
Heavy brush cover	>50% brush cover, stump removal	0.090 MT CO_2e/ Acre
Medium brush cover	>25-50% dense brush cover	0.202 MT CO_2e/ Acre
Light brush cover	0-25% brush cover	0.429 MT CO_2e/ Acre

In Equation 3, carbon in the baseline scenario is estimated to be the sum of tree carbon from FVS and understory carbon. Understory carbon is estimated using emission factors as shown in Table 2 (Scott and Burgan 2005).

Equation 3: On-Site Carbon Storage in Reforestation Baseline Scenario

$$GHG_{RB} = CT_{RB} \times 3.67 + SHU_{RB} \times ASP_{RP}$$

Where			Units
GHG_{RB}	=	On-site carbon storage in reforestation baseline scenario	MT CO_2e
CT_{RB}	=	Carbon within the treatment boundary at the end of the project without reforestation (from FVS)	MT C
3.67	=	Conversion factor from C to CO_2e	CO_2e/C
SHU_{RB}	=	Shrubs and herbaceous understory carbon removed during site preparation from within the treatment boundary in reforestation project scenario (based on land cover type)	MTCO_2e/ Acre
ASP_{RP}	=	Area subject to site preparation	Acres

Table 2. Understory emission factors for reforestation

Cover type	Carbon lost from understory removal during site preparation
Grass	3.6 MT CO_2e/acre
Light to medium shrub cover	13.9 MT CO_2e/acre
Heavy shrub cover	24.0 MT CO_2e/acre

Pest Management

A. General Approach

Pest Management
Net GHG Benefit = Δ in standing live tree carbon stocks (above and belowground) in the treatment and impact boundaries as a result of reduced mortality from pests and disease – carbon in biomass removed from treatment boundary – mobile combustion emissions from mechanical treatments

The process for estimating GHG benefit for pest management can be summarized in these steps:

1. Starting conditions are estimated using TreeMap, which imputes FIA data across all forested lands. The 2022 vintage of TreeMap is used, unless the QM applies retroactively to past treatments, in which case the 2016 or 2020 vintage may be used. TreeMap data are clipped to the size and shape of the treatment polygon and then converted into FVS input tables.
2. FVS is used to estimate forest carbon over 50-80 years in the treatment and impact areas, depending on the productivity of the forest – lower productivity forests require a longer modeling period. Mortality from pest outbreak is not included in the FVS modeling. The FVS modeling is performed for both the treatment scenario and no-treatment scenario. The results from the treatment scenario are used to estimate the carbon removed during pest management treatments.
3. The national data set National Insect & Disease Risk and Hazard Mapping (NIDRM) is queried to find the estimated risk of pest outbreak in the treatment and impact areas without pest management treatment. Before querying, the 2012 NIDRM data is updated to reflect forest pest outbreaks that occurred between 2012 and 2018. Values 'At Risk' in NIDRM represent the expectation that, without remediation, 25 percent or more of the standing live basal area of trees greater than 1 inch in diameter will die over a 15-year time frame due to insects and diseases. Loss estimates assume no remediation.
4. The ending carbon values in the baseline scenario are estimated by adjusting the results of Step 2 by the results of Step 3.
5. The ending carbon values in the treatment scenario are estimated by adjusting the results of Step 2 by an estimate of pest risk with treatment. This

estimate may be provided by site- and treatment-specific estimates sourced from published, peer-reviewed literature directly applicable to the project site or from a Registered Professional Forester familiar with the threat facing the project site and proposed treatments. Then, the carbon removed during treatment is subtracted from the result.

B. Equations

The GHG benefit from pest management activities is calculated as the difference between the baseline and project scenarios using Equation 4. Equation 5 is used to determine the carbon storage and project emissions in the project scenario. Equation 6 is used to determine the carbon storage in the baseline scenario.

Equation 4: GHG Benefit from Pest Management Activities

$$GHG_{PM} = GHG_{PMP} - GHG_{PMB}$$

Where			Units
GHG_{PM}	=	GHG benefit of pest management activities	MT CO_2e
GHG_{PMP}	=	On-site carbon storage and project emissions in pest management project scenario (from Equation 5)	MT CO_2e
GHG_{PMB}	=	On-site carbon storage in pest management baseline scenario (from Equation 6)	MT CO_2e

Equation 5: On-Site Carbon Storage and Project Emissions in Pest Management Project Scenario

$$GHG_{PMP} = \left[\left(CT_{PMNT} + CI_{PMNT}\right) \times \left(1 - R_{PMP}\right) - CR_{PMP}\right] \times 3.67 - BR_{PMP} \times 0.06$$

Where			Units
GHG_{PMP}	=	On-site carbon storage and project emissions in pest management project scenario	MT CO_2e
CT_{PMNT}	=	Standing live tree carbon within the **treatment area** at the end of the project without pest management treatment or disturbance (FVS)	MT C
CI_{PMNT}	=	Standing live tree carbon within the **impact area** at the end of the project without disturbance or pest management treatment (FVS)	MT C
R_{PMP}	=	Percentage of treatment and impact boundaries at risk with pest management treatment	%
CR_{PMP}	=	Carbon removed as part of pest management treatment	MT C

Equation 5: On-Site Carbon Storage and Project Emissions in Pest Management Project Scenario

$$GHG_{PMP} = \left[\left(CT_{PMNT} + CI_{PMNT}\right) \times \left(1 - R_{PMP}\right) - CR_{PMP}\right] \times 3.67 - BR_{PMP} \times 0.06$$

3.67	=	Conversion factor from C to CO_2e	CO_2e/C
BR_{PMP}	=	Biomass removed via mechanical treatments	Bone dry tons
0.06	=	Mobile combustion emission factor for biomass removal in pest management project scenario	MT CO_2e/ bone dry ton

Equation 6: On-Site Carbon Storage in Pest Management Baseline Scenario

$$GHG_{PMB} = \left(SLT_{PMNT} + SLI_{PMNT}\right) \times \left(1 - R_{PMB}\right) \times 3.67$$

Where			Units
GHG_{PMB}	=	On-site carbon storage in pest management baseline scenario	MT CO_2e
SLT_{PMNT}	=	Standing live tree carbon within the **treatment area** at the end of the project without disturbance or pest management treatment (FVS)	MT C
SLI_{PMNT}	=	Standing live tree carbon within the **impact area** at the end of the project without disturbance or pest management treatment (FVS)	MT C
R_{PMB}	=	Percentage of treatment and impact boundaries at risk without pest management treatment	%
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

Fuels Reduction

A. General Approach

Fuels Reduction
Net GHG Benefit = (Δ in standing live tree carbon stocks in the treatment area and impact area as a result of reduced mortality from wildfire) – (carbon in biomass removed from treatment boundary) – (mobile combustion emissions from mechanical treatments)

The process for estimating GHG benefit from fuels reduction can be summarized in six steps:

1. Starting conditions are estimated using TreeMap, which imputes FIA data across all forested lands. The 2022 vintage of TreeMap is used, unless the QM applies retroactively to past treatments, in which case the 2016 or 2020 vintage may be used. TreeMap data are clipped to the size and shape of the treatment polygon and then converted into FVS input tables.
2. FVS is used to estimate forest carbon over 50-80 years, depending on the productivity of the forest – lower productivity forests require a longer modeling period. Four scenarios are modeled in FVS:
    - No Treatment, No Wildfire
    - No Treatment, With Wildfire
    - Treatment, No Wildfire
    - Treatment, With Wildfire
3. The ending carbon values for live tree biomass are summed across the treatment area and impact area for each of the four scenarios.
4. The wildfire likelihood map from FSim is used to determine the likelihood of wildfire in the treatment location.
5. Carbon benefits due to treatment effects on wildfire spread are calculated using TRIAADS. This step estimates the expected benefit of treatments in reducing wildfire probability and severity in both the treatment and impact area.
6. The ending carbon values for the No Wildfire and With Wildfire scenarios are weighted by the fire likelihood to estimate an expected value of ending carbon stock for the Treatment and No Treatment scenarios. These values are adjusted for treatment effects on wildfire spread according to TRIAADS. The difference between the baseline and treatment scenario equals the GHG benefit of the project.

B. Detailed Methods & Equations

The GHG benefit from fuels reduction activities is calculated as the difference between the baseline and project scenarios using Equation 7. Equations 8-8e are used to determine the carbon storage and project emissions in the treatment scenario. Equation 9 is used to determine the carbon storage in the baseline (counterfactual) scenario.

