Energy Research and Development Division
FINAL PROJECT REPORT

DEFORESTATION IN CALIFORNIA – A POORLY UNDERSTOOD GHG EMISSION SOURCE AND EMISSION REDUCTION OPPORTUNITY

Options For Policy And Carbon Offset Methodology

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PREPARED BY:

Primary Author(s):
Katherine M. Goslee
Timothy Pearson

Winrock International
2121 Crystal Drive
Arlington, VA 22202
www.winrock.org

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Prepared for:

California Energy Commission

Simone Brant
Contract Manager

Linda Spiegel
Office Manager
Energy Generation Research Office

Laurie ten Hope
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

Robert P. Oglesby
Executive Director

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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Deforestation in California – a poorly understood GHG emission source and emission reduction opportunity: Policy and Carbon Offset Methodology Options is the final report for the Deforestation in California project (contract number PIR-08-008) conducted by Winrock International. The information from this project contributes to Energy Research and Development Division's Energy Related Environmental Research Program.

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ABSTRACT

Deforestation events occurring daily around California are poorly accounted under current greenhouse gas emission monitoring systems and there is no standard methodology for tracking these emissions. The significance of small-scale development as a source of greenhouse gases is therefore currently unknown.

This report summarized the research conducted over three years to improve estimates of greenhouse gas emissions from small-scale development in California. The research included a spatial analysis, development of emission factors and an estimate of emissions from developments across four study areas, and an analysis of the economic impacts of deforestation for development.

The report provided an overview of existing policy and recommendations for additional policy action that could address emissions from development. Recommendations were focused on four potential policy options: promoting appropriate locations for development, including infill and urban growth boundaries; reducing tree removal through cluster developments; incentive programs; and revising the timberland conversion process.

Additionally, the report analyzed the potential for developing a carbon offset project methodology for reduced emissions from conversion for development.

Keywords: greenhouse gas emissions, development, deforestation, carbon stocks, urban forest, policy, accounting methodology

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Introduction

A poll in 2000 classified urban sprawl and crime as the leading local concerns in the United States. Urban area in the United States has doubled over the past 40 years. In California during the same period there was a 252 percent increase in the urban area. California has the lowest current area of development per capita, but the second highest population growth rate and an average income growth rate that outstrips population growth. This trend in population and income growth rates calls into question whether the area of development is captured correctly in California.

Project Purpose

The purpose of this project was to improve the assessment of forest conversion to development.

Project Results

The research conducted in this project showed that small-scale development was occurring widely across California, with varied impacts on emissions from land use change and tree removal. In general, development was concentrated in oak woodlands that had relatively low initial carbon stocks but were important and vulnerable ecosystems. Development in mixed conifer forests was more likely to be dispersed in nature, often with only one or a few houses built on a relatively large area.

The project focused on the following four geographic target areas to represent the diversity of development in forested areas across the state based on recent development pressures and forest cover:

1. The Sierra Mountain counties of El Dorado, Placer and Nevada.
2. The counties of Marin, Sonoma, Napa and Mendocino (north of the San Francisco Bay Area).
3. Los Angeles and Ventura Counties in Southern California.
4. Shasta County in Northern California.

A spatial analysis was conducted to assess deforestation resulting from development. Twenty-eight sampling areas totaling 123,630 acres were sampled at two points in time three to seven years apart. Change in forest cover was determined using both high resolution imagery (60 cm pixels) and medium resolution imagery (30 m pixels). The high resolution imagery indicated that 569 acres (0.46 percent) were deforested, while the medium resolution imagery indicated that 220 acres were deforested (0.09 percent). The high resolution imagery indicated this was an average of 110 acres deforested annually, divided among woodland and hardwood forests (42 percent), urban landscapes (31 percent), other conifer forests (17 percent) and redwood forests (nine percent). Thirty-six percent of this deforestation occurred in Shasta County, 30 percent on the North Coast, 22 percent in the North Sierra region, and 12 percent on the South Coast.

An emissions analysis was conducted following the spatial study to determine the common practice for conversion of forest land to residential development and to create emission factors that could be paired with areas of deforestation to provide associated greenhouse gas (GHG) emissions. The analysis examined emissions associated with tree canopy loss/deforestation for development.

