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SENT VIA EMAIL and OVERNIGHT MAIL

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Re: Comments on Timber Harvesting Plan: Girard (4-07-043-ELD)

Dear CAL FIRE:

The Center for Biological Diversity (“Center”) submits the following comments for the Girard Timber Harvesting Plan (“THP”), 4-07-043-ELD. The Center is a non-profit, public interest, conservation organization dedicated to the protection of native species and their habitats through applying sound science, policy and environmental law. The Center has over 40,000 members, many of whom reside in California.

THPs are subject to the California Environmental Quality Act (“CEQA”) which mandates that environmental impacts be considered and analyzed, and significant impacts then avoided and/or mitigated. *See Sierra Club v. State Bd. of Forestry*, 7 Cal. 4th 1215, 1228 (Cal. 1994) (“in approving timber harvesting plans, the [agency] must conform not only to the detailed and exhaustive provisions of the [Forest Practice] Act, but also to those provisions of CEQA from which it has not been specifically exempted”). As recently explained in *Joy Road Area Forest & Watershed Assn. v. California Dept. of Forestry & Fire Protection*, 142 Cal. App. 4th 656, 667 (Cal. App. 1st Dist. 2006):

The THP is an informational document designed to serve as an ‘abbreviated’ [EIR], setting forth proposed measures to mitigate the logging operation’s potential adverse impact on the environment. CDF and public review of the THP prior to approval is intended to ensure that the adverse environmental effects are substantially lessened, particularly by the exploration of feasible less damaging alternatives to the proposed harvesting project.

As this court has held in the past, CEQA and the Forest Practice Act are not in conflict, but rather supplement each other and, therefore, must be harmonized. Indeed, courts have long recognized the well-defined relationship between the Forest Practice Act and CEQA.

The Girard THP, which includes 364 acres of clear-cut logging,¹ fails to meet the requirements of CEQA because it ignores the project's impacts on global warming. In recent guidance on analyzing greenhouse gas emissions under CEQA, the Office of Planning and Research (OPR) clearly stated that the greenhouse gas emissions resulting from a project must be quantified, and the significance of the emissions determined.² Nonetheless, the Girard THP fails to: 1) quantify the direct and indirect greenhouse gas emissions resulting from the project; 2) assess whether the emissions are individually or cumulatively significant; and 3) consider mitigation and alternatives.

As explained below, the global warming impacts associated with logging are indeed cumulatively significant. The Girard THP must be revised to address these impacts, and if the revised THP determines the effect of the harvest on global warming is significant, the applicant must fully mitigate the effect. Until the issue is adequately addressed and the THP re-circulated for comments, the proposed harvest is unlawful.

I. BACKGROUND: FOREST ECOSYSTEMS ARE CARBON SINKS THAT CAN PROVIDE A SIGNIFICANT CONTRIBUTION TO CARBON STORAGE AND SEQUESTRATION

A. Carbon Forest Basics

Forests play an important role in reducing the amount of carbon dioxide in the atmosphere. During photosynthesis, trees “breathe in” carbon dioxide and “breathe out” pure oxygen. Through this process, forests remove massive amounts of carbon dioxide from the atmosphere each year.

Forest ecosystems also serve as banks that store carbon for finite periods of time; thus, in a natural state, and/or if managed well, they are carbon sinks and not sources (Tans et al. 1990). Carbon is added to the bank regularly through photosynthesis, which removes carbon dioxide from the atmosphere and stores the carbon contained therein in the organic matter of the forest.

Forest ecosystems are complex, and include not only living and dead trees but understory vegetation, and soil. Each of these elements contains carbon. For example, Turner et al. (1995)

¹ Referred to in the THP at page 84 as “an alternative prescription most closely associated with the clearcutting method, but which retains significant structural components on the unit to provide for visual mitigation.”

² Governor's Office of Planning and Research, Technical Advisory, CEQA And Climate Change: Addressing Climate Change Through California Environmental Quality Act (CEQA) Review (2008) (“OPR Technical Advisory”).

estimated that forests in the coterminous United States contain 36.7 Pg³ of carbon *with half of that in the soil*, one-third in trees, 10% in woody debris, 6% in the forest floor, and 1% in the understory. The location of forest carbon is important because it helps determine how much carbon remains in storage or is lost after disturbances like logging.

B. U.S. Forests Store and Remove Carbon from the Atmosphere

Changes in land use and forestry practices can emit carbon dioxide (e.g., through conversion of forest land to agricultural or urban use, or through logging) or can act as a sink for carbon dioxide (e.g., through net additions to forest biomass). Regardless of the exact number, it is clear that if forests are protected and allowed to flourish they have the potential to store and sequester a significant amount of carbon. Evidence abounds on this topic. For example:

- It is estimated that from 1952-1993, carbon storage in American forests increased by 38% (Birdsey et al. 1993). The authors hypothesize that this may be due to biomass accumulation in temperate forests over the time period.
- Birdsey and Heath (1995) estimated that in 1995 the United States contained 298 million hectares of forests, which stored 54.6 billion metric tons of organic carbon above and below the ground. This amounted to *five percent of all the carbon stored in the world's forests*.
- Pacala et al. (2001) estimated that the coterminous United States was an annual carbon sink of between 0.3 and 0.58 Pg of carbon annually, with half of the storage occurring in forest ecosystems.
- Land use, land-use change, and forestry activities in 2006, resulted in a net carbon sequestration of 883.7 Tg CO₂ e, with 745 Tg of this coming from forest land that was allowed to remain as forest land. Forests (including vegetation, soils, and harvested wood) accounted for approximately 84 percent of total 2006 net CO₂ flux (EPA 2008). Overall in 2006, these activities represent an offset of approximately 14.8 percent of total U.S. CO₂ emissions, or 12.5 percent of total greenhouse gas emissions in 2006 (EPA 2008).
- Between 1990 and 2006, total land use, land-use change, and forestry net carbon flux resulted in a 20 percent increase in CO₂ sequestration, primarily due to an increase in the rate of net carbon accumulation in forest carbon stocks, particularly in aboveground and belowground tree biomass (EPA 2008). The net forest sequestration is a result of net forest growth and increasing forest area, as well as a net accumulation of carbon stocks in harvested wood pools.
- Peters et al. (2007) concluded that North American ecosystems remove 0.65 Pg C/year, offsetting one-third of the 1.85 Pg carbon emissions. Forests account for the majority of this uptake.

³ Pg [petagram]=one billion metric tonnes=1000 x one billion kg

C. Forest Management and Timber Harvest Activities Can Release Carbon Stores

Certain forest management actions, and timber harvest in particular, allow stored carbon to be released into the atmosphere. Thus, in addition to affecting habitat, these anthropogenic activities serve as a withdrawal from the forest carbon bank: carbon is removed from long-term storage and released to the atmosphere, exacerbating global warming and climate change.

Sohngen and Sedjo (2000) estimated that private timberlands in North America stored 46 Tg of carbon/year but released an average of 43 Tg carbon/year from 1995-2005, resulting in a net storage of only three Tg carbon/year. Similarly, other researchers have found large proportions of sequestered carbon are quickly released on private forests (Birdsey et al. 1993; Turner et al. 1995). This can be largely attributed to a difference in management styles as industrialized forests typically put an even greater priority and focus on logging and tree harvesting.

Evidence shows that the carbon dioxide releases from logging can be substantial. In a letter to the California Air Resources Board regarding California Climate Action Registry Forest Protocols, Harmon (2007) wrote:

Timber harvest, clear cutting in particular, removes more carbon from the forest than any other disturbance (including fire). The result is that harvesting forests generally reduces carbon stores and results in a net release of carbon to the atmosphere.

Modeling exercises predict that the amount of carbon sequestered by timberlands in the United States is decreasing. For example, Turner et al. (1995b) found that while U.S. forests sequestered carbon at a rate of 80 Tg yr⁻¹ in the 1990s, these same forests will come close to carbon equilibrium by the 2030s. They state that the most important factor in the declining strength of the forest land base sink is a relatively large increase in harvest levels.

Turner et al. (1995b) predict a rise in average tree growth on private timberland in the U.S. from 204 g m⁻² yr⁻¹ in the 1990s to 229 g m⁻² yr⁻¹ in the 2030s (or from 258 to 293 Tg yr⁻¹). However, this will be offset because the harvest level rises much faster, with tree carbon removals on private timberland increasing by 85 Tg yr⁻¹ over the 50 year scenario. Private timberland begins losing carbon midway through the scenario causing forests to transform from sinks to sources largely due to the loss of trees to logging.

In this same study, however, increases in carbon sequestration up to 15 Tg per year were found when alternative forest policy options were adopted, such as increased afforestation and practices related to increase paper recycling (Turner et al. 1995b). These researchers state that the current forest land base acts to currently offset 6% of U.S. fossil carbon emissions but that proportion is likely to decrease over the coming decades unless changes are made in logging practices and land management (Turner et al. 1995b).

This is especially alarming because conservative estimates project a steady 1 to 2 % increase of fossil carbon emissions for the United States per year. At the same time, the carbon sink associated with the forest land base is projected to decrease (Turner et al. 1995b). Thus, the carbon sink associated with the forest sector in the United States will offset a decreasing

proportion of national fossil carbon emissions over the coming years unless changes in logging practices and land-use management are made.

The total land area of the United States is 765.5×10^6 hectares, of which 200.7×10^6 is timberland (Turner et al. 1995). Depending on how it is treated, all of this timberland has the potential to act as a “sink,” removing and storing carbon dioxide, or a “source” that releases carbon dioxide into the atmosphere. Turner et al. (1995) estimate annual uptake on United States forests at 331 Tg, but stated *that they were largely balanced (266 Tg) by annual losses from logging and decay.*

Turner et al. (1995) suggest that in light of climate change and further disturbance, we need to pay close attention to harvest sizes and trends due to the fact that:

In the U.S., projections call for a 5% loss in the private timberland area by the year 2040 (Alig et al. 1990). A general intensification of forest management, resulting in lower carbon storage per unit area (Cooper 1983, Dewar 1991), and a gradual increase in the harvest level (Haynes 1990), are also expected. These factors will tend to mitigate against a stable or increasing carbon sink (Turner et al. 1993). Increasing temperatures, atmospheric CO₂, and nitrogen deposition could promote higher growth rates (McGuire et al. 1993), but projected climate change is also likely to produce a transient release of forest carbon because carbon sources associated with increasing disturbance rates would be greater than carbon sinks associated with land recovering from disturbance (King and Neilson 1992).

Clearly, land management, and specifically forest management, plays a major role in the global carbon balance. How California chooses to manage its forests – including private forests – has a significant effect on how much carbon dioxide is released and stored. If we are to maintain public and private forests as carbon sinks, which is now more important than ever, continued cumulative disturbance from logging must be reduced.

II. THE THP MUST ADEQUATELY ADDRESS ITS IMPACT ON GREENHOUSE GAS EMISSIONS AND CARBON STORAGE

A. Logging, Especially Clear-Cutting,⁴ Reduces a Forest’s Ability To Sequester Carbon

Studies show that logging can remove ninety-five percent of the non-soil carbon stored in a forest ecosystem and half of this is lost to the atmosphere in the first year (Janisch and Harmon 2002).⁵ Skog and Nicholson (2000) reconstructed the fate of forest carbon in the United States from 1910 to 2000. They found that 71 % of the carbon harvested during that period was

⁴ The term clear-cutting as used here refers to any even-aged harvest method such as visual retention cuts, referred to in the Girard THP as “Alternative Prescription” (Girard THP, page 84).

⁵ Many of the examples and studies cited throughout this paper hail from the Pacific Northwest and/or ecosystems other than the Sierra Nevada. These studies provide the best available information on these topics in the absence of similar studies specific to the Sierra Nevada region.

released into the atmosphere while only 17% was stored in wood products and the remaining 12% was added to landfills.

After a human disturbance such as a clear cut harvest, ecosystems are a source of carbon to the atmosphere because of the decomposition of large woody debris and other forms of detritus. Later in stand development, as tree bole volume rapidly accumulates, forest ecosystems are strong carbon sinks.

Turner et al. (1995b)

Studies of various ecosystems ranging from the Douglas-fir and hemlock communities common to the Pacific Northwest to forests of northwestern Russia characterized by southern taiga vegetation have all resulted in the same conclusion: clear-cutting (or associated techniques such as “visual retention” silviculture) does not increase or maximize stored forest carbon or sequestration ability (e.g., Harmon et al. 1990; Krankina et al. 2004). Depro et al. (2008) modeled forests of all types in all regions of the United States. They found that “[i]n contrast with the no-harvest scenario, increasing the baseline harvest levels to pre-1989 levels leads to a significant decrease in the carbon sequestered in public forests. Our estimates suggest losses ranging from 27 to 35 MMTC per year through carbon storage in wood and paper products.”

A recent EIR conducted for California’s Jackson State Forest pointed out that even-aged management (i.e., clear-cutting) is not the appropriate tool for dealing with climate change:

Brown et al. (2004a) estimated the carbon benefits of an uneven-aged management, group selection harvest regime as compared to an even-aged management, clear-cut harvest regime on JDSF. They found that use of group selection (1.5-acre group size) instead of clear-cuts (20 acres in size) resulted in an increase in carbon storage of 14-27 tons per hectare (5.7-10.9 tons/acre) over a 90-year rotation.