Equation 7: GHG Benefit from Fuels Reduction Activities

$$GHG\ BENEFIT_{FR} = GHG_{TR} - GHG_{NT}$$

Where			Units
$GHG\ BENEFIT_{FR}$	=	GHG benefit of fuels reduction activities	MT CO_2e
GHG_{TR}	=	On-site carbon storage and project emissions in fuels reduction treatment scenario (Eqn 8)	MT CO_2e
GHG_{NT}	=	On-site carbon storage in fuels reduction baseline (no treatment) scenario (Eqn 9)	MT CO_2e

Equation 8 provides an overview of the calculation for carbon stored in the fuel reduction scenario. Equations 8a-8e show how the component parts of Equation 8 are estimated from model outputs.

Equation 8: Carbon Storage and Project Emissions in Fuels Reduction Scenario

$$GHG_{TR} = (C_{TR,NF} - P_{WF} * \Delta C_{TR}) * 3.67 - BR * 0.06$$

Where,			Units
GHG_{TR}	=	On-site carbon storage and project emissions in fuels reduction project scenario	MT CO_2e
$C_{TR,NF}$	=	Carbon within the treatment and impact boundary at the end of the project with fuels reduction treatment but without wildfire (Eqn 8a)	MT C
P_{WF}	=	Probability of a wildfire occurring over the effective period for fuels reduction treatment (default 10 years) (Eqn 8b)	Probability between 0 and 1

Equation 8: Carbon Storage and Project Emissions in Fuels Reduction Scenario

$$GHG_{TR} = (C_{TR,NF} - P_{WF} * \Delta C_{TR}) * 3.67 - BR * 0.06$$

ΔC_{TR}	=	Difference between treatment-wildfire and treatment-no-wildfire carbon at the end of the project, across both the treatment area and impact area	MT CO_2e
3.67	=	Conversion factor from C to CO_2e	CO_2e/C
BR	=	Biomass removed via mechanical treatments	Bone dry tons
0.06	=	Mobile combustion emission factor for biomass removal in fuels reduction project scenario	MT CO_2e/ bone dry ton

Equation 8a: Carbon in treatment and impact areas at end of project with treatment but without wildfire

$$C_{TR,NF} = C^{T}{}_{TR,NF} + C^{I}{}_{NF}$$

Where			Units
$C_{TR,NF}$	=	Carbon within the treatment and impact boundary at the end of the project with fuels reduction treatment but without wildfire	MTC
$C^{T}{}_{TR,NF}$	=	Carbon within the treatment boundary at the end of the project with fuels reduction treatment and without wildfire (from FVS)	MTC
$C^{I}{}_{NF}$	=	Carbon within the impact boundary at the end of the project without wildfire (from FVS)	MTC

Equation 8b calculates the probability of wildfire occurring at any point within the treatment effectiveness period (assumed to be 10 years) by compounding the wildfire probability from FSim over 10 years.

Equation 8b: Probability of wildfire occurring within the treatment effectiveness period

$$P_{WF} = 1 - (1 - APFO_{FR})^{EP}$$

Where			Units
P_{WF}	=	Probability of a wildfire occurring over the effective period for fuels reduction treatment	Probability between 0 and 1
$APFO_{FR}$	=	Annual probability of fire occurrence within the treatment and impact boundaries (mean probability from FSim)	Probability between 0 and 1
EP	=	Effective period for fuels reduction treatment (10 years)	Years

Equation 8c presents the overall logic for calculating the difference between *treatment-no-wildfire* and *treatment-wildfire* carbon. Equations 8e and 8d show how each component is calculated.

Equation 8c: Difference between treatment-wildfire and treatment-no-wildfire carbon

$$\Delta C_{TR} = C_{TR,NF} - C^{T}{}_{TR,WF} - C^{I}{}_{TR,WF}$$

Where			Units
ΔC_{TR}	=	Difference between *treatment-wildfire* and *treatment-no-wildfire* carbon within the treatment and impact boundary at the end of the project	MTC
$C_{TR,NF}$	=	Carbon within the treatment and impact boundary at the end of the project in *treatment-no-wildfire* scenario (Equation 8a)	MTC
$C^{T}{}_{TR,WF}$	=	Carbon in the treatment area at the end of the project in the *treatment-wildfire* scenario (Equation 8d)	MTC
$C^{I}{}_{TR,WF}$	=	Carbon in the impact area at the end of the project in the *treatment-wildfire* scenario (Equation 8e)	MTC

The calculation of ΔC_{TR} is limited by the scope of available modeling tools. FVS calculates carbon storage over time, while TRIAADS simulates wildfire spread spatially across a landscape. FVS cannot model wildfire spread and TRIAADS cannot measure the carbon effects of wildfire spread. Results from the two models are combined in Equation 8d and 8e to estimate how fuel treatments lower wildfire carbon losses.

Equation 8d shows how carbon in the *treatment-wildfire* scenario is estimated. The carbon estimates from FVS are adjusted based on the results of TRIAADS wildfire simulation modeling.

Equation 8d: Carbon in treatment area in *treatment-wildfire* scenario

$$C^T{}_{TR,WF} = C^T{}_{TR,NF} - \left(C^T{}_{TR,NF} - C\_unadj^T{}_{TR,WF}\right) * \frac{PHS^T{}_{TR} * CBP^T{}_{TR,HSTR}}{PHS^T{}_{NT} * CBP^T{}_{NT,HSNT}}$$

Where			Units
$C^T{}_{TR,WF}$	=	Carbon in treatment area at the end of the project with treatment and **with wildfire**	MTC
$C^T{}_{TR,NF}$	=	Carbon in treatment area at the end of the project with treatment and **without wildfire** (from FVS)	MTC
$C\_unadj^T{}_{TR,WF}$	=	Carbon in treatment area at the end of the project with treatment and **with wildfire,** unadjusted for treatment effects on wildfire spread (from FVS)	MTC
$CBP^T_{TR,HSTR}$	=	Conditional burn probability **with treatment** for the portion of the treatment area likely to burn at high severity in the no-treatment scenario (from TRIAADS)	Probability between 0 and 1
$CBP^T_{NT,HSNT}$	=	Conditional burn probability **without treatment** for the portion of the treatment area likely to burn at high severity in the no-treatment scenario (from TRIAADS)	Probability between 0 and 1
$PHS^T{}_{NT}$	=	Proportion of treatment area likely to burn at high severity **without treatment**, conditional on burning (from TRIAADS)	Proportion between 0 and 1

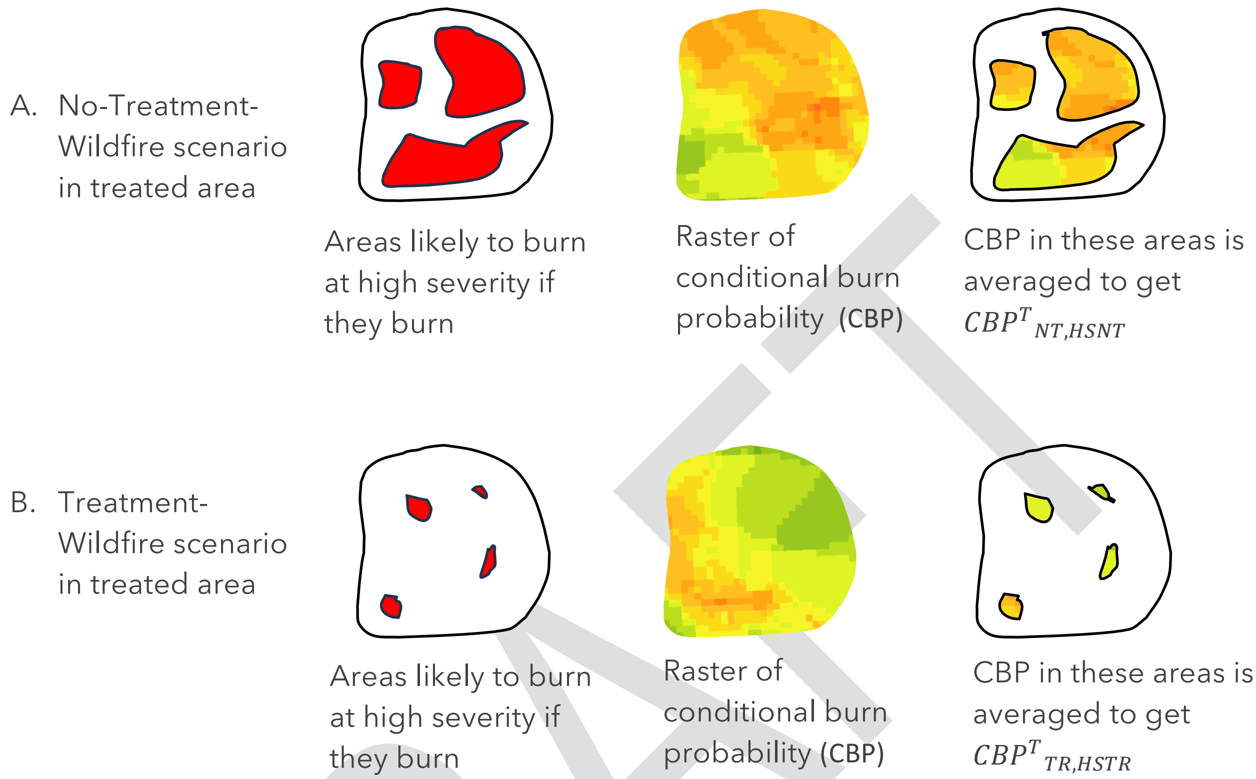
Equation 8d: Carbon in treatment area in *treatment-wildfire* scenario

