

California Air Resources Board

Quantification Methodology **Guide for Project Proponents**

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 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](#).

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Section A. 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 must 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 CAL FIRE 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 Forest Health Grant Program, Wildfire Prevention Grant Program, Forest Legacy, and others. This methodology estimates carbon sequestration from reforestation, avoided losses from pest management, and avoided wildfire emissions from fuel reduction treatments and wood utilization.

The QM for Forest Restoration and Management (FRM) requires geospatial analysis and specialized forest modeling software. Most project proponents will not perform the QM themselves but will instead submit project information and shapefiles for State staff to estimate GHG benefits on their behalf. This document is intended for use by project proponents. It provides instructions for submitting project information and a summary of the QM. For more detailed methods and equations, please see the [Technical Documentation](#).

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
- 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 the CAL FIRE 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.

Section B. Project Types

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, for a project to use this QM, it must include at least one of the following project activity types. For definitions of individual activities, see Section E.

Reforestation: Work conducted to promote the reforestation of understocked forestland and areas burned by wildfire to increase carbon sequestration and rebuild natural habitats and ecosystems. Planting should establish a diverse, native forest, which will result in stable carbon sequestration and storage, improved watershed and habitat functions, and forest resilience.

Pest Management: Work conducted in an area where the primary objective is to address pest control and related forest health improvement, while reducing pest-related mortality, improving tree growth and vigor, stabilizing carbon retained in trees, and increasing forest resilience.

Fuels Reduction: Work conducted in an area where the primary objective is to reduce fuel loads. Work should be focused on treating understory trees and brush with the goals of reducing fire hazards, improving tree growth, stabilizing carbon in retained trees, and increasing forest resilience. There are five types of fuel reduction modeled in the QM:

1. Mastication
2. Prescribed Fire
3. Thinning From Below
4. Pile Burning
5. Other

Biomass Utilization: Work conducted in an area where the primary objective is to utilize woody biomass for wood products, and/or generate energy through combustion or gasification, and/or utilize woody biomass to help develop markets for beneficial uses of the material.

Forest Conservation: Purchases of conservation easements or fee title of forest lands to encourage long-term conservation of working forest landscapes.

Section C. Instructions for Project Proponents

Project proponents are required to provide State staff with project details necessary for the QM, including: 1) geospatial data and 2) activity information. Geospatial data are provided as shapefiles, with one shapefile for each unique activity polygon. Please work with your CAL FIRE program representative for instructions on submitting shapefiles. Activity information is submitted through the [FRM QM Online Submission Form](#).

Steps for submitting information necessary for the QM

1. Categorize each planned treatment activity into Reforestation, Fuels Reduction, Pest Management, or Forest Conservation (see Section B). Determine whether any of those activities will be accompanied by biomass utilization. For each Fuels Reduction treatment, further categorize activities as Mastication, Prescribed Fire, Thinning from Below, Pile Burning, or Other.

2. Generate Treatment Component Numbers.

If your project is part of a CAL FIRE Forest Health Grant, complete the Project Workbook. This will generate Treatment Component Numbers (TCNs) that are required for Steps 3-6.

If you are not a Forest Health grantee or applicant, assign each treatment activity a TCN. Obtain a shapefile for each TCN. Create a field in the attribute table of each shapefile called "TCN" that contains the TCN associated with that activity.

For more information about TCNs, see the guidance document at the [Forest Health Grantee Resources page](#).

3. Submit shapefiles.

If you are affiliated with a CAL FIRE program, follow the shapefile submission guidelines provided by the CAL FIRE program. If you are unsure who your CAL FIRE program representative is, please visit the program website.

If you are not affiliated with a CAL FIRE program, the Online Submission Form will prompt you to share shapefiles via a Google Drive folder, Box folder, or similar. Add links to shared files into the form directly for each activity when prompted. Set the shared folder settings to allow downloads by anyone with the link.

4. Complete the [FRM QM Online Submission Form](#).

5. If necessary, complete the [Supplementary FRM QM Online Submission Form](#). This is for projects with more than four Fuels Reduction activities.
6. A CARB or CAL FIRE representative will contact you with the results of the QM within 2-4 weeks.