In general, harvesting trees greatly impacts climate change; clear-cutting is particularly detrimental because it releases more carbon than any other disturbance including fire (Harmon 2007). When describing harvesting and clear-cutting, Harmon (2007) states: “the result is that harvesting forests generally reduces carbon stores and results in a net release of carbon to the atmosphere.”

The impacts of carbon release also occur from logging forests that have previously been logged. Mackey et al (2008) state:

The remaining intact natural forests constitute a significant standing stock of carbon that should be protected from carbon-emitting land-use activities. There is substantial potential for carbon sequestration in forest areas that have been logged commercially, if allowed to re-grow undisturbed by further intensive human land-use activities.

There are important distinctions between the carbon dynamics of natural forests and industrialized forests, especially monoculture plantations. Most of the biomass carbon in natural forests is stored in the larger, older trees; however, commercial logging removes most of these trees, leaving stands with much younger average ages. As a result, logged forests have a

significantly reduced (more than 40 percent) long-term average standing stock of biomass carbon compared with an unlogged forest (Roxburgh et al. 2006; Brown et al. 1997). In a study of temperate forests in Australia, Roxburgh et al (2006) found that “forests recovering from prior logging have the potential to store significant amounts of carbon, with current biomass stocks estimated to be approximately 60% of their predicted carrying capacity, a value similar to those reported for northern temperate forests.” Brown et al (1997) conducted a study with similar objectives that assessed the sequestration potential for two eastern USA hardwood forests (oak-hickory and maplebeech-birch) recovering from past disturbance by estimating their above-ground biomass density and comparing the results with undisturbed forests considered to be at maximum potential carbon stock capacity. Roxburgh et al. (2006) explain their findings:

Brown, Schroeder & Birdsey (1997) demonstrated that the managed eastern hardwood forests had much lower above-ground biomass density than the old-growth forests, and generally less than 50% of the predicted CCC (carbon carrying capacity) of approximately 250 tC ha⁻¹, suggesting that through recovery and regrowth these forests have the potential to accumulate significant quantities of additional biomass, and thus sequester atmospheric carbon into the future. Although maximum CCC in the eastern USA forests is less than that reported here, the relative difference between managed and mature forests is approximately the same, at 50–60% of predicted CCC.

Industrialized forests have all of their above-ground biomass removed regularly, on a rotation ranging between every 10 to 70 years (Varmola and Delungo 2003). Thus, the carbon stock on a commercially logged forest will always be significantly less than the carbon stock of a natural, undisturbed forest (Mackey et al. 2008).

Unfortunately, specific examples of the climate costs associated with clear-cutting are plentiful. Using a model that took into account the prevalence of clear-cutting practices from 1972-1991, researchers found that forests in the Pacific Northwest released 11.8×10^{12} g C/year (Cohen et al. 1996). From this finding they calculated that even though forests in this region represented only 0.25% of the 4.1 billion hectares of forest on Earth, they were the source of 1.31% of the total land-use related carbon release in the world (Cohen et al. 1996; Dixon et al. 1994). They state:

Although replacing older forests with more vigorous young forest can increase sequestration by live carbon pools, decomposition of the large detrital pools after harvest greatly offsets gains in biomass by living pools for an extended period of time (Cohen et al. 1996).

One study speaks volumes regarding conversion of forests to plantations – the conversion to plantations of over 12 million acres of old-growth forests in western Oregon and Washington in the past 100 years has resulted in the release of 1.5 to 1.8 *billion* MG⁶ of carbon into the atmosphere (Harmon et al. 1990).

⁶ MG= megagram= 10⁶. 1 megagram = 1 metric tonne or 1000 kilograms or 2, 250 lbs.

Moreover, as pointed out in Noss (2001):

Intensification of forestry activities is often promoted on the basis that young, actively growing trees will sequester carbon more rapidly than old-growth forests in which respiration may equal or even exceed photosynthesis (Birdsey 1992). Replacement of old forests with plantations is a “perverse incentive” of the Kyoto Protocol (Brown 1998; Dudley 1998). Simplistic carbon accounting, encouraged by the protocol, ignores the tremendous releases of carbon that occur when forests are disturbed by logging and related activities such as site preparation and vegetation management (Perry 1994; Schulze et al. 2000). It ignores the fate of woody debris and soil organic carbon during forest conversion (Cooper 1983; German Advisory Council on Global Change 1998). Typically, respiration from the decomposition of dead biomass in logged forests exceeds net primary production of the regrowth (Schulze et al. 2000). Considerable time is required - often hundreds of years - for regenerating forests to accumulate the carbon stocks characteristic of primary forests (Harmon et al. 1990). Over several rotations of growth and harvest, the mean carbon pool of intensively managed forests is only about 30% that of primary forests (Cooper 1983). From the standpoint of maintaining biodiversity during climate change, conversion of natural forests to plantations cannot be justified. Tree plantations around the world, especially exotic monocultures, have less biodiversity than natural forests in the same regions (Hunter 1990; Noss & Cooperrider 1994; Perry 1994). Plantations are often markedly less resistant to disturbances such as fire and more subject to pest outbreaks than natural forests (Schowalter 1989; Perry 1994). Pest outbreaks could increase in severity or change in distribution with changing climate (Williams & Liebhold 1995), amplifying the vulnerability of plantations.

Noss (2001) also notes that clear-cutting, especially as practiced by SPI, causes significant habitat fragmentation, which has climate impacts of its own:

Fragmentation may threaten biodiversity during climate change through several mechanisms, most notably edge effects and isolation of habitat patches. Intact forests maintain a microclimate that is often appreciably different from that in large openings. When a forest is fragmented by logging or other disturbance, sunlight and wind penetrate from forest edges and create strong microclimatic gradients up to several hundred meters wide, although they may vary in severity and depth among regions and forest types (Ranney et al. 1981; Franklin & Forman 1987; Chen & Franklin 1990; Laurance 1991, 2000; Chen et al. 1992; Baker & Dillon 2000). With progressive fragmentation of a landscape, the ratio of edge to interior habitat increases, until the inertia characteristic of mature forests is broken. Fragmented forests will likely demonstrate less resistance and resilience to climate change than intact forests. Another potentially serious impact of fragmentation is its likely effect on species migration. By increasing the isolation of habitats, fragmentation is expected to interfere with the ability of species to track shifting climatic conditions over space and time. Weedy species, including many exotics, with high dispersal capacities may prosper under such conditions, whereas species with poor mobility or sensitive to dispersal barriers will fare poorly.

If the Girard THP is to meet its CEQA obligations, it must assess the significant contribution of logging, and especially clear-cutting, to carbon emissions. This is especially true in light of the widespread clear-cutting operations that SPI has already completed, as well as SPI's intent to continue massive and widespread clear-cutting throughout the state of California.⁷ Again, as stated by one forest scientist, "clear cutting in particular removes more carbon from the forest than any other disturbance (including fire). The result is that harvesting forests generally reduces carbon stores and results in a net release of carbon to the atmosphere." (Harmon 2007).

1. Clear-Cutting Reduces The Carbon Stored In Forest Soils And Floors

Over half of the carbon stored in United States forests is in the forest floor and soils (Turner et al. 1995). The carbon stored in forest soils includes two pools: mineral soils and soil organic matter (Jandl et al. 2007). Much of the carbon stored in mineral soils is considered to be quite stable, and does not generally change dramatically in response to land management activities such as logging (Kimmins 1997; Johnson 1992; Heath and Smith 2000). However, the carbon contained in soil organic matter (which supports vegetation growth) does change in response to land management and is often reduced through logging (Jandl et al 2007; Birdsey and Heath 1995; Harmon et. al. 1990). This is because harvesting removes biomass, disturbs the soil and changes the microclimate all at the same time. It is possible that post-harvest soil carbon losses may exceed carbon gains in the aboveground biomass.

For example, Birdsey and Heath (1995) created a representative model for all forest land classes in all 50 states. They highlight the relative contribution of forest floor and soil carbon to the estimated annual increases in carbon storage and state that:

Nationally about 2/3 of the historical and projected positive flux is carbon buildup in the soil and forest floor A search of the literature indicated that a major forest disturbance such as a clearcut harvest, can increase coarse litter and oxidation of soil organic matter. The balance of these 2 processes can result in a net loss of 20% of the initial carbon over a 10-15 year period following harvest (Pastor and Post 1986, Wodddwell et al. 1984).

Citing literature from geographic regions throughout the U.S. and the world, and considering many different types of tree species and communities, Jandl et al. (2007) explored the way in which forest management can affect soil carbon sequestration. The authors summarize the science showing the impact that logging can have on soil carbon:

- Other researchers report large soil C losses after harvesting. Measurement of net ecosystem C exchange showed that for at least 14 years after logging, regenerating forests remained net sources of CO₂ owing to increased rates of soil respiration (Olsson et al., 1996; Schulze et al., 1999; Yanai et al., 2003). Reductions in soil C stocks over 20 years following clear cuts can range between 5 and 20 t C/ha and are therefore significant compared to the gain of C in biomass of the maturing forest (Pennock and van Kessel, 1997).

⁷ See, e.g., <http://www.fire.ca.gov/ResourceManagement/THPStatusUpload/THPStatusTable.html>

- In their research to develop a model to quantify carbon in various types of U.S. forests, Smith and Heath (2002) found that by reducing litter input and increasing decomposition, clear-cut logging reduces forest floor carbon considerably. Decreases of 50% of forest floor mass have been shown for the first 15 years after logging in northern hardwoods (Covington 1981). Covington (1981) states that the initial decrease in forest floor mass is due to “lower leaf and wood litter fall and to more rapid decay resulting from higher temperature, moisture content, and nutrient levels and to early successional litter being more easily decomposed.”
- Because the debris left behind after logging – branches, tops, and brush – continues to decay for many years after the disturbance, recently logged sites, even those that are replanted, continue to release carbon dioxide into the atmosphere for decades (Buchmann and Schulze 1999; Bergeron et al. 2007).
- Trees planted after harvest often emit carbon for years, despite the rapid growth rate of young trees. This is due to the fact that microbes in the forest soil, which release CO₂ as they break down dead branches and roots, work more quickly after a stand is logged. Studies have shown that a replanted clear-cut gives off more CO₂ than it absorbs for as long as 20 years.
- Reforestation – the planting of new trees on a denuded forest site – theoretically helps to offset these releases. But, the decay process releases more carbon into the atmosphere than tiny saplings remove, leaving cutover forest lands as net sources of carbon dioxide for several decades (Lecomte et al. 2006; Fredeen et al. 2005; Turner et al. 1995; Harmon et al. 1990). Cutover lands emit significant amounts of carbon, especially when compared to uncut forests (Bergeron et al. 2008).

2. Clear-Cutting Reduces And Prevents The Development Of Carbon Stores

As discussed earlier, forests are carbon “banks,” storing large amounts of carbon for long periods of time. Old growth forests have an especially vast amount of live vegetation including huge trees, large downed logs, a healthy understory and a rich ground layer. Each of these elements stores considerable amounts of carbon and so it follows that ancient forests are the “banks” holding the most carbon. A report from the IPCC has echoed this sentiment pointing out that the best way to preserve the carbon stored in a forest is to preserve the forest itself: “The theoretical maximum carbon storage (saturation) in a forested landscape is attained when all stands are in old-growth state (Nabuurs et al. 2007).” Studies about the contributions old growth forests make to atmospheric carbon removal and storage and the environmental benefits they provide (i.e., habitat) also highlight the ecosystem services and ecological values that are being lost when old growth forests are logged and replaced with plantation forests.

Some industry advocates like to argue that old-growth forests are “carbon neutral” – that is, they no longer remove carbon from the atmosphere at significant rates.⁸ In addition, there is a

⁸ See, for example “Modern Forestry and Climate Change” by the California Forest Products Commission, available at <http://www.foresthealth.org/> (last accessed June 5, 2008).

widespread and misguided belief that logging or clearing older forests and replacing them with fast-growing younger trees will benefit the climate by sequestering atmospheric carbon dioxide. Such claims are not only factually wrong – older forests continue to remove carbon from the atmosphere at considerable rates – they are also misleading in that they disregard the amount of carbon already stored in the forest ecosystem. Luysaert et al (2008) state: “Our results demonstrate that old-growth forests can continue to accumulate carbon, contrary to the long-standing view that they are carbon neutral.”

This is why short rotation clear-cut forestry (as in the case of this proposed project) is especially problematic; it prevents vast amounts of trees from getting older, let alone from reaching the old growth stage which science shows is best in terms of its implications for carbon uptake and climate change, not to mention overall ecological benefits.