$$C^{T}{}_{TR,WF} = C^{T}{}_{TR,NF} - \left(C^{T}{}_{TR,NF} - C\_unadj^{T}{}_{TR,WF}\right) * \frac{PHS^{T}{}_{TR} * CBP^{T}{}_{TR,HSTR}}{PHS^{T}{}_{NT} * CBP^{T}{}_{NT,HSNT}}$$

$PHS^{T}{}_{TR}$	=	Proportion of treatment area likely to burn at high severity **with treatment**, conditional on burning (from TRIAADS)	Proportion between 0 and 1

The term $C^{T}{}_{TR,NF} - C\_unadj^{T}{}_{TR,WF}$ represents wildfire carbon losses independent of the treatment effects on wildfire spread. The term $\frac{PHS^{T}{}_{TR}*CBP^{T}{}_{TR,HSTR}}{PHS^{T}{}_{NT}*CBP^{T}{}_{NT,HSNT}}$ represents treatment effects on carbon losses through mitigation of fire spread, as shown in Figure 1. Conditional burn probability (CBP) is the probability that a given pixel will burn if an ignition occurs somewhere in the treatment or impact area. Fuel treatments reduce CBP by reducing fire spread. CBP is estimated in TRIAADS. Rather than considering treatment effects on CBP across the entire treatment area, Equation 8d limits CBP to areas expected to burn at high severity if they burn (Figure 1). This reflects the assumption that carbon losses occur predominantly under severe wildfire. CBP in low-severity areas is less important for carbon calculations because low-severity fire kills relatively few overstory trees, where most live forest carbon is stored. The terms $CBP^{T}{}_{NT,HSNT}$ and $CBP^{T}{}_{TR,HSTR}$ are calculated by masking the raster of CBP to the areas expected to burn at high severity, conditional on fire occurrence (“high severity areas”). Then $CBP^{T}{}_{TR,HSTR}$ is multiplied by the proportion of the treatment area that contains high severity areas to estimate the probability of high-severity fire across the treatment area. The same steps are repeated for the Impact Area in Equation 8e.

Figure 1. CBP^T calculations in the treatment and no-treatment scenarios



Equation 8e: Carbon in impact area in treatment-wildfire scenario

$$C^{I}{}_{TR,WF} = C^{I}{}_{NF} - \left(C^{I}{}_{NF} - C^{I}{}_{NT,WF}\right) * \frac{PHS^{I}{}_{TR} * CBP^{I}{}_{TR,HSTR}}{PHS^{I}{}_{NT} * CBP^{I}{}_{NT,HSNT}}$$

Where,			Units
$C^{I}{}_{TR,WF}$	=	Carbon in impact area at the end of the project with treatment and **with wildfire**	MTC
$C^{I}{}_{NF}$	=	Carbon in impact area at the end of the project **without wildfire** (from FVS)	MTC
$C^{I}{}_{NT,WF}$	=	Carbon in impact area at the end of the project **with wildfire** (from FVS)	MTC
$CBP^{I}_{TR,HSTR}$	=	Conditional burn probability **with treatment** for the portion of the impact area likely to burn at high severity in the no-treatment scenario (from randig)	Probability between 0 and 1
$CBP^{I}_{NT,HSNT}$	=	Conditional burn probability **without treatment** for the portion of the impact area likely to burn at high severity in the no-treatment scenario (from randig)	Probability between 0 and 1
$PHS^{I}{}_{NT}$	=	Proportion of impact area likely to burn at high severity **without treatment**, conditional on burning (from randig)	Proportion between 0 and 1
$PHS^{I}{}_{TR}$	=	Proportion of impact area likely to burn at high severity **with treatment**, conditional on burning (from randig)	Proportion between 0 and 1

Equation 9: On-Site Carbon Storage in Fuels Reduction Baseline Scenario

$$GHG_{FRB} = [CTNF_{FRB} + CINF_{FR} - (1 - (1 - APFO_{FR})^{EP}) \times (CTNF_{FRB} + CINF_{FR} - CTWF_{FRB} - CIWF_{FRB})] \times 3.67$$

Where			Units
GHG_{NT}	=	On-site carbon storage in fuels reduction baseline scenario	MT CO_2e
$CTNF_{FRB}$	=	Carbon within the treatment boundary at the end of the project without fuels reduction treatment and without fire disturbance (from FVS)	MT C
$CINF_{FR}$	=	Carbon within the impact boundary at the end of the project without fire disturbance (from FVS)	MT C
$CTWF_{FRB}$	=	Carbon within the treatment boundary at the end of the project without fuels reduction treatment but with fire disturbance (from FVS)	MT C
$CIWF_{FRB}$	=	Carbon within the impact boundary at the end of the project without fuels reduction treatment but with fire disturbance (from FVS)	MT C
$APFO_{FR}$	=	Annual probability of fire occurrence within the treatment and impact boundaries (mean probability from FRAP Fire Probability for Carbon Accounting map tool)	Probability between 0 and 1
EP	=	Effective period for fuels reduction treatment (10 years)	Years
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

Forest Conservation

A. General Approach

Forest Conservation (Avoided Conversion or Forest Management Easements)
Net GHG Benefit = Δ in standing live and dead tree carbon stocks (above and belowground) in the treatment boundary as a result of avoided conversion and/or changes in forest management

The process for estimating GHG benefit from easements can be summarized in these steps:

1. Starting conditions are estimated using TreeMap, which imputes FIA data across all forested lands. The 2022 vintage of TreeMap is used, unless the QM applies retroactively to past treatments, in which case the 2016 or 2020 vintage may be used. TreeMap data are clipped to the size and shape of the easement and then converted into FVS input tables.
2. FVS is used to estimate forest carbon in the easement scenario over 50-80 years, depending on the productivity of the forest – lower productivity forests require a longer modeling period.
    - Avoided Conversion Easements: FVS modeling is performed for only the easements scenario. To estimate forest carbon in the baseline scenario, the result of the FVS modeling is adjusted by “conversion impact” factors depending on threat type, ranging from 80% to 95%. If the threat type is residential, the conversion impact is estimated based on the number of parcels that would be created if the land were converted.
    - Forest Management Easements: FVS modeling is performed for both the easement and baseline scenarios. Project-specific forest management activities are included in both scenarios for the full project duration.
3. The difference between the baseline and easement scenarios equals the GHG benefit of the project.

B. Detailed Methods & Equations

The GHG benefit from avoided conversion easement activities is calculated as the difference between the baseline and project scenarios using Equation 10. Equation 11 is used to determine the on-site carbon storage in the project scenario. Equation 12 is used to determine the on-site carbon storage in the baseline scenario. Note: If biomass will be removed and utilized in the project scenario, or would be in the baseline scenario, the net GHG benefit from utilization is calculated using Equations 16-20.