Forest cover change due to development was quantified per parcel for new builds across 17 sampling areas totaling 101,274 acres. A total of 80 new developments were identified across the analyzed sampling areas. The developments included a total of 557 developed parcels within 14 multi-house developments and 66 single-house developments.

Total emissions in multi-house developments across the study areas ranged from 34 tons of carbon dioxide (tCO_2) to 735 tCO_2. Average emissions per parcel by county ranged from 2.6 tCO_2 in Nevada County to 21.4 tCO_2 in El Dorado County. The average emissions per parcel ranged from 2.0 tCO_2 to 42 tCO_2 per single-house development.

Indirect emissions and removals occurred as a result of an increase or decrease in energy consumption based on tree cover and lost future sequestration from removed trees. Combining annual net emission reductions from energy consumption with annual sequestered carbon yielded total emission reductions per tree retained. The highest reductions resulted from trees located on the west side of houses, with a range from 99 kilograms of carbon dioxide equivalent (kg CO_2e) per tree per year for a 13-inch ponderosa pine in Northeastern California to 541 kg CO_2e per tree per year for a 23-inch water oak also in Northeastern California.

A study was conducted in addition to the emissions analysis to assess the economic implications of deforestation on California homeowners. This research found that if just 10 percent of the total 15,904 acres of deforestation in California occurred on homesites, deforestation losses in California could be worth over $33.4 million per year.

The authors described the potential of four potential policy options based on their findings and the feasibility of policy to address the impacts of deforestation for development with respect to climate change: promoting appropriate locations for development, including infill and urban growth boundaries; reducing tree removal through cluster developments; incentive programs; and revising the timberland conversion process.

The first policy option would involve enacting measures such as zoning or tax structures that concentrated development in areas where the resulting GHG emissions were minimized. This could be accomplished through establishing urban growth boundaries, promoting infill and/or brownfield development, or ensuring that development was focused in areas with low carbon stocks while safeguarding vulnerable ecosystems. All of these measures to locate development in a manner that minimized emissions from changes in land use and land cover would need to be designed and implemented at the local or county level.

The second option would involve planning the location of houses within a development or single parcel in such a manner that terrestrial emissions were reduced. For larger developments this could be achieved through cluster development or density bonuses. Such a practice would encourage developers to cluster development in a certain percent of the total project area, leaving the remaining area as forest land or open space. Policy could encourage or require building in a location where tree removal is minimized for smaller development projects, particularly single homes. Most counties already have street tree ordinances that could be expanded to include all trees over a certain size, regardless of species.

Any policy option could be addressed using incentives as well as regulatory mechanisms and in some cases incentives might be preferable. Potential incentive options could include direct financial assistance, tax breaks for developers, technical assistance, and increased allowance for a number of development units.

Finally, timberland conversion has increased significantly over the past decade, and more oversight is needed. Improved primary oversight of the conversion process by CAL FIRE could be significantly improved with adequate resources. This might be difficult to achieve given tight state budgets, but it could prove to be a relatively low cost strategy to help California meet its commitment to reduce GHG emissions.

It may be possible to develop a carbon offset project methodology for reduced emissions from conversion for development (RECD) in addition to policy measures. Many issues would still need to be addressed for such a method to be achievable, however, including baseline, additionality, leakage, and carbon credit ownership.

A carbon offset project must establish a baseline scenario representing business-as-usual emissions. It can be difficult to define the baseline with accuracy because it reflects a hypothetical situation. There are two primary approaches to establishing a baseline: project-specific baselines and performance standards.

The offset project must be additional, meaning it must be able to prove that the emission reductions would not have occurred in the absence of the carbon project for it to generate a real positive impact on the atmosphere in terms of reduced GHG emissions. Project activities must not be required by law to be considered additional and projects must not be financially viable without carbon financing.

Leakage refers to the increase in emissions outside the project area as a result of emission reductions within the project area. Preventing residential development in areas with forest cover could lead to leakage because of high demand for real estate. A clustered approach to development could reduce potential leakage if the number of lots created by a given development was maintained by reducing the minimum allowable lot size. It would be important for any RECD project to address leakage in a comprehensive manner.

It can be difficult to accurately determine ownership of carbon credits for a development project. A carbon project developer must be able to prove sole ownership of the rights to carbon credits to be able to sell them. This could be defined as the entity responsible for making decisions regarding the removal or retention of vegetation during the housing development process in the case of a RECD project.