In terms of the actual loss of stored carbon, when a forest is logged, some of its carbon may be stored in wood products. However, the evidence shows that this is not what happens to a large percentage of carbon. Instead, large quantities of carbon dioxide are *released* to the atmosphere immediately through the disturbance of forest soils, and over time through the decomposition of leaves, branches, and other detritus of timber production. One study found that even when storage of carbon in timber products is considered, the conversion of 5 million hectares of mature forest to plantations in the Pacific Northwest over the last 100 years resulted in a net increase of over 1.5 billion tons of carbon in the atmosphere (Harmon et al. 1990).

Thus, middle-aged forests may remove carbon dioxide from the atmosphere at higher rates than ancient forests, but they store considerably less carbon overall. Using the bank metaphor: ancient forests have much more carbon in the bank, even though deposits may – in certain regions – slow down a bit. Younger forests make rapid deposits, but they are being made in a carbon account that has been emptied.

Generally, it takes a long time for a cutover forest to become a net carbon sink – that is, a site that removes from the atmosphere more carbon than it releases (Janisch and Harmon 2002; Chen et al. 2004). In a study of mixed conifer forests in Washington, Janisch and Harmon (2002) state:

Given these results, at a rotation age of 80 years, a regenerating stand would store 172 Mg C ha⁻¹ live wood (mean) and 28 Mg C ha⁻¹ CWD.⁹ This is 193 Mg C ha⁻¹ below old-growth rates (Lo + mean old-growth CWD). Given a rotation age of 60 years, a regenerating stand would store a mean of 125 Mg C ha⁻¹ in live wood and 21 Mg C ha⁻¹ CWD. This amounts to a reduction of 247 Mg C ha relative to old-growth stands, consistent with past modeled conversions of old-growth forests to regenerating forests (Harmon et al. 1990). Maximum C stores (live and dead) of 393 Mg C ha⁻¹ were reached about 200 years after disturbance.

Some forests take even longer than 50 years to make the transition (Janisch and Harmon 2002). Once logged, these forests remain net sources of carbon into the atmosphere for a half-century.

⁹ CWD is coarse woody debris.

We recognize this timber harvest plan does not include plans to harvest extensive amounts of old-growth. However, it does include plans to clear cut middle-aged forests, and likely some old trees that still remain from previous cutting. Clear-cutting large swaths of middle-aged trees ensures that these forested areas will not mature into old-growth depriving us of opportunities for increased carbon sequestration and denying plants, animals and humans the other benefits associated with mature forests.

Old-growth forests store considerably more carbon—up to four times as much—than young and middle-aged forests (Law et al. 2003; Pregitzer and Euskirchen 2004; Fredeen et al. 2005; Smith et al. 2004b). Middle-aged forests may remove carbon dioxide from the atmosphere at higher rates than ancient forests, but they store considerably less carbon overall (Pregitzer and Euskirchen 2004; Seely et al. 2002; Fredeen et al. 2005). After modeling the response to various management and silvicultural scenarios of different species commonly found in forests of British Columbia, Seely et al. (2002) reported that “total ecosystem carbon increased with rotation length regardless of species, and this was attributable largely to changes in the live biomass pool.” Specifically they found that 50 year spruce rotations stored 150 Mg ha⁻¹ of carbon whereas spruce with a rotation of 200 years stored ~ 250 Mg ha⁻¹. Pine with 40 year rotations stored 150 Mg ha⁻¹ of carbon while pine with rotation lengths of 150 years stored above 250 Mg ha⁻¹ of carbon. Aspen with a rotation length of 40 years stored 175 Mg ha⁻¹ while 80 - 100 year rotation stored 225 Mg ha⁻¹ of carbon.

Fredeen et al (2005) found similar results and reported that “mean total C stocks for old-growth stands ranged from 423 Mg C·ha⁻¹ (coarse) to 324 Mg C·ha⁻¹ (fine), intermediate between Pacific Northwest temperate forests and upland boreal forests. Total C was lower in second-growth stands because of lower tree (mostly large tree stem), forest floor, and woody debris C stocks.” They estimate that harvesting of old-growth forests in sub-boreal British Columbia lowers total C stocks by 54%–41%. (Fredeen et al. 2005).

Smith et al. (2004b) estimated that young forests contain less than a quarter of the carbon stored in ancient forests of the Pacific Northwest. Other regions, including the southeast and northern Lake states, showed similar trends. In the northeast, five-year-old stands of birch store 52 tons of carbon per hectare while 125-year-old stands store 219 tons (Smith et al. 2006).

The following chart shows the difference in carbon stores between an old-growth forest ecosystem and 60-year-old forest. Much of the difference—roughly 350 Mg C/hectare—is released through logging (Harmon et al. 1990).

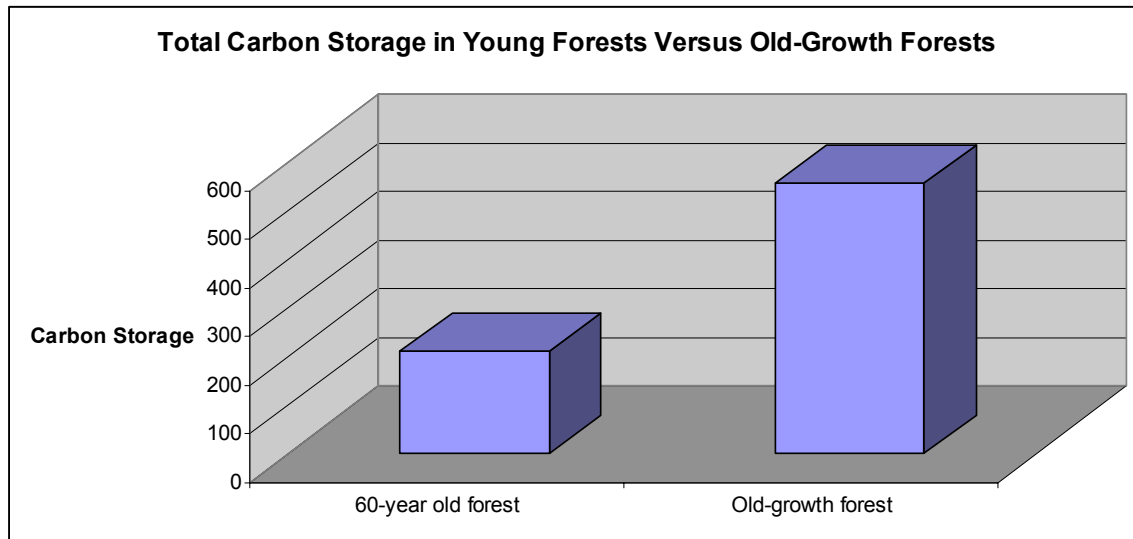


Figure 2: Amount of carbon storage in old-growth versus 60-year old forests. Source Harmon et al. 1990.

The reason old-growth forests store more carbon than younger forests is that they have had more time to grow larger trees and develop a complex forest floor. The following chart shows the carbon storage within the components of a young forest and ancient forest ecosystem.

	60-year-old forest	Old-growth forest
Foliage	5.5	6.2-7.0
Branches	7.0	26.3
Boles (wood and bark)	145	323
Roots (fine)	5.6	5.6
Woody debris and forest floor	10.9-26.1	123
Total	203-218	555-556

Figure 3: Above-ground (non-soil) carbon stores in old-growth forest vs. 60-year-old forest. Numbers in MG of carbon per hectare. Source: Harmon et al. 1990.

Clearly, it is not only older trees that hold large amounts of carbon; forest floors in older forests contain significantly more carbon than forest floors of cutover forests (Lecomte et al. 2006; Fredeen et al. 2005; Harmon et al. 1990). For example, decomposition of trees can take decades, therefore:

the CO₂ released from the decomposition of dead wood adds to the atmospheric carbon pool over decades, whereas natural regeneration or in-growth occurs on a much shorter timescale. For this reason, old-growth forest stands with tree losses do not necessarily become carbon sources, as has been observed in even-aged plantations (that is, where trees are all of the same age) (Luyssaert et al. 2008).

Old forests increase the amount of carbon that is placed into long-term storage in stable forest soils; this carbon is lost through the soil disturbance associated with logging. (Harmon et al.

1990). This can have serious implications for sequestration capabilities as we see from conclusions made by Jandl et al. (2007):

What is beyond dispute is that the formation of a stable soil [carbon] pool requires time. Avoiding soil disturbances is important for the formation of ... crucial elements in the process of [carbon] soil sequestration.

Luyssaert et al (2008) reported similar findings:

In our model we find that old-growth forests accumulate $0.4 \pm 0.1 \text{ tC ha}^{-1} \text{ yr}^{-1}$ in their stem biomass and $0.7 \pm 0.2 \text{ tC ha}^{-1} \text{ yr}^{-1}$ in coarse woody debris, which implies that about $1.3 \pm 0.8 \text{ tC ha}^{-1} \text{ yr}^{-1}$ of the sequestered carbon is contained in roots and soil organic matter.

Jandl et al. (2007) states that “forest ecosystems store more than 80% of all terrestrial aboveground C and more than 70% of all soil organic C (Batjes, 1996; Jobbágy and Jackson, 2000; Six et al., 2002a).” The fact that the majority of sequestered carbon is found in roots and organic soil is significant given that logging, specifically clear-cutting, results in the loss of large amounts of soil and therefore, forest floor carbon. This loss is not only due to the direct impacts of logging, but also as a result of the continued erosion and soil degradation that often comes with logging.

Numerous studies have shown that old-growth forests continue to sequester carbon from the atmosphere (Desai et al. 2005; Law et al. 2003; Chen et al. 2004¹⁰; Field and Kaduk 2004; Paw U et al. 2004; Harmon et al. 2004; Grier and Logan 1977; Knohl et al. 2003). Old-growth Douglas fir forests, for example, “show remarkable sequestration of carbon, comparable to many younger forests (Paw U et al. 2004).” While some regional variation exists, older forests continue to remove carbon at rates greater than or comparable to young forests (Chen et al. 2004; Paw U et al. 2004; Van Tuyl et al. 2005). In the eastern Cascades, for example, forest productivity is *highest* in the region’s oldest forests (Van Tuyl et al. 2005). In contrast, young forests *release* carbon into the atmosphere through the decay of slash left behind after logging (Law et al. 2003).¹¹ As Chen et al. (2004) explains:

The conversion of long-lived forests into young stands may change the system from a sink to a source of carbon for several decades because the lower leaf area in regenerating forests limits photosynthesis while the residual carbon in soils and woody debris contributes to respiration, whereas old-growth forests may continue to function as a net carbon sink in addition to their many other important ecosystem functions.

¹⁰ Chen et al. (2005) showed old-growth Douglas fir forests as a minor source of carbon during an exceptionally dry summer, and a more substantial sink during a year of average rainfall. Thus this study likely underestimates the level of carbon removal from this forest.

¹¹ As a consequence of the Girard THP, there will be emissions associated with the “mechanical piling of brush and slash (which may be reduced by whole tree yarding) with subsequent burning of slash concentrations . . . slash must be disposed of on site, which necessarily involves the burning of piles.”

Contrary to popular belief, young forests do not have the highest carbon sequestration rates or net ecosystem productivity. In fact, Law et al. (2003) examined the variation in productivity and sequestration according to stand age. Net ecosystem productivity was actually the lowest in the initiation stands (9-23 years), moderate in young stands (56-89 years), highest in mature stands (95-106 years) and trended downward in the oldest stands (190-216 years), but was still greater than the youngest stands (Figure 4).

The following chart shows the difference in sequestration rates between various age-classes of forests:

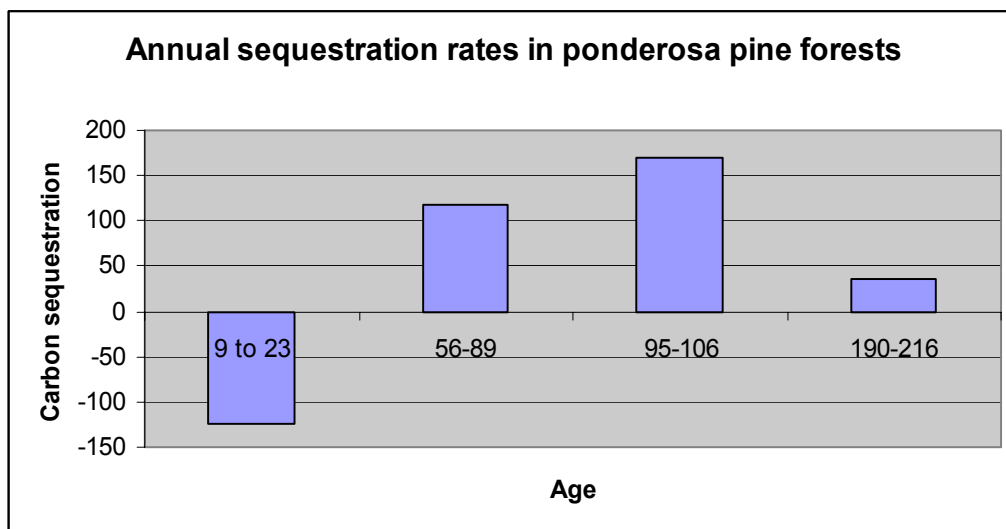


Figure 4: Net ecosystem productivity in ponderosa pine forests is greatest in mature forests (ages 95-106 years) and least in youngest stands (9-23 years old). Measured in grams of carbon per square meter per year. Negative numbers signify net emissions. Source: Law et al. 2003.

