How to use the ‘Berkeley Forests’ Carbon Calculator for a timber harvest plan

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**Relevant issue in the CEQA guidelines and how it translates for a THP**

In 2010, the California Environmental Quality Act (“CEQA”) Guidelines were amended to require lead agencies to assess any new project’s effects on greenhouse gas emissions ([California Code of Regulations 2014](#_ENREF_3)). The need was reaffirmed with respect to timber harvest plans when AB 1504 (2010) amended Section 4513 of the Public Resources Code to include carbon sequestration in the values that must be considered when timberlands are managed with the “goal of maximum sustained production of high-quality timber products.” In 2010, Calfire provided an optional tool and methodology to do the calculations ([Anonymous 2010](#_ENREF_1)). It is up to the Registered Professional Forester (RPF) to decide what tools to use to provide an accurate response.

**What is the project? What is the no-project alternative?**

All forest management scenarios have more carbon sequestration than a ‘no forest’ conversion project. Some managed forest properties are still building up inventories to achieve levels that will allow them to maintain a productive balance of harvest and growth. These properties would not need a detailed analysis that includes the life cycle of wood products since they meet the first order definition of providing increasing carbon storage in their forests (the opposite of greenhouse gas emissions).

Figure 1. Comparison of carbon sequestration of 3 projects: No forest (~0 Carbon/hectare), Let-grow forest, and managed forest

Other properties may not have achieved what they consider to be an inventory level that will provide for a sustainable balance of harvest and growth. Such properties can not simply document growing inventories across the ownership as proof of their net positive situation regarding greenhouse gas emissions. Figure 1 illustrates a full accounting of a California mixed conifer forest over a long time frame. Let-grow forests will produce net climate benefits but not as much as a managed forest if the harvested products are used efficiently. A let-grow forest will also not produce sufficient revenue to cover management and protection costs. As a simple benchmark, the USFS annually spends an average of $25/acre across each of their roughly 20 million acres of forest land they manage in California. Private forests, on the other hand, get no state or federal funds and pay both property taxes and yield taxes. The take home message is that a well-managed forest will create even more carbon sequestration than a let-grow forest when the wood products are efficiently used as they are for best management practices in most, but not all, cases in California.

**What the forest landowner provides in terms of current and future climate benefits**

Forests maintain high levels of net carbon sequestration when they have growing forests with limited mortality. When forest landowners harvest trees, the carbon that had been sequestered in the trees is transferred into wood products AND the now open site has a regenerating forest. Forest landowners have to follow detailed best management practices (BMPs) codified in California’s forest practice regulations regarding their forest and related resources. On the other hand, consumers of wood products or their substitutes such as cement, natural gas, and plastics) do not have to follow any BMPs with respect to global climate benefits and can choose the cheapest products or inefficiently use products and energy. California’s leadership in clean water and air regulations, the initial development of wood-fired energy plants, and landfill reduction guidelines have resulted in longer life times of wood products ([Stewart and Nakamura 2012](#_ENREF_11)) compared to the most commonly used national tables of estimates in ([Smith 2006](#_ENREF_10)). For the tool we developed for current timber harvest plans, we use the most current California-based estimates rather than national estimates based on poorly documented historical sources.

**How the ‘Berkeley Forests’ Carbon Calculator for THPs spreadsheet model works**

The goal of the model is to use empirically based published values based on the best available statewide data sets. This avoids the need for timber harvest plan submitters to translate between various business (e. g. board foot measurements of standing forest volume refer only to the eventual volume of sawn lumber) and scientific units of analysis (total measurements in tonnes can refer to various combinations of bone dry biomass or pure carbon in live trees, dead trees, roots and soil carbon). In addition, submitters of timber harvest plans do not collect information or have any control over how consumers use and dispose of wood products, or what non-renewable products they substituted for.

 The basic principle used here is to model a growing/harvested/regenerated forest over the long cycle necessary to ensure sustainability. We assumed that the long-term average for one acre of forest is mathematically similar to the yearly average over a whole ownership. Since the ‘greenhouse gas emission/carbon sequestration’ component is only one aspect of a CEQA project or the THP equivalent, a synthesis of known patterns in the relevant forest type can provide more useful information than plugging estimates into spreadsheet models of unknown accuracy.

**Steps:** The scale of the positive climate benefits measured in tonnes of carbon or carbon dioxide for a THP can be estimated by 1) choosing the relevant forest type, 2) estimating the equivalent clear cut area (1 hectare = 2.47 acres) of the THP using 1:1 for even-aged regeneration acres and 0.25:1 for uneven-aged regeneration acres, and 3) and multiplying the area by the ‘MgC/ha/yr’ value in cells I10 or I11 to estimate the long term benefits of managed forestry within the THP area.



Figure 2. Relationship of forest density for private forest FIA plots in international units to common MBF/acre (Scribner) used to correlate full forest->product carbon mass balance assessments for carbon sequestration analysis.

**Product half-life and C flows:** This worksheet shows the annual loss of carbon in logging residues left in the forest, a representative basket of California produced wood products, and post-consumer carbon in wood products as they are used for energy, deposited in engineered landfills, or left as uncollected waste ([Stewart and Nakamura 2012](#_ENREF_11)). The references used to develop the annual time step estimates are shown in the notes. The half-life representation of wood products still in use is more realistic than many of the dichotomous ‘yes/no’ carbon storage estimates that are based on conjecture rather than long term data. Any of these coefficients can be changed if the authors have more accurate data.