Equation 10: GHG Benefit from Avoided Conversion Easement Activities

$$GHG_{AC} = GHG_{ACP} - GHG_{ACB}$$

Where			Units
GHG_{AC}	=	GHG benefit of avoided conversion easement activities	MT CO_2e
GHG_{ACP}	=	On-site carbon storage in avoided conversion easement project scenario (from Equation 11)	MT CO_2e
GHG_{ACB}	=	On-site carbon storage in avoided conversion easement baseline scenario (from Equation 12)	MT CO_2e

Equation 11: On-Site Carbon Storage in Avoided Conversion Easement Project Scenario

$$GHG_{ACP} = C_{ACP} \times 3.67$$

Where			Units
GHG_{ACP}	=	On-site carbon storage and project emissions in avoided conversion easement project scenario	MT CO_2e
C_{ACP}	=	Standing live and dead tree carbon within the treatment boundary at the end of the project with the conservation easement	MT C
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

Equation 12: On-Site Carbon Storage in Avoided Conversion Easement Baseline Scenario

$$GHG_{ACB} = C_{ACP} \times (100\% - CI_{ACB}) \times 3.67$$

Where Units

Equation 12: On-Site Carbon Storage in Avoided Conversion Easement Baseline Scenario

$$GHG_{ACB} = C_{ACP} \times (100\% - CI_{ACB}) \times 3.67$$

GHG_{ACB}	=	On-site carbon storage in forest conservation baseline scenario	MT CO_2e
C_{ACP}	=	Standing live and dead tree carbon within the treatment boundary at the end of the project with the conservation easement	MT C
CI_{ACB}	=	Conversion impact within the treatment boundary (based on type of conversion threat, see Table 3)	%
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

The GHG benefit from forest management easement activities is calculated as the difference between the baseline and project scenarios using Equation 13. Equation 14 is used to determine the on-site carbon storage in the project scenario. Equation 15 is used to determine the on-site carbon storage in the baseline scenario. Note: If biomass will be removed and utilized in the project scenario, or would be in the baseline scenario, the net GHG benefit from utilization is calculated using Equations 16-20.

Equation 12b: Conversion impact within the treatment boundary for residential conversion threat

$$CI_{ACB,R} = minimum \left[100, \quad \frac{P \cdot 3}{A} \cdot 100 \right]$$

Where			Units
$CI_{ACB,R}$	=	Conversion impact within the treatment boundary for residential conversion threat	%
A	=	Project area	acres
P	=	Number of unique parcels that would be formed on the project area (Each parcel is assumed to deforest 3 acres of forest vegetation[1])	count
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

[1] California Air Resources Board. (2015). *Compliance Offset Protocol U.S. Forest Projects*.

Table 3. Conversion impact by threat type

Agriculture	90%
Mining	90%
Recreation (e.g. golf course)	80%
Commercial	95%
Industrial	95%
Residential	See equation 12b.

The conversion impact for residential conversion threat depends on the number of parcels (home lots) that would be created without the easement (Equation 12b). The number of parcels can be estimated, for example, by finding the parcel density of nearby developments of the same type. Alternatively, the method for estimating parcel number outlined in the QM for the Sustainable Agricultural Lands Conservation (SALC) program can be used. See https://www.caclimateinvestments.ca.gov/tools.

Equation 13: GHG Benefit from Forest Management Easement Activities

$$GHG_{FM} = GHG_{FMP} - GHG_{FMB}$$

Where			Units
GHG_{FM}	=	GHG benefit of forest management easement activities	MT CO_2e
GHG_{FMP}	=	On-site carbon storage in forest management easement project scenario (from Equation 14)	MT CO_2e
GHG_{FMB}	=	On-site carbon storage in forest management easement baseline scenario (from Equation 15)	MT CO_2e

Equation 14: On-Site Carbon Storage in Forest Management Easement Project Scenario

$$GHG_{FMP} = C_{FMP} \times 3.67$$

Where			Units
GHG_{FMP}	=	On-site carbon storage and project emissions in forest management easement project scenario	MT CO_2e
C_{FMP}	=	Standing live and dead tree carbon within the treatment boundary at the end of the project with the conservation easement (from FVS)	MT C

Equation 14: On-Site Carbon Storage in Forest Management Easement Project Scenario

$$GHG_{FMP} = C_{FMP} \times 3.67$$

3.67	=	Conversion factor from C to CO_2e	CO_2e/C

Equation 15: On-Site Carbon Storage in Forest Management Easement Baseline Scenario

$$GHG_{FMB} = C_{FMB} \times 3.67$$

Where			<u>Units</u>
GHG_{FMB}	=	On-site carbon storage in forest management easement baseline scenario	MT CO_2e
C_{FMB}	=	Standing live and dead tree carbon within the treatment boundary at the end of the project without the conservation easement (from FVS)	MT C
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

Biomass Utilization

A. General Approach

Biomass Utilization
Net GHG Benefit = Carbon stored long-term in wood products + avoided emissions from fossil fuel-based energy displaced by biomass energy – stationary combustion emissions from biomass energy production + avoided emissions from alternative form of biomass disposal

Biomass may be removed and utilized for wood products or electricity generation in conjunction with other project activities. The QM calculates the GHG benefits of wood products and energy generation through long-term carbon storage and avoided fossil fuel emissions, respectively. In some situations, the QM also estimates the benefits of avoiding more carbon-intensive disposal methods including open pile burning, landfilling, and on-site decay. However, avoided disposal emissions are only included for projects that involve the utilization of biomass that would otherwise be removed from the forest, but the removal was not part of the project being modeled. In other words, the counterfactual must be forest treatments that result in woody biomass waste accumulating in the forest or at roadside landing sites. The methodology does not account for avoided disposal emissions of material that would only require disposal as a result of the project, and there are no GHG benefits in this QM for utilizing biomass that would have been utilized even without this project.

While many projects affect short-term biomass utilization, most project activities are not expected to impact long-term biomass removal and utilization over the 50–80-year life of the project. Long-term biomass utilization is assumed to be equal in the baseline and project scenarios for all project types except avoided conversion easements, in which land that would be converted continues to operate as a working forest, and forest management easements, which involve a change in forest management practices. Biomass that would be removed and utilized in the baseline scenario and project scenario are therefore included in the biomass utilization calculations if sufficient data exist from project proponents.

B. Detailed Methods & Equations

The GHG benefit from biomass utilization activities is calculated as the sum of the benefits of activities that result in carbon being stored long-term in wood products, the displacement of fossil fuel-based energy with biomass energy, and avoidance of biomass disposal emissions using Equation 16.

Equation 16: GHG Benefit from Biomass Utilization Activities

$$GHG_{BU} = GHG_{WP} + GHG_{EG} + GHG_{AE}$$

Where			Units
GHG_{BU}	=	GHG benefit of biomass utilization activities	MT CO_2e
GHG_{WP}	=	GHG benefit from utilizing biomass for wood products (from Equation 18)	MT CO_2e
GHG_{EG}	=	GHG benefit from utilizing biomass for electricity generation (from Equation 19)	MT CO_2e
GHG_{AE}	=	GHG benefit from avoided biomass disposal emissions (only applicable to biomass utilization activities for biomass *not* removed by other activities within this project (from Equation 20)	MT CO_2e

The GHG benefit from carbon stored long-term in wood products is calculated based on the net quantity of biomass utilized for wood products, mill efficiency, and the carbon storage factor of the wood products generated. Equation 17 is used to determine the net amount of carbon transferred to wood products as a result of project activities. Projects may use the actual efficiency from the mill where trees will be delivered, supported with documentation, or the appropriate default mill efficiency provided in Table 4. If trees will be delivered to more than one mill with different efficiencies, applicants may provide a weighted mill efficiency. After determining the carbon transferred to wood products, Equation 18 is used to determine the net amount of carbon stored long term in wood products as a result of project activities. To do this, Equation 18 calculates the percentage of removed biomass that will go into each wood product class category. If not available from the mill that wood is delivered to, assume that 100% of the biomass goes into "miscellaneous products." Carbon storage factors, the percent of carbon transferred to wood products that remains stored long-term, are provided.