Law et al. (2003) also found that the old stands had the highest level of carbon storage in live mass by age 200 and it did not decline after that (mean 17.6 kg Cm⁻²). Overall ecosystem carbon storage increased rapidly until 150-200 years and did not decline in older stands (Law et al. 2003).

3. The Rate Of Carbon Uptake By Regeneration Does Not Offset The Loss Of Carbon Stocks From Clear-Cutting

It is true that the *rate* of carbon uptake by young trees in plantations and re-growth forests is high (Mackey et al. 2008). However, this carbon uptake over a rotation would not compensate for the amount of carbon presently stored in natural forests that would be lost if they were harvested (Harmon et al. 1990; Schulze et al. 2000). For example, Harmon et al. (1990) found that the conversion of 5 X 10⁶ hectares of old growth conifer forest to younger plantations in western Oregon and Washington in the last 100 years has added 1.5 X 10⁹ to 1.8 X 10⁹ megagrams of carbon to the atmosphere. In addition they found that there was 2.2 to 2.3 times as much storage in a 450 year old natural stand than in a 60-year old plantation and that carbon storage is reduced by 350-370 Mg of C per hectare as a result of conversion of old-growth to plantation. Even

considering a long-term perspective, transforming old-growth forests into plantations results in the loss of up to 50% of total ecosystem carbon (Kurz et al. 1997).

Luyssaert et al. (2008) report that:

In fact, young forests rather than old-growth forests are very often conspicuous sources of CO₂ because the creation of new forests (whether naturally or by humans) frequently follows disturbance to soil and the previous vegetation, resulting in a decomposition rate of coarse woody debris, litter and soil organic matter (measured as heterotrophic respiration) that exceeds the NPP (net primary production) of the regrowth. (Harmon et al. 1990; Janish and Harmon 2000; Wirth et al. 2002; Knohl et al. 2002; Kowalski, A. S. et al. 2004; Pregitzer and Euskirchen 2004; Irvine et al. 2007.)

While younger trees grow and sequester carbon quickly, they have not had the time necessary to build up large stores of carbon like those found in forests that are allowed to reach greater maturity. Thus, logging a forest before it reaches old-growth status results in the long-term loss of stored carbon; effectively turning what would have continued to be a carbon sink (if the forest was left alone) into a carbon source, for at least a few decades (Harmon and Krankina, 2008, personal communication). This is because actively growing forests will accumulate carbon at a fairly fast rate and they will continue to do so unless they are harvested ((Harmon and Krankina, 2008, personal communication). This involves the actual loss of carbon that is released from logging and the potential for carbon storage that is lost by cutting down trees before they have reached their storage capacity.

4. Clear-Cutting Is Particularly Destructive To Forest Carbon Stores

Not only does it take time to establish elements in the soil needed for carbon sequestration, because of the time it takes trees to grow, it takes more than 150 years for a cutover forest to produce the amount of living and dead biomass that exists in an old-growth forest (Janisch and Harmon 2002). This is important information to consider in light of the fact that managed forests, logged at an 80-year rotation, store only half the carbon of old-growth forests (Janisch and Harmon 2002).

A clear explanation for why clear-cutting and the replacement of forests with even-aged plantations are so detrimental is provided by Luyssaert et al. (2008):

We speculate that when high above-ground biomass is reached, individual trees are lost because of lightning, insects, fungal attacks of the heartwood by wood-decomposers, or trees becoming unstable in strong wind because the roots can no longer anchor them. If old-growth forests reach high above-ground biomass and lose individuals owing to competition or small-scale disturbances, there is generally new recruitment or an abundant second canopy layer waiting in the shade of the upper canopy to take over and maintain productivity.

In reasonable agreement with our observations (Fig. 1b), self-thinning theory predicts that the ratio between heterotrophic respiration and NPP is constant and around 0.65 +/-

0.02 (indicating a carbon sink; Supplementary Fig. 4), as long as stand density is driven by small-scale, rather than stand-replacing, disturbances. Old stands, with sufficiently high densities (that is, through development of a multilayer canopy structure) are thus expected to maintain biomass accumulation for centuries. Hence, we postulate that biomass accumulation and decline are largely driven by stand structure.

The authors conclude that forests continue to act as carbon sinks unless they suffer from a “stand-replacing” disturbance; clear-cutting middle aged trees as proposed in this project is clearly a “stand-replacing” anthropogenic activity.

These results are specifically relevant to this timber harvest plan since Sierra Pacific Industries is proposing to clear-cut 364 acres of trees and will do so before the trees reach an age when they achieve the highest sequestration rates. Cutover lands emit significant amounts of carbon, especially when compared to uncut forests (Bergeron et al. 2007). By cutting trees down before they reach their highest level of productivity and sequestration capabilities, the industry is undermining state and global carbon sequestration goals and attempts to curb climate change.

In addition to the carbon deficit that logging results in, there are other impacts. Even careful commercial forestry operations in high conservation value forests impose substantial costs to other forest ecosystem services such as biodiversity conservation, watershed maintenance, recreation and other forest amenities (Harmon et al. 1990).

The need for forest protection, specifically protection of older trees and forests in light of climate change is supported by recent science. Luyssaert et al. (2008) conclude that as long as stand density is driven by small-scale, rather than stand-replacing activities, forests will remain carbon sinks. They recommend the protection of these forests from anthropogenic disturbance, like the proposed timber harvest plan we are commenting on:

The present paper shows that old-growth forests are usually carbon sinks. Because old-growth forests steadily accumulate carbon for centuries, they contain vast quantities of it. They will lose much of this carbon to the atmosphere if they are disturbed, so carbon-accounting rules for forests should give credit for leaving old-growth forest intact.

The Girard THP at issue here states that there is no late seral forest habitat in the THP areas because whatever patches of such forest may exist, they do not comprise 20 contiguous acres and thus need not be recognized. (e.g., pg. 178 “Late Seral Forest Characteristics: The stands on the Plan area do not exhibit the characteristics of late seral forest. The stand structure is almost exclusively young to moderately aged conifers, with very few scattered, large residuals. These are neither dense enough nor extensive enough to meet the WHR 6 stand type.”). Regardless, SPI has failed to identify the age, as well as the number of trees at each age, for the trees present in the THP site. This failure prevents an accurate assessment of the carbon value of old trees, as well as the value of moderately aged trees – in other words, assessing carbon impacts involves much more than just stating whether “late seral forest” exists on the site of the THP – it involves providing an accurate assessment of all the trees on the THP site in terms of number and age class. Moreover, an even-aged SPI forest will forever lack older trees due to its rotation schedule, and CAL FIRE and SPI must consider that fact.

Without such relevant information, there is inadequate information to make an informed decision as to the impacts of the THP on carbon emissions – “[an agency] cannot discharge its obligation to disapprove plans that do not incorporate feasible measures to reduce the significant adverse effects of the plan on the environment if it is unable to identify those significant adverse impacts due to a lack of information.” *Sierra Club v. State Bd. of Forestry*, 7 Cal. 4th 1215, 1228 (Cal. 1994); *Id.* at 1236 (lead agency “had an obligation imposed by CEQA to collect information regarding the presence of old-growth-dependent species on the site of the proposed timber harvest” before approving THP); *Friends of the Eel River v. Sonoma County Water Agency*, 108 Cal.App.4th 859, 874 (Cal. App. 1st Dist. 2003) (“An EIR must contain an accurate description of the project’s environmental setting.”). “When the informational requirements of CEQA are not complied with, an agency has failed to proceed in a manner required by law. If the deficiencies in an EIR preclude[] informed decisionmaking and public participation, the goals of CEQA are thwarted and a prejudicial abuse of discretion has occurred.” *San Joaquin Raptor Rescue Center v. County of Merced*, 149 Cal.App.4th 645, 672 (Cal. App. 5th Dist. 2007).

5. The Amount Of Carbon Stored In Harvested Materials And Wood Products Does Not Offset The Carbon Released From Clear-Cutting

Advocates for increased logging and/or use of wood products often argue that increased harvesting will result in more carbon being stored in forest and wood products. This is misleading because after logging, only a small fraction of the carbon stored in forest ecosystems is turned into forest products like paper and lumber (Harmon et al. 1996). Their study states that “despite the large mass of carbon (1,692 Tg) harvested in Oregon and Washington, only a small fraction (23%) is currently stored in forest products.” The majority of forest carbon is left behind in the forest to decompose naturally, burned on site, or transported to a mill where it is burned for fuel. Each of these outcomes of logging results in the release of carbon into the atmosphere.

Harmon et al. (1990) supported this with research showing that although the pool of forest products in use or in landfills will tend to increase as harvest levels increase, the majority of the harvest does not go into long term storage and the magnitude of this sink is not large relative to fossil emissions. Thus, industry advocates that argue that shorter rotations result in larger amounts of stored carbon in forest products fail to consider all of the facts. The carbon stored in forest products does not offset the losses in the forest itself because the forest ecosystem loses carbon a lot faster than the amount gained by forest products (Harmon and Krankina, 2008, personal communication).

For the small proportion of logged material that is turned into a product, science shows that the amount of carbon stored in wood products is quite small relative to the amount of carbon stored in forest ecosystems. Worldwide, forest ecosystems store 100 times more carbon than wood products (Nabuurs and Sikkema 2001).

Because forest products continue to decay over time, the carbon stored in these products is slowly released into the atmosphere. The half-life of carbon stored in wood in single-family homes is estimated to be 100 years, meaning that half of the carbon stored in lumber is released in the first 100 years (Skog and Nicholson 2000). However, Harmon et al. (1990) estimate a 2%

annual replacement rate for wood products that are used in long-term storage. Other forest products have a much shorter half-life, and thus release their stored carbon more quickly. Pallets and sheet paper, for example, have a half-life of six years (Skog and Nicholson 2000). Other paper products have a half-life of only a year.

In terms of storage of forest carbon, there is clearly no comparison between forest products and living material. Trees not only store carbon indefinitely, but they remove it from the atmosphere creating a negative net emission of carbon. Therefore, it is difficult to demonstrate, as industry would like us to believe, that the carbon in wood-based products will remain in the terrestrial biosphere carbon reservoir for a longer period than it would have if it had remained in an unlogged natural forest.

Sierra Pacific Industries released a report in 2007 that concluded that “[w]hen accounting for carbon stored in wood products and harvest residues, intensively managed forest show substantial increases in carbon sequestration over passive forms of management” (James et al. 2007). A careful scientific review of the claims made in the Sierra Pacific Industry report found that the report’s conclusions were “not fully consistent with the results of calculations (Krankina 2008).” The analyses showed that the report relied on “unrealistic” carbon yields, and relied on some assumptions that are “questionable” and others that are “demonstrably untrue.” One of the assumptions dealt with the amount of carbon stored in pools, including wood products. Krankina (2008) states:

The assumption that forest products taken out of service and transferred to landfills retain carbon in perpetuity (p. 29; bottom) is clearly untrue. While the decomposition is slow in landfills it does occur and carbon is gradually released into the atmosphere. The no-decomposition assumption is yet another one that biases the results in favor of intensive management scenario Finally, the assumption that wood products are taken out of service at an annual rate of 1% per year is also unrealistic. This would imply that 50% of long-term wood materials produced in 1930-ies are still in service today

Krankina (2008) concludes that: “The ‘several significant flaws’ in the report’s methodology bias the calculation results in favor of intensive management.” (See below for more detailed information regarding the SPI report).

In addition, Mackey et al. (2008) argue that to truly evaluate the benefits of wood products, it is necessary to account for all carbon losses and gains associated with logging and associated industrial processes if we are to look at this from a carbon-mitigation perspective. Comprehensive carbon accounting is needed that includes carbon uptake and emissions from all human activities associated with commercial logging and processing of the associated wood-based products, as well as carbon storage in products. Due to the immense amount of carbon spent harvesting trees, it is likely that the amount stored in wood products is minimal in mitigation terms.

6. Clear-Cutting Reduces The Resilience Of The Forest Ecosystem To The Impacts Of Climate Change

In addition to severe climate and carbon implications, the impacts of clear cutting/plantation forestry reach further to biodiversity and overall forest health. For instance, as discussed in Mackey et al. (2008), the difference between natural and managed/plantation forests is considerable when addressing a broad range of issues:

Natural forests are more resilient to climate change and disturbances than plantations because of their genetic, taxonomic and functional biodiversity. This resilience includes regeneration after fire, resistance to and recovery from pests and diseases and adaptation to changes in radiation, temperature and water availability. Regrowth forests and plantations have reduced genetic diversity and structural complexity, and therefore reduced resilience to pests, diseases and changing climate conditions (Hooper and Vitousek 1997; Hooper et al. 2005, McCann 2007).

The significance of these impacts is even more apparent when considered cumulatively in light of other land use changes and overall impacts from climate change.