Frequently Asked Questions for completing the FRM QM Submission Form

This section contains answers to common questions regarding the online form. If you need help completing the online form, please contact ForestQM@arb.ca.gov.

1. How do I know which Forest Productivity Site Class to choose?

Productivity Site 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](#). 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 Forest Inventory and Analysis (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.

If you are not sure what Site Class to choose, select “I don’t know” on the form and State staff will make a determination.

2. What if my project involves multiple activities in the same area, such as thin, pile, and burn, or masticate and then burn?

Please report each individual activity separately on the FRM QM Online Submission Form. For example, if you plan to masticate and then broadcast burn, there will be a TCN for mastication and another TCN for broadcast burning. When completing the form, enter each activity separately – e.g., Mastication will be entered under Fuels Reduction Activity 1 and Broadcast Burn will be entered under Fuels Reduction Activity 2.

The exceptions are reforestation and pile burning. Site preparation for reforestation is listed as a separate activity on the Project Workbook but is combined with reforestation in the form. Likewise, pile burning contains two entries in the Project Workbook, Piling and Pile Burning, but only requires one entry in the Form. This is because the QM models Piling and Pile Burning as one activity.

In the question “Is this treatment linked to another closely related treatment in the same location?”, enter the TCNs of related treatments that will occur on the same land area, whether or not they have their own entries in the online form.

For example, if you plan to thin, pile, and burn the same area, each of those three activities will be assigned a unique TCN in the Project Workbook – e.g., 2.1, 2.2, and 2.3. When completing the Form, enter the thin/pile/burn as two activities: Thin from Below (2.1) and Pile Burning (2.3). When entering information about 2.1, list 2.2 and 2.3 as “closely related treatments” and do the same for 2.2 and 2.3. See Table 1 for an example. State staff will ensure that the QM modeling reflects the compounding benefits of related treatments.

Table 1. Treatment Examples

Treatment combination	Project Workbook	Section in the online form	Is this treatment linked to another closely related treatment in the same location?
Mastication followed by broadcast burn	TCN 1.1 Mastication	Fuels Reduction Activity 1	1.2
	TCN 1.2 Broadcast Burning	Fuels Reduction Activity 2	1.1
Thinning followed by piling and burning	TCN 2.1 Thinning (Manual)	Fuels Reduction Activity 3	2.2, 2.3
	TCN 2.2 Piling (Manual)	Fuels Reduction Activity 4 (TCN listed as 2.3)	2.1, 2.3
	TCN 2.3 Pile Burning	Fuels Reduction Activity 4	2.1, 2.2

3. How do I decide whether my treatments are Pest Management or Fuels Reduction?

The management actions within Pest Management and Fuels Reduction treatments can look similar. For example, both treatment types may involve thinning, piling, and burning woody material. To determine which project type to use, consider the primary objective of the treatments. If trees are being targeted for removal due to their susceptibility to pest infestation, choose Pest Management, even if the activities

performed are listed as Fuels Reduction activity types. If trees and shrubs are instead being targeted because of they pose hazards as ladder fuels for wildfire, choose Fuels Reduction.

4. What if my project includes different activity types (e.g. pest management and fuel reduction) that overlap?

When treatment polygons overlap, State staff will calculate GHG benefits for only one treatment type in the overlapping area. Table 2 is used to identify which treatment type the overlapping area is apportioned to.

Table 2. 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

Section D. Methods overview

General Approach

The 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. The Forest Vegetation Simulator (FVS) is used to model forest growth and treatments, and the FVS outputs are entered into the Calculator Tool. General method summaries are provided below. For more detailed equations and methods for each activity type, see [Technical Documentation](#).

A. Reforestation

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. Pest Management

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.

6. The difference between the baseline and treatment scenario equals the GHG benefit of the project.

C. Fuels Reduction

Fuels Reduction
Net GHG Benefit = Δ in standing live tree carbon stocks (above and belowground) in the treatment boundary and impact boundary (optional) 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.

D. Forest Conservation

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.

E. Biomass Utilization

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.

Section E. 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.

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 C.