Project Benefits

This research helped to improve estimates of greenhouse gas emissions from small scale development in California and provided recommendations for reducing those emissions. Reducing greenhouse gas emissions is a key objective for California to help mitigate climate change.

CHAPTER 1: Introduction

In a poll in 2000, urban sprawl was classified, along with crime, as the leading local concern in the US. Across the country, urban area has doubled over the past 40 years. In California during the same period there was a 252 percent increase in the urban area. Among regions in the US, California has the lowest current area of development per capita, but the second highest population growth rate and an average income growth rate that outstrips population growth (cf. Swails et al 2009). This trend in population and income growth rates stimulates the question of whether the area of development is captured correctly in California. Thus the purpose of this project was to improve the assessment of forest conversion to development.

Deforestation events occurring daily around California are poorly accounted under current greenhouse gas emission monitoring systems and there is no standard methodology for tracking these emissions. Therefore, the significance of small-scale development as a source of greenhouse gases is currently unknown.

Assessments of deforestation for development do exist but no confident emission estimates can be paired with the estimates of rates of deforestation. In addition, deforestation is monitored using medium-scale imagery that only poorly tracks the most common form of urban development – scattered development. It is therefore likely that deforestation rates are underestimated and actual emissions are entirely unknown. For these reasons, Winrock International, under funding and guidance from CA PIER, has conducted a multi-year study of small-scale development and its impacts on greenhouse gas emissions and reductions.

The findings of our research under this project show that small scale development is occurring widely across California, with varied impacts on emissions from land use change and tree removal. In general, development is concentrated in oak woodlands that have relatively low initial carbon stocks, but are important and vulnerable ecosystems. Development in mixed conifer forests is more likely to be dispersed in nature, often with only one or a few house built on a relatively large area.

Development has, predictably, slowed somewhat as a result of the recent economic downturn, but it has continued, with approximately the same number of custom built homes developed, while fewer production developments are being built. Production developments tend to result in a higher level of emissions, as roads, driveways, and infrastructure are developed before the exact home site is located for each property. In addition, the early infrastructure of such a development may allow for a somewhat large number of houses from the onset, although it is often many years before all of the houses are actually built. Because this study covered the period of time during the economic downturn, it is likely that fewer developments, and lower emissions, were seen than would have occurred under a healthy economy.

This report addresses policy recommendations for development and GHG emissions, and discusses the potential for development of a carbon project methodology. Chapter 2 summarizes the project findings to date. Chapter 3 reviews existing policies related to development and GHG emissions. Chapter 4 provides policy recommendations to balance the costs and benefits of development strategies in terms of both economics and GHG emissions. Chapter 5 discusses the possibility of developing a project methodology to assess potential carbon credits generated from reduced-emission development projects.

CHAPTER 2:
Summary of Findings to Date

The final reports for each of the previous products under this work are included as annexes to this report. They are briefly described here as well.

2.1 Desk Study

The project began with a desk study (Swails et al, 2009), which described development and associated deforestation on private lands in California, including the laws and regulations that govern development and the forest ecosystems in which development is most likely to occur.

In 2006 the governor of California signed AB32, setting targets for emissions reductions and promoting programs that address climate change at the county and local levels. Housing policies and programs implemented by local governments to address climate change will directly and indirectly influence deforestation associated with development by increasing urban tree cover and changing patterns of urban expansion to encourage denser development and discourage urban sprawl. The many programs and local regulatory processes implemented under AB32 provide an opportunity for extra protection to wooded lands from development, but only if the benefit of protecting forests is understood.

California has approximately twice the amount of conifer dominated forest land as hardwood dominated land—68 percent is dominated by conifer trees and 32 percent by hardwood trees (CALFIRE 2003). Approximately 12.6 million acres in California are privately owned forests (FRAP 2010), many of which are at risk for development. Most conifer forests are publicly owned, and privately owned conifer forests may be protected by timberland or Timber Production Zone status. However, the most common method of conversion of TPZs has changed from direct permitting to non-permitting processes with a corresponding lack of control by state agencies over the process.

Hardwood forests and woodlands are found at lower elevations, closer to urban areas, and are largely privately owned. Lands with hardwood tree cover are overall more vulnerable to development than lands with conifer tree cover. Many programs that specifically target hardwood woodlands and forests for conservation have been implemented at the state and local level. Analysis of changes in the wildland urban interface, composed predominantly hardwood forests and woodlands, in California over the past decade reveals that dispersed development is expanding more rapidly than more concentrated development.