In general, natural forests provide 1) carbon that spends a longer time in the system, 2) a system that is more resilient to environmental perturbations and 3) natural processes that enable ecological systems and their component species to respond to changing conditions. These differences between natural and managed forests have already been found to have important implications for California forests. A study modeling climate change impacts on the productivity, health, and value of a forest in the Sierra Nevada highlights the impact that climate change will have on these ecosystems, specifically plantations. Battles et al. (2008) found that, “conifer tree growth was reduced under all downscaled climate change scenarios. The reductions in growth were most severe (31%) for pine plantations – a common management regime for industrial landowners. Only 18% decreases in productivity were reported for mature stands (a status representative of approximately 20% of the federal forest in the region).”

To reiterate, logging has significant negative impacts on carbon stores. It decreases the number of existing large trees/old trees, reduces the carbon stored in forest soils and floors, reduces and prevents the development of carbon stores, reduces the resilience of the forest ecosystem to the impacts of climate change, and is not offset by the amount of carbon stored in harvested materials and wood products. All of these issues must be appropriately and adequately addressed if the THP is to meet its CEQA obligations. As stated in *Joy Road Area Forest & Watershed Assn. v. California Dept. of Forestry & Fire Protection*, “[any] analysis which understates information concerning the severity and significance of cumulative impacts impedes meaningful public discussion and skews the decisionmaker’s perspective concerning the environmental consequences of the project, the necessity for mitigation measures, and the appropriateness of project approval.” 142 Cal. App. 4th at 667.

B. The Unpublished White Paper Developed By SPI Is Incorrect In Its Findings And Is Wholly Inadequate To Address the Greenhouse Gas and Climate Impacts Of A THP

SPI recently publicized a white paper titled: “Carbon Sequestration in Californian Forests: Two Case Studies in Managed Watersheds.” “Because this research was funded ... by [SPI],” CAL FIRE, like the U.S. Supreme Court, should “decline to rely on it.” *Exxon Shipping Co. v. Baker*, 128 S. Ct. 2605, 2626 (U.S. 2008). Regardless, this paper has not been published in a peer-reviewed journal and is a highly biased and fatally flawed justification of SPI’s forest management practices through selective presentation of data and analysis with regard to forest carbon stores and sequestration.

The SPI paper concludes that the Intensive Scenario – in which existing forests are replaced by even aged monocultures, thereby converting them into forest plantations – results in an increase in sequestered carbon of 75 to 95 tons C/acre over 100 years compared to minimum compliance with Option C of the California Forest Practice Rules. (Option C of the CA Forest Practice Rules serves as the baseline for forest projects under the California Air Resources Board’s forest protocols.)

Two reviews of the SPI study conducted by experts on science, climate and logging found the study to lack credibility. One review was conducted by Dr. Olga Krankina, a professor and researcher of climate impacts at Oregon State University. Another was conducted by Peter Miller, a senior scientist with the National Resources Defense Council, a board member for the California Climate Action Registry, and a doctoral candidate in environmental planning at the University of California at Berkeley, whose research is on conservation planning in a changing climate. Our own review of the SPI paper also found many incorrect assumptions, flaws with the study methods, results and conclusions drawn from these results. Findings and conclusions from these reviews are outlined in the following sections.

1. The Conclusions Of The SPI Paper Are Based On A Comparison Of Incomparable Management Scenarios, And Fail To Include Critical Comparisons Of Alternatives

The SPI paper compares the total amount of carbon sequestered under four management scenarios for two different watersheds in the Sierra Nevada. These include Custodial Management (light to moderate selection harvests), Option C Selective Management (heavy thinning that reduces the stocking to minimum allowed level), Intensive Management (converting all remaining mixed conifer forests to Ponderosa Pine plantations with 80-year rotation age) and Regulated Management (hypothetical – even distribution of plantations by eight 10-year classes).

The first issue with these scenarios is that the “regulated management” option cannot be directly compared to the first three. The first three scenarios are generally comparable because they are initiated with the results of the current forest inventory (meaning they start from the same baseline). However, the regulated management scenario has an initial condition of a fully established “normal” or “regulated” forest. In other words, its starting point is actually achieved

by 80 years of the Intensive Management Scenario. Krankina (2008) states: “Therefore direct comparison of projected gains in carbon pools that involve Regulated management Scenario (e.g., p. 3; bottom paragraphs) is inappropriate.”

For example, in a comparison of the total carbon pool and the forest carbon pool across management scenarios, SPI reports results and makes the following conclusion based on these results:

Intensively managed and regulated forests show substantial increases in the forest carbon pool and total carbon pool yield when compared to the other more extensive Option C Selection and Custodial management approaches (James et al. 2007).

This is an unfair comparison and conclusion given the different starting points of each scenario. This strongly and inappropriately biases the results in favor of Intensive and/or Regulated management.

At the same time, the SPI paper fails to analyze important alternatives that would “be critical for a meaningful assessment of the role of forest management practices (Krankina 2008).” Krankina (2008) notes the absence of both the “business- as- usual scenario” that would show the long-term effects of current management and the “no management” scenario that would show the long-term effect of natural processes of carbon exchange. Krankina (2008) highlights the importance of the lack of consideration of the latter with the following:

No management intervention scenario is not considered. Reduction of timber harvest in PNW National Forests resulted in dramatic increase in forest carbon stores (Alig et al. 2006). Figures in Appendix I suggest that allowing the existing mixed conifer forests attain age 160 years would result in forest carbon pool that is more than twice as high as the average forest carbon store in a regulated scenario for plantations.

Miller (2008) also points out how SPI fails to include an alternative that prioritizes carbon sequestration and/or considers other environmental variables/impacts. Miller (2008) sums up the problem with omitting this management scenario in terms of carbon and wildlife impacts:

The SPI analysis fails to include a scenario with reduced harvest levels that allow a forest to sequester significantly increased amounts of carbon in forest biomass. Both watersheds evaluated in the SPI analysis are middle-aged forests that are near their maximum rates of growth and with reduced harvest levels could double or triple the volume of carbon sequestered as well as provide valuable wildlife habitat (p. 50). However, even the Custodial scenario is only designed to “maintain current stocking levels” (p. 20). A comparison of any of the SPI scenarios with a scenario designed to maximize forest carbon would demonstrate the climate benefits of a high-habitat value approach. Consideration of demand-side forest product programs like recycling and wood use efficiency could allow for reduced harvests (Miller 2008).

Any conclusions the SPI paper draws from these inadequate comparisons are flawed and incomplete, and are not useful in estimating the relative capacity of the management scenarios to sequester carbon.

2. The SPI Paper's Estimate Of The Carbon Pool Is Incomplete, Not Scientifically Valid, And Not Justified

The SPI paper estimated net changes in various carbon pools over 10 future decadal planning periods. SPI compared differences in carbon storage across components including live biomass, dead biomass, soil carbon, off site products, and off site land fills. In order to estimate live biomass, the authors tested three different statistical LBM models to determine tree biomass from forest stand characteristics. The SPI paper states:

It was not possible to directly verify which of the above models (1 through 3) provide the most accurate biomass assessments for the watersheds in this study over the entire planning horizon (p. 25) (James et al 2007).

Nonetheless, the SPI paper then ignored these limitations and provided a comparison of forest carbon over time using each of the models. This comparison resulted in SPI's assertion of "significant differences among the LBM models particularly for the Intensive scenario (Miller 2008)." However, SPI neglected to adopt a scientifically valid or reliable model or at least to provide a valid justification for their choice, and instead stated that they "arbitrarily used Model 2 as a comparative basis (p.34)." Despite differences in a comparison across management scenarios, SPI chose to report only the results of the arbitrarily-chosen Model 2 which produces the largest increase in sequestration from the Intensive scenario compared to the Option C scenario. Thus, SPI may have greatly overestimated the carbon sequestration benefit of their management scenarios by choosing to only focus on this model. In fact:

The net carbon benefit estimated using either of the other two models appears to be approximately 40% lower than the reported results. (p. 33) Model 2 also produces an estimate of decreased sequestration from the Option C scenario that is approximately 50% larger than either of the other two models (Miller 2008).

SPI recognizes the inadequacy of this approach. With specific regard to the lack of appropriate models, the SPI paper states:

None are perfect and it would appear that live biomass estimation methods currently available in California are the most limiting in terms of precision when estimating total carbon stored in forest stands (p.26)...It is also difficult to determine if existing biomass models were appropriate for use in California forests. Therefore, the study concluded the two main problems in providing an accurate forest carbon appraisal system in California that could be applied at the project level under the CCAR protocols were a) imprecise biomass modeling systems and b) shortcomings of publicly available forest growth models (p.41).

Nonetheless, the SPI paper ignored these deficiencies, and did not modify their analysis to correctly represent this difficulty or lack of data. Instead they report and highlight the results that make it appear that intensive management will be the best for carbon sequestration. As a result, the conclusions and results are highly misleading in both their certainty and their substance.

3. The SPI Paper Used Incorrect Assumptions And Statistics That Biased The Results In Favor Of Intensive Management

Krankina (2008) asserts: “The approach adopted in the report includes several assumptions that bias the results in favor of intensive management.” We highlight several of these below:

- **The SPI paper incorrectly assumes that dead biomass pools are in equilibrium when there is a change in forest management.**

Assuming that the amount of carbon stored in dead biomass (logs and snags or fallen trees) remains the same despite changes in forest management is incorrect. There is carbon stored in dead biomass (snags, logs, etc.) and when a forest is harvested, carbon is released from these pools. If the dead biomass is allowed to remain on the ground it will continue to accumulate carbon over time. In addition, logging removes trees that would have eventually died and fallen. Aggressive logging reduces the amount of trees that die and subsequently fall, thereby decreasing the amount of dead trees on the ground and the amount of carbon that is stored in these pools. Both studies cite this as a flaw:

- ... stasis is assumed for all dead biomass pools including snags and forest floor (which has to include logs even though they are not mentioned). As a result the SPI projections do not include losses or gains in dead biomass pools. In reality, logs and snags are created by tree mortality and are NOT in stasis (equilibrium) when there is a change in forest management. These are significant carbon pools and losses from these pools were shown to be a major source of carbon to the atmosphere as old-growth forests were harvested in the PNW (Harmon et al. 1990). As forest stands grow older, dead biomass pools increase unless timber harvest removes live trees. Aggressive management reduces tree mortality which is input into dead biomass carbon pools; the result is the extremely low level of dead biomass, especially coarse woody debris in intensively managed forests. There is a vast body of literature on the subject. Omission of the essential link between live and dead biomass pool is a major flaw of the report that likely biased the results in favor of intensive management scenario. (Krankina 2008).
- The SPI analysis assumes that soil carbon levels remain constant across management scenarios, despite the significant soil disturbance proposed under the Intensive scenario. In the Intensive scenario, forest soils would be mechanically ripped to three feet deep after existing stands were cleared, likely resulting in a significant loss of soil carbon. (p. 48)(Miller 2008).

- **The SPI paper inappropriately overestimates the contribution of wood products to the carbon pool.**

The SPI report states that they used the following assumptions to account for carbon storage in the long-term wood product carbon pool:

25% of long-term wood products are assumed to go to landfills when they are taken out of service. Recent studies (Ximenes et al., 2005) indicate that the decomposition of wood products in landfills is insignificant so we assume wood carbon in landfills is permanently sequestered (p. 29)..... Wood products are subsequently taken out of service at an annual rate of 1% of year (Winjnn et. al. 1998).

In fact, these are incorrect assumptions. Forest products that end up in landfills do slowly decompose and release carbon, thus they do not permanently sequester it as SPI suggests. The fact that the SPI study is based on this falsity has skewed their results to favor scenarios that include intensive logging. Both reviews of the SPI paper, as well as existing science, dispute these assertions and support the idea that SPI has overestimated the contribution of wood products to the carbon pool to favor intensive management:

- The assumption that forest products taken out of service and transferred to landfills retain carbon in perpetuity (p. 29; bottom) is clearly untrue. While the decomposition is slow in landfills it does occur and carbon is gradually released into the atmosphere. The no-decomposition assumption is yet another one that biases the results in favor of intensive management scenario. Finally, the assumption that wood products are taken out of service at an annual rate of 1% per year is also unrealistic. This would imply that 50% of long-term wood materials produced in 1930-ies are still in service today (Krankina 2008).
- The analysis also assumes wood carbon in landfills is permanently sequestered, disregarding both the U.S. Department of Energy and the Environmental Protection Agency’s methodology that includes decay rates for land filled wood.¹² (p. 29) The use of a more realistic lifetime and decay rates would result in significantly reduced estimates of carbon storage in wood products and a smaller, if any, net climate benefit from increased wood product production in the Intensive scenario (Miller 2008).
- In the text of the report the authors identify two different possible options for tracking harvest residue (e.g. tree tops, branches, and foliage). The first option is to assume that this material contributes to maintaining forest floor biomass, which the study elsewhere assumes to remain constant at 11.5 tons C/acre. (p. 23) The second option is to assume that this material comprises an additional pool of sequestered carbon. Of course, this latter approach assumes that the forest floor carbon pool somehow remains constant without continued additions to compensate for decomposition.