Equation 17: Carbon Transferred to Wood Products

$$C_{WP} = (BWP_P - BWP_{FCB} + BWP_{FCP}) \times 0.5 \times ME$$

Where,

			Units
C_{WP}	=	Carbon transferred to wood products	MT C
BWP_P	=	Biomass to be removed from the project area (with and without the project) and delivered to a mill to be utilized for wood products in the project scenario	Bone dry tons (BDT)
BWP_{FCB}	=	Biomass that would be removed from within the treatment boundary and utilized for wood products without the conservation easement (avoided conversion and forest management)	BDT
BWP_{FCP}	=	Biomass that is expected to be removed from within the treatment boundary and utilized for wood products with conservation easement (avoided conversion and forest management)	BDT
0.5	=	Conversion factor from wood to carbon	C/wood
ME	=	Mill efficiency	%

Table 4. Default Mill Efficiencies

Hardwood	Softwood
56.8%	67.5%

Equation 18: GHG Benefit of Carbon Stored Long-Term in Wood Products

$$GHG_{WP} = [(C_{WP} \times SL \times 0.463) + (C_{WP} \times HL \times 0.250) + (C_{WP} \times SP \times 0.484) + (C_{WP} \times OS \times 0.582) + (C_{WP} \times NP \times 0.380) + (C_{WP} \times P \times 0.058) + (C_{WP} \times MP \times 0.176)] \times 3.67$$

Where			Units
GHG_{WP}	=	GHG benefit of carbon stored in wood products	MT CO_2e
C_{WP}	=	Carbon transferred to wood products	MT C
SL	=	Percentage of biomass that will go into softwood lumber	%
0.463	=	Carbon storage factor for softwood lumber	%
HL	=	Percentage of biomass that will go into hardwood lumber	%
0.250	=	Carbon storage factor for hardwood lumber	%
SP	=	Percentage of biomass that will go into softwood plywood	%
0.484	=	Carbon storage factor for softwood plywood	%
OS	=	Percentage of biomass that will go into oriented strand board	%
0.582	=	Carbon storage factor for oriented strand board	%
NP	=	Percentage of biomass that will go into nonstructural panels	%
0.380	=	Carbon storage factor for nonstructural panels	%
P	=	Percentage of biomass that will go into paper	%
0.058	=	Carbon storage factor for paper	%
MP	=	Percentage of biomass that will go into miscellaneous products	%
0.176	=	Carbon storage factor for miscellaneous products	%
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

The GHG benefit from utilizing biomass for electricity generation is calculated as the net quantities of biomass utilized for electricity generation via combustion and gasification, multiplied by a process specific emission reduction factor. Equation 19 is used to determine the net GHG benefit from generating electricity.

Equation 19: GHG Benefit from Utilizing Biomass for Electricity Generation

$$GHG_E = (BEC_P - BEC_{FCB} + BEC_{FCP}) \times 0.18 + (BEG_P - BEG_{FCB} + BEG_{FCP}) \times 0.23$$

Where			Units
GHG_E	=	GHG benefit from utilizing biomass for electricity generation	MT CO_2e
BEC_P	=	Biomass to be removed from the project area (with and without the current project) and delivered to a biomass facility generating electricity via combustion as part of the project	Bone dry tons (BDT)
BEC_{FCB}	=	Biomass that would be removed from within the forest conservation treatment boundary and utilized for electricity generation via combustion without the conservation easement	BDT
BEC_{FCP}	=	Biomass that is expected to be removed from within the forest conservation treatment boundary and utilized for electricity generation via combustion with the conservation easement	BDT
0.18	=	Emission reduction factor for electricity generation via combustion	MT CO_2e/ BDT
BEG_P	=	Biomass to be removed from the project area (with and without the current project) and delivered to a biomass facility generating electricity via gasification as part of the project	BDT
BEG_{FCB}	=	Biomass that would be removed from within the forest conservation treatment boundary and utilized for electricity generation via gasification without the conservation easement	BDT
BEG_{FCP}	=	Biomass that is expected to be removed from within the forest conservation treatment boundary and utilized for electricity generation via gasification with the conservation easement	BDT
0.23	=	Emission reduction factor for electricity generation via gasification	MT CO_2e/ BDT

If the project funds the utilization of biomass removed as part of management practices not associated with the project, the project may include the GHG benefit of avoided CH_4 and N_2O emissions from an open pile burn, landfilling, or leaving biomass to decay on-site using Equation 20.

Equation 20: GHG Benefit from Avoided Biomass Disposal Emissions

$$GHG_{AE} = \left[(BDT_{PBB} \times 0.16) \times 0.907185 + (BDT_{LB} \times 0.21) + (BDT_{DB} \times 1.25) \times 0.907185\right]$$

Where			Units
GHG_{AE}	=	Avoided emissions from open pile burning, landfilling, or leaving biomass to decay on-site	MT CO_2e
BDT_{PBB}	=	Biomass that would be removed and open pile burned without the project	Bone dry tons (BDT)
0.16	=	Emission factor for open pile burning of removed biomass	Ton CO_2e /BDT
BDT_{LB}	=	Biomass that would be removed and landfilled without the project	BDT
0.21	=	Emission factor for landfilling removed biomass	MT CO_2e /BDT
BDT_{DB}	=	Biomass that would be removed and left to decay on-site without the project	BDT
1.25	=	Emission factor for leaving removed biomass to decay on-site	Ton CO_2e /BDT
0.907185	=	Conversion factor from ton to metric ton	MT/ton

Overlapping Treatment Areas

When multiple treatment areas or impact areas overlap within one project, Table 5 is used to identify which treatment type the overlapping area is apportioned to.

Table 5. Approach for Apportioning Acreage Within Overlapping Boundaries

	Pest management treatment area	Pest management impact area	Fuels Reduction treatment area	Fuel reduction impact area	Forest Conservation
Reforestation (R)	R	R	N/A	R	R
Pest management treatment area (PMT)		PMT	FRI	PM	PM
Pest management impact area (PMI)			FR	FRI	C
Fuels Reduction treatment area (FRT)				FRT	FR
Fuels reduction impact area (FRI)					C

When impact areas overlap within one treatment type (e.g., two neighboring fuels reduction treatments have overlapping impact areas), the following rule is used: If two impact areas have >50% overlap, the larger impact area is included in the calculations and the smaller impact area is dropped. When more than two impact areas overlap, the largest is kept and all other impact areas with >50% overlap with the largest one are dropped, and that step is repeated with the next largest impact area until overlap is minimized.

III. QM Procedure

To estimate GHG benefits for each of the project types, download the items shown in Table 6 and then follow the procedure for your activity type(s).

Table 6. Downloads required for each project type

Data or software	Restoration	Pest Management	Fuel Reduction	Conservation	Biomass Utilization
Forest Restoration & Management **Calculator Tool** at *https://www.caclimateinvestments.ca.gov/tools*	X	X	X	X	X
Code repository from *https://github.com/arb-ca/ForestHealthQM*	X	X	X		
FVS software from *https://www.fs.usda.gov/fvs/software/complete.php*	X	X	X	X	
TreeMap files from *data.fs.usda.gov/geodata/rastergateway/treemap* • TreeMap 2022 CONUS (RDS-2025-0032.zip) • TreeMap 2020 CONUS (RDS-2025-0031.zip) • TreeMap 2016 (RDS-2021-0074_Data.zip)	X	X	X	X	
California State Boundary (for visualization) from *https://data.ca.gov/dataset/ca-geographic-boundaries*	X	X	X	X	
FVS Variant Map from *https://www.fs.usda.gov/managing-land/forest-management/fvs/documents*	X	X	X	X	
FSim rasters for 2011 and 2047 (`RDS-2025-0006.ZIP`) from *https://www.fs.usda.gov/rds/archive/catalog/RDS-2025-0006*			X		
LANDFIRE fuel raster for California (`us_250 40 Fire Behavior fuel`) from *https://www.landfire.gov/viewer*			X		
NIDRM Data from the NIDRM website, including 2018 update layer for California and 2012 "Composite Hazard from all pests"		X			
PostCRPT tool results from the wildfire preceding reforestation *https://reforestationtools.org/postfire-conifer-reforestation-planning-tool*	X				

REGIMPUTE .kcp files for the FVS variant(s) relevant to your project. Choose the kcp file(s) with "Regen_SpeciesMethod" in the name. See the *REGIMPUTE website*	X	X	X		

Table 7 provides FVS input values that are used in all FVS modeling runs in this QM. Refer to Table 7 when prompted in the FVS Procedure sections below.

Table 7. FVS Input values common to all project types

Location in FVS GUI	**Parameter or Keyword**	**Value**
Simulate ↳ Time	Common starting year	Year in which treatment, planting, or easement will take place
Simulate ↳ Time	Common ending year	End of Project (as shown in Calculator Tool) + 1[2]
Simulate ↳ Time	Growth and reporting interval (years)	5
Simulate ↳ Components ↳ Keywords ↳ Fire and Fuels Extension ↳ CarbCalc	Biomass predictions	1 = Use Jenkins and others
	Units	2 = Combined
Simulate ↳ Components ↳ Keywords ↳ Fire and Fuels Extension ↳ FireCalc	The fire behavior calculations should use:	1 = the new fuel model selection logic
	Fuel model set for use with the new fuel model logic:	2 = use all 53 fuel models

[2] The extra year is added onto Project Lifespan to ensure that FVS creates outputs for the final year of the project.