Zoning ordinances that restrict housing density could present obstacles to developers that wish to retain native vegetation on development sites. For example, county zoning ordinances impose density limits that make it difficult in some cases for developers to concentrate housing in one part of the development site because the resulting housing density would be too high for the local zoning. Also, in urban areas, zoning ordinances can limit infill development by preventing high density housing. In some cases, zoning ordinances would need to be revised by local and county governments to promote low impact, cluster, and conservation development. Avoiding deforestation for development could help local, county, and state governments meet targets for emissions reductions.

Based on these recent development pressures and forest cover, the desk study identified the following four geographic target areas on which to focus further analysis (see Figure 1):

1. The Sierra Mountain counties of El Dorado, Placer and Nevada
2. The counties of Marin, Sonoma, Napa and Mendocino (north of the San Francisco Bay Area)
3. Los Angeles and Ventura Counties in Southern California
4. Shasta County in Northern California

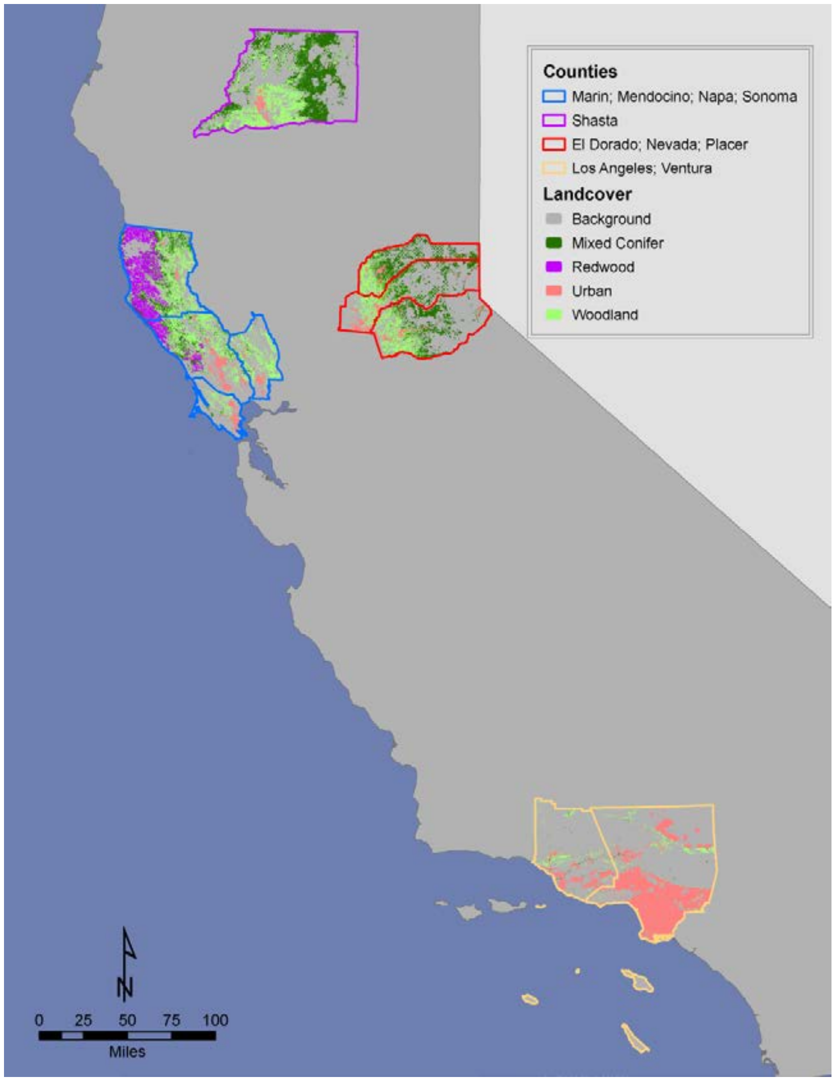

Figure 1: Sites Chosen For in-Depth Study

2.2 Spatial Analysis

A spatial analysis was undertaken to assess deforestation resulting from development (Pearson et al. 2011). Deforestation in California has been monitored using medium scale imagery (30 m pixels) that poorly tracks the most common form of urban development—scattered development. It is therefore likely that deforestation rates are underestimated. The spatial analysis focused on four landscape categories (redwood, other conifer forest, woodland and hardwoods, and urban) across the four regions and used high resolution images (0.6 m pixels) for a sampling of deforested areas to assess actual area of deforestation.