¹² Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*, Annex 3 p. 235, April 2007. Department of Energy, “Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program: Chapter 1, Emission Inventories, Part I: Appendix.” p. 220, June 2006

Nevertheless, having identified these two options, the study only reports results using the latter option. As a result, the study concludes that in the Intensive scenario, harvest residue comprises a large incremental pool of sequestered carbon, totaling approximately 20-40 tons C/acre of additional sequestration by the end of the timeframe. (p. 39) In contrast, the report concludes that harvest residue adds no more than 5 tons C/acre under either the custodial or option C scenarios (Miller 2008).

- **The SPI paper fails to address carbon flows among carbon stores.**

The SPI paper fails to include any discussion of carbon flows from one carbon pool to another (i.e. forest floor, dead biomass, etc). As we have previously mentioned, these carbon pools do not remain constant with a change in management, but rather flows between them change. By failing to consider all components of an ecosystem and how carbon flows from one pool to another, as well as the feedback between pools, the SPI paper is not valid when applied to any ecosystem (personal communication Harmon 2008).

There are many global studies that do actually consider carbon flows; overall they show that logging at short intervals has a negative impact on carbon sequestration opportunities. Throughout China and Europe and across the globe, there is overwhelming evidence that longer intervals between harvest results in the storage of more carbon. In Finland, Liski et al. (2001) and Pussinen et al. (2002) found that longer rotation lengths stored more C in forests than shorter ones. This was also true in a larch dominated boreal forest in China (Jiang et al. 2002), western Canadian boreal forests (Seely et al. 2002), forests in the United Kingdom (Dewar and Cannell 1992, Thornley and Cannell 2000), and tropical plantations (Schroeder 1992).

- **The SPI paper fails to adequately estimate greenhouse gas emissions from other sources.**

SPI does not correctly estimate greenhouse gas emissions from other sources. Miller (2008) states:

GHG emissions from logging, transport, and landfills are ignored or assumed to be zero even though the Intensive management approach is likely to have significantly increased emissions in all of these categories compared to less intensive management approaches. (p. 26-30)

- **The SPI paper's numerous flaws and inadequacies all serve to subvert the fact that greenhouse gas emissions will increase with the intensive management approach.**

All of the above incorrect assumptions had a significant effect on the results that SPI chose to highlight and the conclusions that SPI chose to draw from them, thus calling their validity into question. For example, Krankina (2008) reports:

The role of wood products and harvest residues is very important in supporting the conclusions of SPI Report: they account for more than a half of all carbon gains projected for Intensive management scenario. Yet, the estimated increase in carbon pools

associated with wood products and harvest residues is the function of assuming that these pools are at zero level at the start of the planning period and this assumption is clearly untrue.

Similarly, assumptions regarding carbon pools over time led to skewed conclusions (Krankina 2008):

Change in carbon pools over time as reported on Figure 12.2 indicates that among the 3 comparable scenarios (i.e., excluding the theoretical “regulated scenario”) the least intrusive “custodial management” results in greater forest carbon pools during the first 40 years of projection period for Upper San Antonio Creek watershed and during 60+ years in Canyon Creek watershed. When the total carbon pool is considered (including harvest residues and wood products; Figure 12.4) there is little difference among the three comparable scenarios during the first 40 years of projection period, but still custodial management results in slightly bigger carbon pools. Thus during the time period that is both policy-relevant and critical in terms of addressing climate change the custodial management gives better results than other management scenarios (!). This is a truly amazing result considering that the calculations were biased in favor of intensive management scenario as described above. Nevertheless the SPI Report concludes in summary on page 3 (bottom) that “Intensively managed and regulated forests show substantial increases in the forest carbon pool and total carbon pool yield when compared to the other more extensive Option C Selection and Custodial management approaches.” This is also the main message of the press release based on SPI Report. These conclusions of the SPI Report are supported by calculation results only for the last 3-4 decades of the 100-year projection period, but they are untrue for a significant (and the most policy-relevant) portion of the time-interval examined.

Miller (2008) highlights a similar shortcoming in the interpretation and presentation of the results as related to the timeframe of the study:

The SPI analysis only provides a comparison of the sequestered carbon at the end of the 100-year study timeframe. However, the relevant comparison for climate policy is the average amount of sequestered carbon over the life of the project. Because the transition to the Intensive management approach initially results in a decrease in total carbon sequestered, it shows a net decrease in carbon sequestration relative to custodial management for the first 40 years of the analysis. (p. 40) Even under the favorable assumptions of this analysis, Intensive management does not result in an increase in average sequestration relative to custodial management for over 50 years. Overall, the average differences between the scenarios are much smaller than the reported differences at the end of the timeframe.

In conclusion, as detailed above the SPI paper contains substantial inconsistencies that “call into question both the quantitative conclusions and the value of those conclusions for the development of climate policy (Miller 2008).” Specifically, a review of the SPI paper shows that the overall conclusion drawn by SPI, that the Intensive Scenario is the best in terms of carbon

sequestration, is inconsistent with the actual results of their calculations. In fact, their calculations show the opposite:

While the press release and the text of the report emphasize the advantages of intensive management scenario, the calculation results indicate that within the first 40-60 years of future projections the “custodial management” scenario leads to greater carbon storage than the intensive management scenario. Thus the conclusions of the report are not fully consistent with the results of calculations. This inconsistency is significant because the effects of carbon removal from the atmosphere are critical within the next decades and the time horizon of policy decisions tends to be even shorter (Krankina 2008).

The fact is that even with SPI’s biased calculations, the results show the advantage of less intensive management. This fact implies that if done differently, a revised analysis that incorporated correct assumptions and better methodology would show even different results. For example:

Inclusion of soil carbon losses and process emissions, adoption of a more realistic wood product lifetime, proper accounting of harvest residues, and use of either one of the other LBM models would result in a dramatic reduction in the estimated climate benefits of Intensive management (Miller 2008).

Given these omissions, incorrect assumptions, and flaws in methodology, the SPI paper presents incorrect findings and conclusions and fails to provide useful policy guidance in reviewing or assessing the THP’s impact on carbon stores and climate change. Consequently, CAL FIRE can not defer to the SPI paper instead of conducting an adequate analysis of the carbon impacts of logging/clear-cutting – because of the numerous errors and deficiencies of the SPI studies, to defer to them would violate CAL FIRE’s duty under CEQA:

The cumulative impact analysis must be substantively meaningful. A cumulative impact analysis which understates information concerning the severity and significance of cumulative impacts impedes meaningful public discussion and skews the decisionmaker's perspective concerning the environmental consequences of the project, the necessity for mitigation measures, and the appropriateness of project approval. While technical perfection in a cumulative impact analysis is not required, courts have looked for adequacy, completeness, and a good faith effort at full disclosure.

Joy Road Area Forest & Watershed Assn. v. California Dept. of Forestry & Fire Protection, 142 Cal. App. 4th at 667. Specifically, CAL FIRE can not rely on the conclusions of the SPI paper with regard to: 1) calculating and quantifying emissions associated with the THP, 2) the impacts of clear-cutting and/or the “intensive management approach” on greenhouse gas emissions and climate change, 3) the amount of carbon stored in wood products, 4) the estimation of the forest carbon pool, 5) information regarding dead biomass carbon pools and how they are affected by forest management, 6) carbon flows among carbon stores, or 7) greenhouse gas emissions from other sources.

III. THE THP MUST IDENTIFY AND QUANTIFY ALL GREENHOUSE GAS EMISSIONS ASSOCIATED WITH IT

The removal of a tree in the name of logging results in a direct release of carbon because the tree no longer removes carbon from the atmosphere and the removal of the tree results in a loss for future potential storage capacity from that tree. In addition to the loss of carbon from the logging of live biomass, there is also loss of carbon from removal of dead biomass as well as from the impacts to the soil – all of these impacts must be quantified in order to do an accurate assessment of the carbon implications of the timber harvest.

In addition to these direct contributions to carbon emissions as an outcome of tree loss and soil impacts, the process of cutting down trees, transporting them, making them into wood products, etc. likewise has significant contributions to carbon emissions and these too must be quantified in order to make an accurate assessment of the THP's carbon implications. Therefore, in any project, emissions that need to be accounted for include not only “green carbon” from killing living biomass and accelerating the rate of decomposition of dead biomass, but also “grey carbon” from burning fossil fuels for energy to do work (Mackey et al. 2008). As stated by Mackey et al. (2008):

When considering the carbon accounts associated with industrialized forests, it is [] necessary to include carbon emissions resulting from: a) forest management (for example, the construction and maintenance of roads, post-logging regeneration burns); b) harvesting (including use of machinery); c) transportation of logs, pulpwood and woodchips; and d) manufacturing.

A full evaluation of associated emissions, costs and energy is especially important for this project because in contrast with natural forests, industrialized forests contain a very small number of species and are not self-sustaining systems. They contain copies of genetic information that require a succession of energy inputs during their lifetime, from seedling propagation to harvest. Most of these energy inputs are sourced from fossil fuels and include site preparation (removal of existing vegetation), seed collection, growth trials to test the potential survival of species, seedling nursery inputs to grow seedlings for planting, planting of seedling trees, application of herbicides to suppress competition from weed species, measures to prevent animal species (vertebrates and invertebrates) from browsing on the seedlings, fertilizer application and continuing maintenance to suppress plant and animal pest species and fire (Mackey et al. 2008).

Mackey et al. (2008) continues:

As plantations are not self-sustaining systems, when the trees are harvested or die, energy inputs (again, sourced mostly from fossil fuels) are required to establish a new crop of trees. All of these fossil-fuel inputs, including those required for the manufacture of consumables such as fertilizer and pesticides, need to be taken into account, along with the biological processes, when assessing the carbon sequestration potential of tree plantations (and other agricultural crops). As plantations are eventually harvested, the fossil-fuel inputs, such as those required for road-making and upgrading, transport of the

saw-logs for processing, the energy needs (and carbon dioxide emissions) for processing of timber or woodchips, and other industrial processes, should also be deducted from the gross pre-harvest carbon stock.

For the Girard THP, there has been no effort to “calculate, model, or estimate the amount of CO₂ and other GHG emissions from the project, including the emissions associated with [logging trucks, logging equipment, energy consumption, or the many other operations associated with logging.]” OPR Technical Advisory (2008). Until that occurs, the THP cannot even begin to come into compliance with CEQA and FPA obligations. In addition, calculating and quantifying the emissions from a THP is not too speculative – in the analogous context of the National Environmental Policy Act (NEPA), the Ninth Circuit has already rejected the argument that “global warming is too speculative to warrant NEPA analysis.” *Center for Biological Diversity v. Nat’l Highway Traffic Safety Admin.*, 538 F.3d 1172, 1221 (9th Cir. 2008).

Furthermore, “the fact that a single methodology does not exist...requires the [respondent] to do the necessary work to educate itself about the different methodologies that *are* available” – it is incumbent on the THP to “disclose all it can” about its impacts and educate about methodologies that are available to inventory the emissions from the THP. *Berkeley Keep Jets Over the Bay Comm. v. Board of Port Comm’rs (“Berkeley Jets”)*, 91 Cal. App. 4th 1344, 1370 (Cal. App. 1st Dist. 2001).

In its recent white paper, CEQA & Climate Change, Evaluating and Addressing Greenhouse Gas Emissions from Projects Subject to the California Environmental Quality Act (Jan. 2008), the California Air Pollution Control Officers Association (CAPCOA) has set forth methodologies for analyzing greenhouse gas pollution (CAPCOA 2008). The CAPCOA information should be helpful for addressing “grey” carbon – e.g., emissions from a) logging machinery, b) the transportation of logs and any other byproducts, c) the manufacturing of wood products, pesticides, and fertilizers, and d) the construction and maintenance of roads. Moreover, the OPR paper on CEQA And Climate Change discusses various models such as the EMFAC model (page 17), which can be used to “calculate emission rates from all motor vehicles in California. The emission factors are combined with data on vehicle activity (miles traveled and average speeds) to assess emission impacts.”

For “green” carbon quantification, the following studies, among others, provide useful guidance for addressing forest carbon pools (aboveground living biomass, belowground living biomass, dead biomass, and soils (mineral and organic horizons)):

- Hamburg, S.P. 2000. Simple Rules For Measuring Changes In Ecosystem Carbon In Forestry-Offset Projects. *Mitigation and Adaptation Strategies for Global Change* 5:25-37

This paper lays out some general rules for measuring changes in ecosystem carbon:

1. Changes in carbon stocks of four compartments must be addressed: aboveground living biomass, belowground living biomass, soil, and necromass.