Reforestation Procedure

A. Steps to run Reforestation QM

1. Refer to Table 6 to identify the data and scripts required. Download and install or unzip each item.
2. Open the Forest Restoration & Management **Calculator Tool** excel file and populate the green cells with project information.
3. Customize the file paths, End of Project year, and fire year in Scripts 1, 2, 0 and 7 from *https://github.com/arb-ca/ForestHealthQM/R-code*
4. Run Scripts 1, 2, 0 and 7, in that order
    - Scripts 1, 2, and 0 only need to be run once per project. Script 7 must be run once per reforestation treatment.
5. Open **FVS software** and run simulations for the reforestation and baseline scenarios
    - See section *B. Reforestation FVS Procedure* below for step-by-step FVS instructions
6. Configure Script 5 for each of the FVS output files
    - Replace the file paths and directory locations at the start of the script to match the FVS output
    - Adjust `area_ac` to match your planned reforestation acreage
    - Set `end_yr` to match End of Project in the Calculator Tool.
7. Run Script 5
8. Return to the Forest Restoration & Management **Calculator Tool** excel file and populate the yellow cells with results from Script 5

B. Reforestation FVS Procedure

1. Start a new project
2. Select the appropriate variant, which can be found at the end of the Script 7 results
3. Add stands
    - This simulation will have only one representative stand. Under `Stands`, select and add `Bareground.`
4. Set `Time` and `CarbCalc` variables according to Table 7, leaving other values as defaults
5. Under `Select Outputs`, select `Carbon and fuels`
6. Add planted seedlings for the **Project Scenario**
    - Under `Management`, select `Planting & Natural Regeneration` and set the following parameters:

- Year or cycle number = year of site preparation (year of planting will be determined in the next input)
  - If there is no site preparation, enter the year of planting
- Years following disturbance = the number of years between site preparation and planting. If site preparation and planting occur in the same year or if there is no site preparation, enter 0.
- Sprouting = Off
- Type of regeneration = Plant
- Enter the trees/acre by species that will be planted
- For Percent survival, enter 70 (or less, if you expect higher mortality)
- Uniform spatial distribution
- If more than two species will be planted, select Change to freeform

7. Add ingrowth regeneration
   - Under Editor, upload the regeneration file for the project's FVS variant
   - E.g., Regen_SpeciesMethod_WS.kcp
   - Save in run
8. Rename "PL," assign MgmtID to "PL," and Run
9. Configure for the **Baseline Scenario**
   - Duplicate and rename the run to "BS"
   - Remove planted seedlings
10. Add naturally regenerating seedlings
    - Under Management, select Planting & Natural Regeneration and set the following parameters:
      - Year or cycle number = year of the wildfire
      - Sprouting = Off
      - Years following disturbance = 20
      - Type of regeneration = Natural
      - Enter the TPA by species that are predicted by Script 7
      - Percent survival= 80
      - Height = 3 (ft)
      - If more than two species are predicted, select Change to freeform
      - Uniform spatial distribution
11. Add the CycleAt keyword under Base FVS System
    - Set Year 20 years after wildfire
12. Add growth modifiers
    - Select Diameter Growth Modifiers under Modifiers tab
    - Select Adjust small tree diameter growth
    - Change the Multiplier value to 0.7 and Year or cycle number to the year of the fire. Leave All species selected.

- Repeat for the `Height Growth Modifier` called `Adjust small tree height model`. Again use a multiplier value of `0.7`.

13. Change the MgmtID to "BS" and Run
14. Download FVS outputs in the `View Outputs` tab
    - Under `Load`, select all runs and then select `FVS_Carbon` and move to `Explore`
        - Select all years and all variables
        - Download

Pest Management Procedure

C. Steps to run Pest Management QM

1. Refer to Table 1 to identify the data and scripts required. Download and install or unzip each item.
2. Open the Forest Restoration & Management **Calculator Tool** excel file and populate the green cells with project information.
3. Script `Prep_NIDRM.qmd`
   - Replace the file paths with the locations of NIDRM files that you downloaded in Step 1
   - Run
4. Script `1-Intersect_TreeMap_treatments.qmd`
   - Set the TreeMap vintage based on the year of your treatments
   - Define the project name, treatment name, and shapefile name
   - Customize the file paths
   - **Run**
5. Script `2-Prepare-FVS-inputs-TM.qmd`
   - Customize the file paths and then **Run**
6. Open **FVS software** and run a simulation for a no-treatment and treatment scenario
   - See section *B. Pest Management FVS Procedure – Treatment Area* below for step-by-step FVS instructions
7. Run FVS simulations in the Impact Area
   - See section *C. Pest Management FVS Procedure – Impact Area* below for step-by-step instructions
8. Script `3-FVS-post-processing-FR.qmd`
   - Script 3 is run once per treatment, so if your project contains multiple treatments you may need to run it several times. Make sure that each time you run Script 3, it points to the correct FVS output file and areas file (areas file is created in Script 1)
   - Set `end_year` based on End of Project as shown in the Calculator Tool
9. Script `6-Query-NIDRM.qmd`
   - Customize the `NIDRM_updated.tif` file path (created in Step 3) and the file path for the pest management activity shapefile
   - **Run**
10. Return to the Forest Restoration & Management **Calculator Tool** excel file and populate the yellow cells with results from Script 6 and FVS.

D. Pest Management FVS Procedure – *Treatment area*

1. Start a new project
2. Upload the treatment area FVS input file generated from Script 2 into FVS
   - These files will be located in the folder "FVS_Input" and will follow the naming convention "FVS_input_" + project_ID + TCN
     - Example: `FVS_input_8GG24601_3.3.xlsx`
3. Add all stands
4. Configure for all runs
   - Set `Time` and `CarbCalc` variables according to Table 2, leaving other values as defaults
   - Add natural regeneration
     - Under Editor, upload the regeneration file for the project's FVS variant
       - E.g. `Regen_SpeciesMethod_NC.kcp`
     - Save in run
5. Under `Select outputs`, choose `Carbon and fuels`
6. Rename as BSPM (Baseline Pest Management) and title the MgmtID as BSPM, then Run
7. Configure and run for TRPM (Treatment Pest Management)
   - Duplicate the BSNF run and rename as TRPM
   - Under `Components`, select `Management, Fuel Treatments`, and then the appropriate fuel treatment type
     - Generally, the best treatment type will be `Thin a species across a DBH range`, potentially followed by piling and burning
     - Enter information specific to your treatment
   - Under `Event Monitor`, select `Compute Stand Variables in Editor`, then paste in the following:
     `LiveCRem = TreeBio(0,0,1,All,0.,200.,0.,500.)*0.5*0.907185`
   - Rename MgmtID to "TRPM" and **Run**
8. Download FVS outputs in the `View Outputs` tab
   - Under `Load`, select both runs and then select `FVS_Carbon` and `FVS_Compute` and move to `Explore`
     - Select all stands and all years
     - Select `MgmtID`, `StandID`, `Year`, `Aboveground_Total_Live`, `Belowground_Live`, and `LIVECREM`
     - Download

E. Pest Management FVS Procedure – *Impact area*

1. Start a new project
2. Upload the impact area FVS input file generated from Script 2 into FVS

- These files will be located in the folder “FVS_Input” and will follow the naming convention “FVS_input_IA_” + project_ID + TCN
    - Example: `FVS_input_8GG24601_3.3.xlsx`

3. Add all stands
4. Configure according to Step 4 in Section B above
5. Under `Select outputs`, choose `Carbon and fuels`
6. Rename as IAPM and title the MgmtID as IAPM, then Run
7. Download FVS outputs in the `View Outputs` tab
    - Under `Load`, select `FVS_Carbon` and move to `Explore`
        - Select all stands and all years
        - Select `MgmtID`, `StandID`, `Year`, `Aboveground_Total_Live`, and `Belowground_Live`