Twenty-eight sampling areas totaling 123,630 acres were sampled at two points in time, 3-7 years apart, and change in forest cover was analyzed using both high resolution imagery (60 cm pixels) and medium resolution imagery (Landsat 30 m pixels). The high resolution imagery indicated that 569 acres (0.46 percent) were deforested, while the medium resolution imagery indicated that 220 acres were deforested (0.09 percent). According to the high resolution imagery, this was an average of 110 acres deforested annually, divided among forest types as follows:

- 42 percent occurring on woodland and hardwood forests
- 31 percent on urban landscapes
- 17 percent on other conifer forests
- 9 percent on redwood forest

Thirty-six percent of this deforestation occurred in Shasta County, 30 percent on the North Coast, 22 percent in the North Sierra region, and 12 percent on the South Coast.

These figures confirm the assumptions of the desk study that the majority of deforestation occurs on woodlands and urban areas. Housing development in rural areas tended to occur more frequently in non-forested areas. There were less than 12 instances of areas of forest that changed into housing developments (one or more streets of new houses, rather than one individual house). The majority of these areas were in the woodland category where the tree density is lower than either mixed conifer or redwood. None of these new developments occurred in the redwood category. Urban deforestation is more common but most instances are of single or few trees at one location. For example backyard trees are removed for construction of a swimming pool.

The results of the spatial analysis showed that interpretation of very high resolution remote sensing imagery results in higher estimates of deforestation due to development than those obtained from interpretation of the commonly used Landsat imagery. In fact, the medium resolution imagery systematically underrepresented deforestation relative to the high resolution imagery, and studies relying solely on medium resolution imagery may be missing more than half of the deforestation that is occurring in California.

2.3 Emissions Analysis

2.3.1 Direct Emissions

Following the spatial study, an emissions analysis was conducted to determine the common practice for conversion of forest land to residential development and create emission factors that can be paired with area of deforestation to give associated greenhouse gas emissions (Goslee *et al*, 2012). The analysis examined emissions associated with tree canopy loss/deforestation for development.

Forest cover change due to development was quantified per parcel for new builds across seventeen sampling areas totaling 101,274 acres. Forest cover change was analyzed only for the parcels that had undergone new development during the sampled period; results were separated into multi-house and single house development. To assess additional development emissions beyond new builds a subset of the study areas in one forest type (redwood) in one region (north coast) were further analyzed (four sample areas, totaling 20,270 acres). Across the study, 14 multi-house developments and 66 single house developments were identified, and in the subsample 5 secondary developments in already developed parcels were identified.

Across the 17 sampling areas analyzed (9.7 square mile per area), a total of 80 new developments, 5 secondary developments, and 26 forest clearings were identified (Table 1)[1]. The developments included a total of 557 developed parcels within 14 multi-house developments and 66 single house developments, as well as 5 parcels with secondary development and 26 parcels with clearing.

Table 1: Characteristics of the Parcels Examined byC

County	Sampling Area Count	Parcel Count	Multi-House Development Count	Single House Development Count	Secondary Development Count*	Forest Clearing without Development*
El Dorado	1	30	1	2	-	-
Los Angeles	3	51	2	2	-	-
Mendocino	3	24	0	1	2	19
Napa	1	26	1	8	-	-
Nevada	2	23	1	4	-	-
Shasta	5	345	7	39	-	-
Sonoma	2	58	2	10	3	7

*Those counties with no numbers for secondary development and forest clearing without development were only analyzed for forest loss resulting from new development.

Across counties, the average size of a parcel in a multi-housing development ranged from 0.17 acres in Sonoma to 1.83 acres in Los Angeles. The average forest loss ranged from 16 percent in Nevada County to 88 percent in Los Angeles County. For single house developments, the average size of a parcel ranges from 0.14 acres in Napa to 8 acres in El Dorado. The average forest losses range from 6 percent in El Dorado to 78 percent in Napa.

[1] In one of the sampling sites in Mendocino County and two in Nevada County no forest loss was identified within the analyzed time period.