2. Aboveground living biomass should be measured directly in all projects through the use of stand level inventories and either volume based yield tables and associated conversion factors, or allometric equations.
 3. Belowground living biomass can be estimated through the use of root/shoot ratios or allometric equations, but conservative ratios need to be employed based on the specificity of data available.
 4. Changes in soil carbon need to be measured in all projects except those where it is clear from the scientific literature that soil carbon is increasing or constant.
 5. Soil needs to be measured to a depth of at least 1 m and organic and mineral soil horizons need to both be considered.
 6. Soil samples need to be collected on a quantitative basis (bulk density and C concentration from the same samples) so that error estimates associated with the change in pool size can be calculated.
 7. Changes in the necromass pool should be measured if there is evidence of a recent (what is recent varies with ecosystem type and decay rates, but in most systems would not exceed 10 years) disturbance (natural or anthropogenic).
 8. If, following a disturbance, the decline in the aboveground living biomass is assumed to have been totally converted to carbon dioxide (thus requiring it be considered a negative stock change), then the necromass pool need not be measured.
- Harmon, Mark E and B. Marks. 2002. Effects of silvicultural treatments on carbon stores in Douglas-fir – western hemlock forests in the Pacific Northwest, U.S.A.: results from a simulation model. *Canadian Journal of Forest Research* 32: 863-877.

This paper discusses STANDCARB, which is a model that can be used to determine long term outcomes from various forestry management regimes and practices. The object of STANDCARB is to simulate the accumulation of C over succession in mixed-species, mixed-aged forest stands.

In this article the model is parameterized for stands in the Pacific Northwest (but it can be parameterized for other ecosystems) and can be used to investigate the stand-level effects of various regeneration strategies, clear-cutting, effects of thinning, patch cutting, tree species replacement by design or by natural succession, slash burning, and wildfires. The model consists of 11 modules that allow for a simulation of certain parts, function and activities in the ecosystem: soil texture, climate, plant, dieout, neighbour, growth, mortality, decompose, harvest, burnkill, and site prep.

The model must be calibrated based on the ecosystem being simulated (in the instance of this study – the Pacific Northwest) and then the simulations are actually run. Harmon and Marks (2002) ran five simulations of eight forest management scenarios to test the effects of initial conditions, tree establishment rates, rotation length, tree utilization level, and slash burning on ecosystem and forest products C stores. There are eight different treatments that were simulated; agricultural row crop, old growth to plantation, agriculture to plantation, agriculture to old growth, low-severity burn, low-severity burn to protection, moderate-severity burn, moderate-severity burn to protection. And in each treatment the results were examined relative to the

increase or decrease of carbon stores. The predictions that are put forward all hinge on the calibration of the software and the inclusion of forest products. Calibration was done by using existing field data from reputable sources. Forest products were included to comply with the law of conservation of mass.

As in many C models, STANDCARB does not include the effects of nutrient cycling. It operates under the assumption that nutrient stores will not be influenced by the treatments enough to lead to major changes in site productivity. STANDCARB provides output on 10 live state variables, nine “dead” state variables, and three state variables related to the volume harvested. The state variables are saved as means and standard errors of the mean for each year.

Further explanation directly from Harmon and Marks (2002) explains:

STANDCARB is programmed in C++ and uses difference equations on an annual time step for all variables, except those used to estimate the effects of climate on tree establishment, growth, and decomposition. These climate-related variables are calculated on a monthly time step. Spatially, STANDCARB is designed to simulate the dynamics of a number of cells within a stand. Each cell represents the area occupied by a single, mature tree (in these particular simulations an area of approximately 0.04 ha), although depending on age a cell can represent either a cohort of trees or a single tree. Within a cell, spatial arrangement of trees is not considered. This approach allows the model to have flexibility in terms of species mixtures and (or) tree ages, and allows the user to estimate the degree of spatial variation among cells within a simulation.

STANDCARB uses a number of levels of organization to estimate changes in C stores within a stand (see Fig. 1 on page 865 of Harmon and Marks 2002). A stand is composed of a number of cells, each which contains up to four layers of vegetation, six detritus pools, and a stable soil C pool. The four layers of vegetation that can occur in each cell are upper trees, lower trees, shrubs, and herbs. The two tree layers can have different species, whereas the shrub and herb layers are viewed as single “species”. Each cell can have any combination of layers except that lower trees can only occur when upper trees are present. Each of the layers can potentially have six live parts: (i) foliage, (ii) fine roots, (iii) branches, (iv) sapwood, (v) heartwood, and (vi) coarse roots. In addition to these parts, bole, aboveground, belowground, and total live mass are derived from combinations of these parts. Each of the live parts of each layer contributes material to a corresponding detritus or dead pool. Thus, foliage adds material to the dead foliage, fine roots to dead fine, etc. Finally, all the detritus pools in a cell can potentially add material to a stable soil pool.

- Harmon, Mark E., Ken Bible, Michael G. Ryan, David C. Shaw, H. Chen, Jeffrey Klopatek, and Xia Li. 2004. Production, Respiration, and Overall Carbon Balance in an Old-growth *Pseudotsuga-Tsuga* Forest Ecosystem. *Ecosystems* 7:498–512.

This paper provides useful guidance on the specifics of measuring the following forest components. The indented language is directly from the study itself and explains how each topic was measured/addressed:

Tree Biomass

All trees larger than 5-cm DBH (diameter at breast height) were measured for diameter and height. Biomass of all live tree parts and volume for the bole were calculated using allometric equations (Gholz and others 1979; Means and others 1994). Species specific allometric equations were used when available, and substitutions for some minor species were used. Coarse-root allometric equations were used for roots larger than 5 mm in diameter. The mass of roots 2–5 mm in diameter from fine-root cores was added to the allometric equation estimates to calculate the total mass of coarse roots. Leaf mass was estimated using a sapwood area-based estimate using DBH-sapwood thickness and leaf-area relationships developed for the H. J. Andrews Experimental Forest in the central Cascades of Oregon (Gholz and others 1976; Waring and others 1982; Means and others 1999). Sapwood volume was estimated from equations developed by Harcombe and colleagues (1990) that predict the proportion of the total bole in sapwood from DBH.

Fine Roots

20 soil cores of 5-cm diameter to a depth of 1 m were removed to estimate biomass of fine roots less than 2 mm in diameter. In each 1-ha quadrant of the crane plot, five cores were sampled at random distances along transects placed diagonally across the quadrant. Organic horizons were sorted by hand to remove live and dead fine roots. Mineral soil was subdivided into 20-cm depths and then washed using a root elutor to separate roots. Roots were sorted into size classes and live versus dead, oven dried at 55_C, and weighed. Subsamples of root material were placed in an oven at 550_C for 4 h to determine ash-free dry weights. Means and standard errors were calculated using all 20 samples as a basis.

Understory Plants

The aboveground biomass of understory shrubs and trees larger than 5-cm DBH was estimated by recording their diameter at the base within a 25 · 1-m belt transect at each location. The biomass of understory plants was calculated using allometric equations (Means and others 1994). In cases where equations for a species (particularly herbaceous ones) did not exist, equations from similar species were used.

Coarse Woody Detritus

Downed coarse woody detritus (larger than 10 cm in diameter at the large end) was measured using the line-intercept method (Harmon and Sexton 1996). All standing dead trees larger than 10-cm DBH and more than 1 m tall (snags) were inventoried on the entire 12-ha set of plots by measuring the basal and top diameters and height as well as assigning them to decay classes. Volume was determined for each species and decay class of logs and snags, and these were converted to mass by multiplying by species and decay class specific density values (Harmon and Sexton 1996).

Fine Woody Detritus

The mass of downed fine wood (less than 10 cm in diameter) was measured by harvesting all the wood in one hundred 1 · 1-m quadrats. Dead coarse roots were estimated assuming they equaled 18%–26% of snag and log mass. This range was calculated by assuming that belowground woody tissues were the equivalent of 15%–20% of the aboveground woody biomass and then simulating the decomposition of the boles and roots at rates indicated by the field data for a 100-year period. The ratio for dead trees was then computed as the ratio of dead coarse roots and dead boles for this entire period. Suspended fine woody debris on snags was estimated using a similar set of calculations. In this case, dead attached branches were estimated to equal 10%–13% of the snag mass. As branches fall off of snags, we assumed that they were only attached to decay class 1 and 2 snags. The decomposition of fine woody debris on the forest floor was measured by placing fresh branches of Douglas-fir and western hemlock on the forest floor and retrieving four branches of each species after 1, 2, and 3 years.

Forest Floor

The store of C in the forest floor that is, excluding highly decomposed, buried coarse woody debris (CWD), but including partially and highly decomposed leaves, cones, and wood less than 1 cm in diameter was determined by two methods. The first used a 5-cm-diameter, stainless steel corer that was driven into the soil. The core was then extracted, and decomposed wood was separated from the other material. The second method sampled forest floor at the locations of the 10 soil pits by using five similar-sized cores.

Mineral Soil

The estimates of C stores in mineral soil are from Remillard (1999). Soil texture, the fraction of particles larger than 2 mm in diameter, bulk density, and C content were determined in 10 soil pits that were at least 1 m deep. The latter three variables were determined for three depths: (a) 0–20 cm, (b) 20–40 cm, and (c) 40–100 cm. The fraction of particles larger than 2 mm in diameter was estimated for each sample depth. Soil C was calculated based on the C content of all fractions, the bulk density, fraction of coarse particles, and depth.

The information above demonstrates that measuring forest carbon emissions can be, and has been, done. Therefore, there is no reason that an inventory of the Girard THP's carbon emissions can not be done. Without a complete inventory, the THP cannot adequately inform the public and decision-makers about its impacts. Similarly, without identifying, calculating and quantifying all the greenhouse gas emissions that will result from the project, there is simply no way that the THP can then adequately discuss alternatives, avoidance, and mitigation measures to reduce those impacts. *See Joy Road Area Forest & Watershed Assn. v. California Dept. of Forestry & Fire Protection*, 142 Cal. App. 4th at 667.

IV. THE THP MUST DETERMINE THE CUMULATIVE SIGNIFICANCE OF ITS CARBON IMPACT

In order to comply with CEQA, CAL FIRE “must determine whether any of the *possible* significant environmental impacts of the project will, in fact, be significant.” *Protect the Historic Amador Waterways v. Amador Water Agency*, 116 Cal. App. 4th 1099, 1109 (Cal. App. 3d Dist. 2004). Moreover, CEQA requires CAL FIRE to determine the significance of the THP’s emissions with or without established significance thresholds – lack of established significance thresholds does not excuse CAL FIRE from its obligation under CEQA to determine the significance of a THP’s impacts. As noted in the CAPCOA white paper on CEQA and Climate Change, “[t]he absence of a threshold does not in any way relieve agencies of their obligations to address GHG emissions from projects under CEQA.” CAPCOA 2008 at 23. *See also* OPR Technical Advisory document, p. 4 (“Even in the absence of clearly defined thresholds [of significance] for GHG emissions, the law requires that such emissions from CEQA projects must be disclosed and mitigated to the extent feasible whenever the lead agency determines that the project contributes to a significant, cumulative climate change impact.”)

Any determination of whether there is a fair argument that the THP may have a significant impact must also include the consideration of the California Global Warming Solutions Act of 2006 (AB 32), wherein the State of California recognized that “global warming poses a serious threat to the economic well-being, public health, natural resources, and the environment of California” and required that existing levels of greenhouse gases be reduced to 1990 levels by 2020. Health & Safety Code §§ 38501(a), 38550. As recently pointed out in the OPR Technical Advisory document, p. 3, “AB 32 . . . acknowledge[s] that [GHG] emissions cause significant adverse impacts to human health and the environment.” Moreover, SB 97 “amends the CEQA statute to clearly establish that GHG emissions and the effects of GHG emissions are appropriate subjects for CEQA analysis.” OPR Technical Advisory document, p. 3.

Because AB 32 establishes that existing greenhouse gas levels are unacceptable and must be substantially reduced within a fixed timeframe, any additional emissions that contribute to existing levels frustrate California’s ability to meet its ambitious and critical emissions reduction mandate. Even ignoring emissions from smaller sources would be neglecting a major portion of the greenhouse gas inventory. In accordance with the scientific and factual data, and in order to account for the fact that any additional emissions are problematic, CAL FIRE should adopt a zero significance threshold for any Project’s greenhouse gas emissions.

The THP’s contribution to emissions is especially serious when considered from a cumulative perspective. An impact is considered cumulatively significant where its “effects are individually limited but cumulatively considerable.” *See Friends of the Old Trees v. Dep’t of Forestry & Fire Prot.*, 52 Cal. App. 4th 1383, 1394 (Cal. App. 1st Dist. 1997) (“[T]he Forest Practice Act and the Forestry Rules establish a statutory and regulatory framework that, construed together with CEQA, confers on the Department the obligation to see that cumulative impacts and alternatives to the project, as well as other specified environmental information, be taken into consideration in evaluating THP’s.”). As explained in *Joy Road Area Forest & Watershed Assn. v. California Dept. of Forestry & Fire Protection*, 142 Cal. App. 4th at 667:

[T]he substantive CEQA requirement of assessing cumulative environmental impact must be included in the evaluation of each THP by CDF. “[C]umulative damage [is] as a whole greater than the sum of its parts *Furthermore, the cumulative impact analysis must be substantively meaningful.* A cumulative impact analysis which understates information concerning the severity and significance of cumulative impacts impedes meaningful public discussion and skews the decisionmaker's perspective concerning the environmental consequences of the project, the necessity for mitigation measures, and the appropriateness of project approval. While technical perfection in a cumulative impact analysis is not required, courts have looked for adequacy, completeness, and a good faith effort at full disclosure.