Fuels Reduction Procedure

A. Steps to run Fuels Reduction QM

1. Prepare project shapefiles
    - There should be one shapefile for each treatment activity. Assign each activity a Treatment Component Number (TCN). Each shapefile must have a field in its attribute table called "TCN" that contains the TCN of the activity.
2. Refer to Table 1 to identify the data and scripts required. Download and install or unzip each item.
3. Prepare raster data
    - Using the tool of your choice (e.g., ArcGIS Pro), perform raster math to average the 2011 and 2047 FSim rasters
    - For faster processing times, you may also want to clip the TreeMap rasters to a smaller size – e.g. the size of California or your county or park
    - Save the LANDFIRE fuel raster for California in the folder `ForestHealthQM/R-code/gigafire-randig-calfire-lemma/data/base_data`
4. Open the Forest Restoration & Management **Calculator Tool** excel file and populate the green cells with project information.
5. Configure R scripts `1-Intersect_TreeMap_treatments.qmd` and `2-Prepare-FVS-inputs-TM.qmd`
    - Replace the file paths and directory locations at the start of each script to match the file and directory locations on your computer
    - Set the TreeMap vintage in Script 1 based on the year of your treatments
    - Define the project name, treatment name, and shapefile name
6. Run Scripts 1 and 2
    - You only need to run each of these scripts once per project, even if there are multiple treatment types in your project. They read in all shapefiles in a specified folder, prepare them for FVS, and save files that are used as inputs for TRIAADS and FVS
    - In cases where impact areas within a project overlap, Script 1 does not create impact area files for every treatment (See Section II, Overlapping Treatment Areas).
7. Open **FVS software** and run a simulation for each combination of treatment and scenario, for a total of four FVS runs per treatment activity
    - See section *B. Fuels Reduction FVS Procedure – Treatment Area* below for step-by-step FVS instructions
8. Run FVS simulations in the Impact Area
    - This step is only necessary for the TCNs that were identified in Script 1 as needing impact area analysis, based on treatment overlap

- See section *C. Fuels Reduction FVS Procedure – Impact Area* below for step-by-step instructions

9. Configure and run Scripts 3-4
   - Script 3 is run once per treatment, so if your project contains multiple treatments you may need to run it several times. Make sure that each time you run Script 3, it points to the correct FVS output file and areas file (created in Script 1).
   - In Script 3, set `end_year` based on project duration, as shown in the Calculator Tool
10. Run TRIAADS
    - See section *D. TRIAADS Procedure* below for step-by-step instructions
11. Return to the Forest Restoration & Management **Calculator Tool** excel file and populate the yellow cells with results from the scripts and Impact Area Tool

B. Fuels Reduction FVS Procedure– *Treatment Area*

1. Start a new project in FVS
2. Upload a treatment area FVS input files generated from Script 2 into FVS
   - These files will be located in the folder "FVS_Input" and will follow the naming convention "FVS_input_" + project_ID + TCN
     - Example: `FVS_input_8GG24601_3.3.xlsx`
3. Add all stands
4. Configure for all runs
   - Set `Time`, `CarbCalc`, and `FireCalc` variables according to Table 2, leaving other values as defaults
   - Add natural regeneration
     - Under Editor, upload the regeneration file for the project's FVS variant
       - E.g. `Regen_SpeciesMethod_NC.kcp`
     - Save in run
5. Select outputs
   - `Carbon and fuels`
   - `Fire and mortality`
   - `Stand structure`
6. Rename as BSNF (for Baseline No Fire) and title the MgmtID as BSNF, then **Run**
7. Configure and run for BSWF (Baseline With Fire)
   - Duplicate the BSNF run and rename it BSWF and save
   - Add the `SimFire` keyword under the `Fire and Fuels Extension`
     - For `Year or cycle number`, enter the year 5 years after treatment

  - Note: If the treatment takes multiple years (e.g. thin/pile/burn), `SimFire` should occur five years after the first component of the treatment is completed
  - `Wind speed` → 20 mph
  - `Moisture level` → `1 = very dry`
  - `Temperature` → 90
  - `Mortality code` → 1
  - `Percentage of stand area burned` → 100
  - `Season of fire` → `4 = Fall`
- Rename MgmtID to "BSWF" and **Run**

8. Configure and run for TRWF (Treatment With Fire)
   - Duplicate the BSWF run and rename as TRWF
   - Under `Components`, select `Management, Fuel Treatments`, and then the appropriate fuel treatment type
     - Choose between `Thin from Below`, `Mastication`, `Prescribed burn, Thin with fuel piled and burned`, or `Pile burn surface fuel`
     - Enter information specific to your treatment
       - Note: if treatment type includes thinning, set the parameter `Proportion of small trees left` to 0.01
   - Under Event Monitor, select Compute Stand Variables in Editor, then paste in the following:
     - `LiveCRem = TreeBio(0,0,1,All,0.,200.,0.,500.)*0.5*0.907185`
   - Rename MgmtID to "TRWF" and **Run**
9. Configure for TRNF (Treatment No Fire)
   - Duplicate the TRWF run and rename as TRNF
   - Delete `SimFire`
   - Rename MgmtID to "TRNF" and **Run**
10. Download FVS outputs in the `View Outputs` tab
    - Under `Load`, select all runs and then select `FVS_Carbon` and `FVS_Compute` and move to `Explore`
      - Select all stands and all years
      - Select the variables `MgmtID`, `StandID`, `Year`, `Aboveground_Total_Live`, `Belowground_Live`, and `LIVECREM`
      - Download and save the file as Project ID + TCN + "treatment_carbon"
        - E.g. 8GG24601_1.4_treatment_carbon.xlsx
    - Return to Load and
    - for `BSNF` and `TRNF`, select `FVS_PotFire` and `FVS_StrClass`
      - Select only the year 5 years after treatment, when `SimFire` is scheduled
      - Select all variables

    - Download and save the file as Project ID + TCN + "treatment_TRIAADS"
        - E.g. 8GG24601_1.4_treatment_TRIAADS.xlsx

C. Fuels Reduction FVS Procedure– *Impact Area*

1. Start a new project in FVS
2. Upload the Impact Area FVS input files generated from Script 2 into FVS
    - These files will be located in the folder "FVS_Input" and will follow the naming convention "FVS_input_IA" + Project_ID + TCN
3. Add all stands
4. Configure according to Step 4 in Section B above
5. Select outputs
    - `Carbon and fuels`
    - `Fire and mortality`
    - `Stand structure`
6. Rename as IANF (for Impact Area No Fire) and title the MgmtID as IANF, then **Run**
7. Configure and run for wildfire scenario
    - Duplicate the IANF run and rename it IAWF and save
    - Add the `SimFire` keyword under the `Fire and Fuels Extension` and configure according to Step 7 in Section B above.
    - Rename MgmtID to "IAWF" and **Run**
8. Download FVS outputs in the `View Outputs` tab
    - Under `Load`, select both runs and then select `FVS_Carbon`, `FVS_PotFire` and `FVS_StrClass` and move to `Explore`
        - Select all stands and all years
        - Leave all variables selected
        - Download and save the file as Project ID + TCN + "IA_TRIAADS"
            - E.g. 8GG25501_1.4_IA_TRIAADS.xlsx

D. Fuels Reduction TRIAADS Procedure

1. Go to Script 1 and identify the folder defined as `triaads_output_dir`. Go to that directory in File Explorer and locate the shapefile and associated files (.shx, .dbf, .prj) for the treatment and impact areas of the TCN you plan to run in TRIAADS. Zip those files into to zipped folders.
    - Example: `intersected_8GG24601_1.3.zip` and `intersected_IA_8GG24601_1_3.zip`
2. Open runshiny.R and change the file path to match your computer, then run.
3. The Shiny app will appear. Upload the zipped files from Step 1.

- If the treatment will not have impact area analysis, as identified in Script 1, uncheck the box "Include Impact Area Analysis" and upload only one zipped folder.

4. Set the Extent Expansion to 50%
5. Hit Prepare Data
6. Move to the second tab. Upload the FVS output files containing results for the treatment and impact area.
    - Upload two files, one treatment and one impact area. The MgmtID field in each must contain the labels defined in Sections B and C (e.g. BSNF, IANF), with PotFire and StrClass columns. Must have "IA" or "treatment" in the file name.
7. Select the year in which wildfire will be modeled (five years after first treatment)
8. Prepare Landscape Inputs
    - Leave the fuel moisture values as they are
9. Run Randig for Control and Treatment
    - This may take a few minutes. Be patient and wait until results figures appear.
10. In Analysis tab, select Run Analysis. Then download the table of results.

Forest Conservation Procedure

There are two types of Forest Conservation projects: Avoided Conversion Easements and Forest Management Easements. For Avoided Conversion, FVS is run in the easement scenario. For Forest Management Easements, FVS is run in both the easement scenario and the baseline (counterfactual) scenario.