Emission factors were estimated from biomass carbon stocks per forest type in all sampled counties, derived from the National Biomass and Carbon Dataset (NBCD), and adjusted for the amount of carbon stored in long-lived harvested wood products and in post-development plantings (Table 2). Area of forest cover loss was multiplied by the emission factor for the specific forest type for the county where the loss was observed to estimate total carbon emissions associated with residential developments.

Table 2: Emission Factors in t CO_2/ac, by Forest Type and Geographic Area.

County	Study Area	Land cover category			
		Mixed Conifer	Redwood	Woodland	Urban Forest
		t CO_2 ac^{-1}			
El Dorado	**22**	119	-	68	70
Los Angeles	**26**				29
	27	48	-	29	29
	28				29
Mendocino	**1**				206
	2	150	216	97	197
	3				162
Napa	**9**	108	220	48	48
Nevada	**18**	105	-	73	105
	20				107
Shasta	**10**				118
	11				50
	12	120	-	48	49
	14				48
	15				115
Sonoma	**7**	142	216	87	192
	8				89

As shown in the spatial analysis, the majority of deforestation for development occurred in woodland forests, which have lower carbon stocks (and therefore emission factors) than redwood or mixed conifer forests. Development that was seen in redwood and mixed conifer forests was single home developments or clearing within existing developments. In all of the study areas, there appears to be little correlation between parcel size and the percent of forest cover loss in multi-parcel developments, though there is some correlation for single house developments.

Average emissions per parcel by county ranged from 2.6 t CO_2 in Nevada County to 21.4 t CO_2 in El Dorado County (Table 3). There was high variability for all counties, resulting in a 90 percent confidence interval of 12-58 percent of the mean. Total emissions in multi-house developments across the study areas ranged from 34 t CO_2 in a Shasta County development with 27 parcels averaging only 0.09 acres in size to 735 t CO_2 in another Shasta County development with 114 parcels averaging 0.39 acres. Average per parcel emissions by development ranged from 1.3 t CO_2 in the Shasta County development with small average parcel size to 21.4 t CO_2 in a development in El Dorado County with a higher average parcel size, moderate forest cover loss, and a moderately high emission factor.

Table 3: Impacts of Multi-House Developments by County

County	Average Parcel Size (ac)	Initial Forest Cover (ac)	Average Forest Loss (%/parcel)	Sum Loss (t CO_2)	Average Parcel Loss (t CO_2)
El Dorado	1.21	0.59	49	600	21.4
Los Angeles	1.83	0.49	88	596	12.6
Napa	0.23	0.15	79	106	5.0
Nevada	0.91	0.22	16	49	2.6
Shasta	0.34	0.23	76	2,327	7.6
Sonoma	0.17	0.09	78	234	6.2

For single house developments, the average emissions for single house parcels ranged from 2.0 t CO_2 in Napa County to 42 t CO_2 per development in Shasta County (Table 4). There was wide range in the emissions within each county due to few samples and high variability, with a 90 percent confidence interval of 35-268 percent of the mean. The average emissions per acre also varied widely, with a low of 2.0 t CO_2/ac in El Dorado County, which has a relatively large average parcel size, and a high of 27 t CO_2/ac in Mendocino County, though this is based on only one development. Sonoma County, which has smaller parcels, relatively high percent forest loss, and high carbon stocks, had the second highest emissions at 22 t CO_2/ac.

Table 4: Impacts of Single House Developments by County

County	Average Parcel Size (ac)	Initial Forest Cover (ac)	Average Forest Loss (%)	Sum Loss (t CO_2)	Average Parcel Loss (t CO_2)	Average Emissions per acre (tCO_2/ac)
El Dorado[¥]	8.43	3.8	6	40	20.0	2.0
Los Angeles[¥]	1.74	0.6	58	20	9.8	8.6
Mendocino*	1.79	0.9	24	48	48	26.6
Napa	0.14	0.1	78	16	2.0	13.9
Nevada	3.6	2.6	20	205	51	13.6
Shasta	3.69	2.4	44	1,644	42.1	12.2
Sonoma	1.35	1.0	49	250	25.0	22.0

[¥]Only two developments found in El Dorado and Los Angeles Counties
*Only one development found in study area in Mendocino County.