**Mixed conifer:** The first forest type is the most extensive of the four forest types in California. Each forest type has the same format with the specific values driven by the FIA plot based growth model based on ‘COLE: Carbon On Line Estimator’ ([Van Deusen and Heath 2014](#_ENREF_12)) that can be accessed at www.ncasi2.org/COLE/. The ‘let-grow’ scenario is based on all FIA plots and the regenerated forests are based on the subset of private plots that captures the higher level of management used on private lands. The ‘scenario’ tables summarize the values in the annual time step charts at the bottom of the sheet. They separate out some of the sub-sectors of the forest and wood products that are often used as comparisons.

The spreadsheet uses conservation of mass principle to track the carbon in both the let-grow forest scenario as well as the harvest/regenerate scenario. All harvested products (not just the wood volume that goes into lumber) are tracked. The first set of color-coded columns represent the first harvest and regeneration cycle. The second set of columns represent the second harvest and the final set of columns combine the ‘long tail’ of benefits from the first harvest and the second harvest.

The model tracks logging slash that is left on site to decompose ([Harmon, Krankina et al. 2001](#_ENREF_4)) as well as the material that is collected and used for bioenergy ([Mayhead and Tittmann 2012](#_ENREF_6)). The default estimate that 75% collection of logging residues (mainly tops and branches) is lower than the 95% estimated by operators in Stewart and Nakamura (2012) and higher than the national estimate of 60% used in the 2010 RPA Assessment ([Ince, Kramp et al. 2011](#_ENREF_5)). An estimate of the fossil fuel energy used in the harvest, 3% of the energy in the harvested wood, ([Wihersaari 2005](#_ENREF_13)) is subtracted at the point of harvest. The allocation of input wood on the sawlogs to energy, wood products and waste (<1%) is based on ([Morgan, Brandt et al. 2012](#_ENREF_7)). The 1:1 substitution benefit for solid wood products used in buildings is only applied to the 66% of products that are solid (as opposed to chip based) wood products ([Sathre and O'Connor 2010](#_ENREF_8)). As wood products are thrown away by the first consumer, we track the carbon life cycle based on the estimates in the ‘Product half-life and C flows’ tables based on ([Skog 2008](#_ENREF_9) ). The second harvest and regeneration cycle continues while still tracking the carbon that remains from the first cycle. The long-term additive benefits of the efficient use of carbon embodied in products or used for energy is clear as the second rotation has even a higher total. No account is taken for technological improvements in forest management, sawmill efficiencies, or the regulation of waste in the consumer sector as this analysis over time is used as a proxy for a yearly analysis over an ownership.

 Both the managed and let-grow approaches both provide considerably more climate benefits than alternative land uses such as residential land use, grazing lands, or fire burned areas with only grass and shrub regeneration. It is important to point out the large fraction of climate benefits from the managed forest scenario depend on tracking the wood used for energy and the wood stored in landfills. The estimates used here assume that BMPs will be followed in the consumer sector.

**Ponderosa pine:** Ponderosa pine forests typically have less precipitation and lower site quality. Forest volume growth is slower and levels off more noticeably. Losses from fires, bark beetles are more significant.

**Douglas-fir:** Douglas-fir forest types generally have more precipitation and more growing days than mixed conifer forests.

**Redwood:** Redwood forests have the best growing conditions and exhibit rapid growth with limited evidence of leveling off of annual growth rates.

**Comparison** This table compares the estimated total carbon benefits using BMPs for both forest management and consumer use of product management, coefficients from the USFS publication GTR NE 343 that is the basis for many assessments, and an approach that seems to match the compliance offset protocol U.S. Forest Offset Projects ([California Air Resources Board 2013](#_ENREF_2)) that only counts carbon in forests or in long lived wood products for ARB certified offsets.

Table 1: Estimated Carbon Storage per hectare based on COLE2 and ‘Berkeley Forests’ Carbon Calculator for THPs’ model in MgC per hectare per year

|  |  |  |  |
| --- | --- | --- | --- |
| Accounting Framework  | MgCha-1 | MgCha-1yr-1 | % of Full Benefits |
| Full Climate Benefits | 32,976 | 137 | 100% |
| GTR NE 343 Benefits Only | 21,922 | 91 | 66% |
| 2010 Calfire GHG  | 18,017 | 75 | 55% |

The exact numbers are less important than the relative differences using the same forest stands but different accounting approaches for the wood products. The use of the older GTR NE 343 coefficients for bioenergy and product half-life drops the benefits by 30% for two growth cycle scenario. The 2010 Calfire GHG calculator uses a very different setup with multiple units and is similar to the GTR NE 343 as is does not include the benefits from energy, landfill, and production substitution. The errors are smaller but still substantial for shorter time frames.

**Conclusion**

If the submitter can assume that California consumers will utilize best management practices (BMPs) with respect to the efficient use of wood products, and that they will successfully regenerate their forest to be as least as productive as current forests, then they can be justified in estimating that their THP that embodies the requirements for sustainable forestry (i.e. it does not involve a conversion permit) will generate even greater net climate benefits than the project alternatives of 1) a let-grow forest or 2) a forest conversion.

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