Climate change is the classic example of a cumulative effects problem; emissions from numerous sources combine to create the most pressing environmental and societal problem of our time. *Center for Biological Diversity v. NHTSA*, 538 F.3d at 1218 (“the impact of greenhouse gas emissions on climate change is precisely the kind of cumulative impacts analysis that NEPA requires agencies to conduct.”). While a particular project’s greenhouse gas emissions represent a fraction of California’s total emissions, courts have flatly rejected the notion that the incremental impact of a project is not cumulatively considerable because it is so small that it would make only a de minimis contribution to the problem as a whole. *Communities for a Better Environment v. California Resources Agency*, 103 Cal. App. 4th 98, 117 (Cal. App. 3d Dist. 2002); *see also Kings County Farm Bureau v. City of Hanford*, 221 Cal. App. 3d 692, 720 (Cal. App. 5th Dist. 1990) (“[p]erhaps the best example of [a cumulative impact] is air pollution, where thousands of relatively small sources of pollution cause a serious environmental health problem”). As noted by former D.C. Circuit Judge Wald in a 1990 dissenting opinion, recently quoted with unanimous approval by the Ninth Circuit in *Center for Biological Diversity v. NHTSA*:

[W]e cannot afford to ignore even modest contributions to global warming. If global warming is the result of the cumulative contributions of myriad sources, any one modest in itself, is there not a danger of losing the forest by closing our eyes to the felling of the individual trees?

538 F.3d at 1217. Moreover, as stated in *CEQA and Climate Change: Addressing Climate Change Through California Environmental Quality Act Review*, from the Governor’s Office of Planning and Research:

When assessing whether a Project’s effects on climate change are cumulatively considerable, even though its GHG contribution may be individually limited, the lead agency must consider the impact of the project when viewed in connection with the effects of past, current, and probable future projects Lead agencies should not dismiss a proposed project’s direct and/or indirect climate change impacts without careful consideration, supported by substantial evidence. Documentation of available information and analysis should be provided for any project that may significantly contribute new GHG emissions, either individually or cumulatively, directly or indirectly (e.g., transportation impacts).

Accordingly, because the THP's "felling of the ... trees" will contribute to greenhouse gas emissions, CAL FIRE must unequivocally consider the THP's emissions to be a cumulatively significant impact.

In sum, the contribution of THPs to carbon emissions is a serious and significant problem, and therefore it is important that THPs perform a thorough analysis of their cumulative contribution to carbon emissions and that CAL FIRE adequately address the issue. Many THPs are currently under consideration for approval, many THPs have recently been approved, and there are numerous past and future THPs – all of these must be considered together, and along with the effects of past, current, and probable future projects that are also contributing to global warming, in order to properly account for their cumulative impact to greenhouse gas emissions. Until that occurs, no THP will be in compliance with CEQA.

V. THE THP MUST ANALYZE AND ADOPT ALL FEASIBLE MITIGATION MEASURES AND ALTERNATIVES TO REDUCE ITS CARBON IMPACT

The failure to recognize the cumulatively significant impacts from the THP directly leads to the failure to consider feasible mitigation measures and alternatives to reduce the cumulatively significant impact. CEQA requires that agencies "mitigate or avoid the significant effects on the environment of projects that it carries out or approves whenever it is feasible to do so." Pub. Res. Code § 21002.1(b); *see also* 14 CCR 15252 ("The document used as a substitute for an EIR or negative declaration in a certified program shall include at least the following items: (1) A description of the proposed activity, and (2) Either: (A) Alternatives to the activity and mitigation measures to avoid or reduce any significant or potentially significant effects that the project might have on the environment")

A rigorous analysis of reasonable alternatives to the project must be analyzed to comply with this strict mandate. "Without meaningful analysis of alternatives in the EIR, neither courts nor the public can fulfill their proper roles in the CEQA process." *Laurel Heights Improvement Ass'n v. Regents of University of California*, 47 Cal.3d 376, 404 (Cal. 1988). Moreover, "[a] potential alternative should not be excluded from consideration merely because it would impede to some degree the attainment of the project objectives, or would be more costly." *Save Round Valley Alliance v. County of Inyo*, 157 Cal. App. 4th 1437, 1456-57 (Cal. App. 4th Dist. 2007) (quotations omitted). An analysis of alternatives should also quantify the estimated greenhouse gas emissions resulting from each proposed alternative.

Here, potential alternatives include different silvicultural techniques (i.e., non even-aged management), and/or reduced cutting. All of these alternatives, and any others, must be considered as they would "avoid or reduce" the cumulatively significant effect of the THP.

In addition to thoroughly evaluating project alternatives, "the [THP] must propose and describe mitigation measures that will minimize the significant environmental effects that the EIR has identified." *Napa Citizens for Honest Gov't v. Napa County Bd. of Supervisors*, 91 Cal.App.4th 342, 360 (Cal. App. 1st Dist. 2001). Mitigation of a project's significant impacts is one of the "most important" functions of CEQA. *Sierra Club v. Gilroy City Council*, 222 Cal.App.3d 30, 41 (Cal. App. 6th Dist. 1990). Therefore, it is the "policy of the state that public agencies should

not approve projects as proposed if there are feasible alternatives or feasible mitigation measures which will avoid or substantially lessen the significant environmental effects of such projects.” Pub. Res. Code § 21002. Importantly, mitigation measures must be “fully enforceable through permit conditions, agreements, or other measures” so “that feasible mitigation measures will actually be implemented as a condition of development.” *Federation of Hillside & Canyon Ass’ns v. City of Los Angeles*, 83 Cal.App.4th 1252, 1261 (Cal. App. 2d Dist. 2000). After all measures have been implemented to reduce emissions in the first instance, remaining emissions that cannot be eliminated may be mitigated through offsets. Care should be taken to ensure that offsets purchased are real (additional), permanent, and verified, and all aspects of the offsets should be discussed in the THP.

Mitigation options for dealing with emissions from logging operations (e.g., machinery use, transportation emissions, processing of timber or woodchips, pesticides, road construction and maintenance, etc.) are available and include, but are not limited to:

- upgrade to higher efficiency equipment
- reduce harvest levels to leave more trees and more soil intact
- reduce discing, soil disturbance during and after harvest
- afforest/reforest enough additional acreage to offset the emissions
- purchase offsets

VI. THE THP MUST ADDRESS THE IMPACT GLOBAL WARMING WILL HAVE ON THE PROJECT

Climate change poses enormous risks to California. Scientific literature on the impact of greenhouse gas emissions on California is well developed.¹³ The California Climate Change Center (“CCCC”) has evaluated the present and future impacts of climate change to California and the project area in research sponsored by the California Energy Commission and the California Environmental Protection Agency (Cayan et al. 2007). The severity of the impacts facing California is directly tied to atmospheric concentrations of greenhouse gases (Cayan et al. 2007; Hayhoe et al. 2004). According to the CCCC, aggressive action to cut greenhouse gas emissions today can limit impacts, such as loss of the Sierra snow pack to 30%, while a business-as-usual approach could result in as much as a 90% loss of the snowpack by the end of the century. As aptly noted in a report commissioned by the California EPA:

Because most global warming emissions remain in the atmosphere for decades or centuries, the choices we make today will greatly influence the climate our children and grandchildren inherit. The quality of life they experience will depend on if and how rapidly California and the rest of the world reduce greenhouse gas emissions (Cayan et al. 2007).

Some of the types of impacts to California and estimated ranges of severity – in large part dependent on the extent to which emissions are reduced – are summarized as follows:

¹³ Additional reports issued by California agencies are available at <http://www.climatechange.ca.gov>, and IPCC reports available at <http://www.ipcc.ch/>.

- A 30 to 90 percent reduction of the Sierra snowpack during the next 100 years, including earlier melting and runoff.
- An increase in water temperatures at least commensurate with the increase in air temperatures.
- A 6 to 30 inch rise in sea level, before increased melt rates from the dynamical properties of ice-sheet melting are taken into account.
- An increase in the intensity of storms, the amount of precipitation and the proportion of precipitation as rain versus snow.
- Profound impacts to ecosystem and species, including changes in the timing of life events, shifts in range, and community abundance shifts. Depending on the timing and interaction of these impacts, they can be catastrophic.
- A 200 to 400 percent increase in the number of heat wave days in major urban centers.
- An increase in the number of days meteorologically conducive to ozone (O₃) formation.
- A 55 percent increase in the expected risk of wildfires (Cayan et al. 2007).

Given that California's temperatures are expected to rise "dramatically" over the course of this century (Cayan 2007), affecting snowpack and precipitation levels, and because California's ecosystems depend upon relatively constant precipitation levels, and water resources are already under strain (Cayan 2007), California will face significant impacts.

For instance, there will likely be shifts in the range of California's tree species. Parmesan (2006) notes that "upward movement of treelines has been observed in Siberia (Moiseev & Shiyatov 2003) and in the Canadian Rocky Mountains, where temperatures have risen by 1.5°C (Luckman & Kavanagh 2000)." And Breshears et al. (2008) states

Warming temperatures associated with anthropogenic increases in greenhouse gases have led ecologists to predict that vegetation gradients will "march" up the hill as climate envelopes shift with elevation, at a lag that scales with species' generation times. [T]he finding of Kelly and Goulden is particularly significant in that (i) it documents synchronous change among dominant species across an entire vegetation gradient; (ii) the change occurred relatively rapidly, rather than with a major lag as previously postulated; and (iii) the magnitude of elevation change corresponds directly to expectations associated with co-occurring temperature change.

In other words, range shifts are not just speculation as to what *might* happen down the road. The above articles show that such shifts are happening *now*. Range shifts will very likely have significant impacts here in California; indeed, specifically in regard to California, Loarie et al. (2008) "project that up to 66% [of California endemic flora] will experience >80% reductions in range size within a century." Loarie et al. (2008) also note that "the foothills of the northern Sierra Nevada are extremely vulnerable to species loss." Consequently, timber harvest plans must address these imminent changes.

Seedling failure and tree mortality will also be a result of warming. Van Mantgem et al. (2007), when researching the “apparent climatically induced increase of tree mortality rates” in the Sierra Nevada of California, “found that mortality rate, but not recruitment rate, increased significantly over the 22 years of measurement (1983–2004).” “Though [the researchers] detected no change in recruitment rates during [their] study,” they noted “it is possible that recruitment and mortality are responding with differing lags or response strengths to climatic changes (Brubaker 1986; Lloyd 1997). Tree seedling dynamics are strongly influenced by climate (van Mantgem et al. 2006; Ibañez et al. 2007).” (Van Mantgem et al. 2007).

Moreover, as explained in Battles et al (2008), plantation forests will likely be especially hard hit by global warming:

Stem volume growth declined under all four climate projections [examined in the study]. Declines were typically most severe for the pine plantations and least severe under single tree selection (Tables 2, 3, and 4).

By the end of the century (i.e., 2071–2100), the severity of the declines, as measured by stem volume increment, ranged from a minimum of 5% relative to baseline (single tree selection, PCM B1) to a maximum of 25% (pine plantation, GFDL A2).

The intensity and extent of the moisture deficit that develops during the summer are considered to be limiting factors in the growth and viability of Sierran conifers (Royce and Barbour 2001a). Higher summer temperatures in a Mediterranean climate (absent any changes in precipitation) could induce greater tree water stress through higher evapotranspiration rates and/or faster depletion of moisture in the soil profile. These changes would hasten the onset of drought stress that occurs in the late summer and early fall before the winter rains return. The result would be a shorter growing season due to lack of moisture, which is already recognized as a primary growth constraint on most commercial timber sites in Sierran forests (Royce and Barbour 2001b).

Despite cultivating a species that is most tolerant of summer temperature (ponderosa pine, Figs. 2 and 4), plantations showed the biggest relative loss of stem volume increment and a comparable absolute loss of timber production.

Monodominant stands (i.e., forests where one tree species constitutes more than 50% of the stand) are at most risk. A spatially mixed forest limits the spread of both pathogens and insects.

These factors will impact the planned THP, as well as exacerbate its own environmental impacts. Thus, when analyzing the project, the THP must take into account global warming. To ignore the impact of global warming on timber harvesting and the resources impacted by the THP would significantly understate THP impacts. *See, e.g., Laurel Heights Improvement Ass’n v. Regents of Univ. of Cal.*, 47 Cal.3d at 392 (EIR is intended “to demonstrate to an apprehensive citizenry that the agency has, in fact, analyzed and considered the ecological implications of its action.”).

CONCLUSION

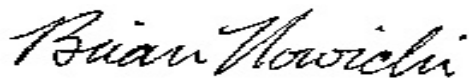
The Girard THP must be revised in order to, among other things, 1) quantify the direct and indirect greenhouse gas emissions resulting from the project; 2) assess whether the emissions are individually or cumulatively significant; and 3) consider mitigation and alternatives. Until all issues are adequately addressed and the THP re-circulated for comments, the proposed harvest is unlawful.

Thank you for your consideration of these comments. Please contact us if you have any questions.

Sincerely,



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