A. Steps to run Forest Conservation QM

1. Refer to Table 1 to identify the data and scripts required. Download and install or unzip each item.
2. Open the Forest Restoration & Management **Calculator Tool** excel file and populate the green cells with project information.
3. Customize the file paths and End of Project year in Scripts 1, 2, and 3 from *https://github.com/arb-ca/ForestHealthQM/R-code*
4. Run Scripts 1 and 2
5. Open **FVS software** and run simulations for the project (easement) scenario.
    - See section *B. Forest Conservation FVS Procedure* below for step-by-step FVS instructions
6. If the easement is a Forest Management Easement, run FVS for the baseline scenario.
7. Configure Script 3 for each of the FVS output files
    - Replace the file paths and directory locations at the start of the script to match the FVS output
    - Adjust `area_ac` to match your planned reforestation acreage
    - Set `end_yr` to match End of Project in the Calculator Tool.
8. Run Script 3
9. Return to the Forest Restoration & Management **Calculator Tool** excel file and populate the yellow cells with results from Script 5

B. Forest Conservation FVS Procedure

1. Start a new project
2. Upload the FVS input file generated from Script 2 into FVS
    - These files will be located in the folder "FVS_Input" and will follow the naming convention "FVS_input_" + project_ID + TCN
        - Example: `FVS_input_8GG24601_3.3.xlsx`
3. Add all stands
4. Configure for all runs

- Set `Time` and `CarbCalc` variables according to Table 2, leaving other values as defaults
- Add natural regeneration
    - Under Editor, upload the regeneration file for the project's FVS variant
        - E.g. `Regen_SpeciesMethod_NC.kcp`
    - Save in run

5. Under `Select outputs`, choose `Carbon and fuels`
6. Configure for project (easement) scenario
    - The FVS keywords used in this step depend on the specifics of the parcel and should reflect the most likely forest management practices over the entire project duration if an easement is placed on the parcel. Refer to FVS documentation to find the keywords that best represent your project. If the project is an Avoided Conversion Easement and no forest management is planned, no additional keywords are needed.
7. Rename as PRFC (Project Forest Conservation) and title the MgmtID as PRFC, then Run
8. If the project is a Forest Management Easement, configure and run for NPFC (No Project Forest Conservation)
    - Duplicate the PRFC run and rename as NPFC
    - Add management keywords that reflect the most likely forest management activities throughout the 50-80-year project duration if no easement is placed on the parcel. Refer to FVS documentation to find the keywords that best represent your location.
    - Rename MgmtID to "NPFC" and **Run**
9. Download FVS outputs in the `View Outputs` tab
    - Under `Load`, select both runs and then select `FVS_Carbon` and move to `Explore`
        - Select all stands and all years
        - Select `MgmtID`, `StandID`, `Year`, `Aboveground_Total_Live`, `Belowground_Live`, and `Total_Removed_Carbon`
        - Download

Biomass Utilization Procedure

A. Steps to run Biomass Utilization QM

The procedure for running the Biomass Utilization portion of the QM is the simplest of all activity types. No tools or scripts are required other than the calculator tool. The biomass utilized from reforestation, pest management, or fuels reduction activities are inputted in the Calculator Tool, along with the types of wood products that will be created with the biomass. The benefits from Forest Conservation biomass utilization are calculated automatically based on inputs in the easement tab(s).

1. Open the Forest Restoration & Management **Calculator Tool** excel file and populate the green cells with project information.
2. Fill in the appropriate mill efficiency based on site-specific information, if available, or Table 5.

Notes on inputs to the Biomass Utilization section of the Calculator Tool:

1. Cell E16: "Biomass to be removed from the project area as part of implementing reforestation, pest management, or fuels reduction activities and delivered to a mill, with and without the current project (BDT)"

   Note: This includes biomass that will be removed both with or without funding for the current project. This does not include biomass removal as part of Conservation Easements.

2. Cells E40-42: "Biomass that would be removed and open pile burned without project (BDT)," "Biomass that would be removed and landfilled without project (BDT)," "Biomass that would be removed and left to decay on-site without project (BDT)"

   Note: Avoided disposal emissions are only included for projects that involve the utilization of biomass that would otherwise be removed from the forest, but the removal was not part of the project being modeled – in other words, the counterfactual must be forest treatments that result in woody biomass waste accumulating in the forest or at roadside landing sites. The values in cells E40-42 should not include material that would only require disposal because of the project.

IV. Definitions

Fuels Reduction Activity Types

- **Mastication**: Pulverizing vegetation down to ground level using a masticator.
- **Prescribed Broadcast Burning**: Prescribed burning where fire is applied to the majority or entire area within a well-defined boundary for reduction of fuel hazard, as a resource management treatment, or both.
- **Thinning from Below**: Cutting trees to reduce stocking or fuel loading, including pre-commercial thinning.
- **Pile Burning**: Burning of piled material including hand and machine piles.
- **Other**: Please provide specific information including explanation of why this does not fit within the activities listed.
- **Biomass Removal**: Biomass (tree limbs, tops, and woody material) removed from the site by manual or mechanical means. For the purposes of this Quantification Methodology, "biomass" refers to both merchantable timber and woody waste material.

Reforestation Activity Types

- **Site Preparation**: The removal or alterations of fuels or ground material to prepare for reforestation. Includes constructing piles, soil ripping, etc.
- **Herbicide treatment**: Application of herbicide to target and kill undesirable plants prior to planting.
- **Planting**: The establishment or re-establishment of forest cover artificially by planting seedlings and/or cuttings with or without site preparation.

Boundary definitions

- **Treatment boundary**: the geographic area in which forest treatments will occur. The treatment boundary applies to all activity types.
- **Impact boundary:** the geographic area beyond a pest management or fuels reduction treatment boundary where the treatments reduce the risk of future carbon stock loss. Treatment boundaries are not included in impact boundaries.
    - The impact boundary of a pest management activity is the overall project site (i.e., the external boundary that encompasses all project treatments).
    - The impact boundary of a fuels reduction activity, sometimes referred to as the shadow effect, is the area in which fuel reduction activities are intended to protect by modifying fire behavior or likelihood of fire. Applicants can

determine the impact boundary based on modeled or observed fire behavior.

Other definitions

- **Site Productivity Class**: a code indicating the classification of forest land in terms of inherent capacity to grow crops of industrial wood. For more information, see Section E.

V. Reference Tables

Project Lifespan

Project Lifespan depends on the Site Productivity Class, as shown Table 8.

Table 8. Project lifespans by Site Productivity Class

Forest Practice Site Class	Project Lifespan
I	50 Years
II	60 Years
III	60 Years
IV	80 Years
V	80 Years

Note: If the treatment takes multiple years (e.g. thin/pile/burn), Project Lifespan begins when first treatment component occurs. For example, if thinning occurs in 2027 and pile burning occurs in 2028 and site class is I, the project ends in 2077.

Site Productivity Class

- Site Productivity Class is a code indicating the classification of forest land in terms of inherent capacity to grow crops of industrial wood.
- The best reference for Forest Productivity Site Class is Article 4 of the California Forest Practice Rules, which includes the guide in Table 9.
- If your project does not fall within the forest types included in the California Forest Practice Rules, you may use the site class reference in the FIA Database User Guide, which identifies the potential growth in cubic feet/acre/year and is based on the culmination of mean annual increment of fully stocked natural stands.

Table 9. Forest Productivity Site Class guide from the California Forest Practice Rules

	Young Growth Redwood		Douglas Fir		Ponderosa Pine, Jeffery Pine, Mixed Conifer & True Fir			
	Site Index[3]		Site Index		Site Index		Site Index[4]	
Site Class	feet@ 100yrs.	meters@ 100yrs.	feet@ 100yrs.	meters@ 100yrs.	feet@ 100yrs.	meters@ 100yrs.	feet@ 300yrs.	meters@ 300yrs.
I	180 or more	54.86 or more	194 or more	59.12 or more	114 or more	35.11 or more	163 or more	49.68 or more
II	155–179	47.24–54.56	164–193	49.99–58.83	93–113	28.35–34.44	138–162	42.06–49.38
III	130–154	39.62–46.94	134–163	40.84–49.68	75–92	22.86–28.04	113–137	24.44–41.76
IV	105–129	32.00–39.32	103–133	31.39–40.54	60–74	18.29–22.56	88–112	26.82–34.14
V	Less than 105	Less than 32.00	Less than 103	Less than 31.39	Less than 60	Less than 18.29	Less than 88	Less than 26.82

[3] Average total height in feet and meters of dominant trees at 100 years of age
[4] Average total height in feet and meters of dominant trees at 300 years of age

VI. References

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