Due to the variation seen in percent forest loss across developments, it is not possible to create emission factors by size of development from this analysis. However, the carbon stocks by forest type can be used to develop emission factors based on area deforested. The variation across counties requires that these factors be county-specific. Because carbon emissions are linked directly with the area deforested, the carbon impact of the multi-housing developments varies greatly from county to county. It is not possible to make a generalization of the impacts of either multi-housing or single house developments that is applicable across the state. However, emission factors could be developed for areas of specific interest throughout the state, and applied to the relevant average percent forest loss to estimate total emissions.

2.3.2 Indirect Emissions

The emissions analysis was expanded to address the climate implications of development beyond carbon emissions that result from the removal of existing trees, and assess indirect emissions from energy use and foregone future sequestration (Goslee and Pearson, 2012). Estimations of indirect emissions and emission reductions in California were modeled for the study areas using a tree carbon calculator (CTCC) and the Forest Vegetation Simulator (FVS), both developed by the US Forest Service.

It was found that the highest emission reductions from cooling resulted from larger trees, usually on the west side of the house (afternoon sun). The highest emission reductions from heating systems came from trees on the north side where no winter sunlight is blocked but the coldest winds are obstructed. In a number of cases, emissions from heating systems increased with the retention of a tree, particularly coniferous trees on the south side of houses – due to blocking winter sun and associated warmth by the constant canopy.

The average net emission reduction from energy use was 82.7 kg CO_2e per tree per year across the study areas. This ranged from increased emissions of 35 kg CO_2e per tree per year for 13″

south-side ponderosa pine to emission reductions of 201 kg CO_2e per tree per year for 23” near west-side water oak.

Total CO_2e stored in trees modeled with CTCC ranged from 383 kg per tree for a 13” blue spruce in Northeast California, to 4,829 kg per tree for a coast live oak in the Coastal areas of Northern California. The annual increase in CO_2e sequestered ranged from 37 kg per tree per year for a 13” ponderosa pine to 340 kg per tree per year for a 23” water oak. The annual sequestered CO_2e as projected by FVS ranged from 1.0 metric tons CO_2e per acre for oak woodlands in Shasta County to 8.6 metric tons CO_2e per acre for mixed conifer in Mendocino County.

Combining annual net emission reductions from energy consumption with annual sequestered carbon yields total emission reductions per tree retained. The highest reductions result from trees located on the west side of houses, with a range from 99 kg CO_2e per tree per year for a 13” ponderosa pine in Northeastern California to 541 kg CO_2e per tree per year for a 23” water oak also in Northeastern California. The total CO_2e stored in these trees is 403 kg and 4,663 kg, respectively.

2.4 Economic Analysis

In addition to the emissions analysis, a related study was conducted to assess the economic implications of deforestation on California homeowners (Sohngen, Hite, and Marzen, 2012). There is substantial evidence indicating that forest cover has an important positive impact on home value. Overall, estimates in the literature suggest that trees provide value to homes amounting to around 4-19 percent of total home value. Thus, the loss of forest cover as development occurs likely has a negative effect on home value.

For six California study areas, house sales in two time periods were linked with tree canopy cover and a regression model was developed predicting house value as a function of house amenities, with one of the amenities being tree canopy cover. The model suggests that tree canopy cover enhanced house value by $175 per 1 percent increase in tree canopy to over $2,414 per 1 percent increase in tree canopy cover, depending on the area. The large range of results makes sense given the large diversity of ecological and economic conditions in California. The lowest value, for instance, occurred in areas of LA County with little possibility of tree cover, while the highest value occurred in Sonoma County (one of more affluent areas of the state). For the areas analyzed, trees accounted for 1.0 percent to 12.7 percent of the total value of homes.

The study also estimated that an acre of forest converted to non-forest in California represented a total loss in house values from $4,806 to over $146,000. The highest loss estimate occurred in the North Coast region and was heavily influenced by estimates from Sonoma County. Estimates for the more sparsely populated Northern Sierra region were the lowest. Given that relatively little of the total deforestation in the state occurred in the high value North Coast region, the average loss for the state of California was estimated at $21,003 per acre. Thus, if just 10 percent of the total 15,904 acres of deforestation occurs on homesites, then deforestation losses in California could be worth over $33.4 million per year.

Further economic analysis was conducted in the form of two case studies to estimate the specific impact development has on house value (Sohngen, Petrova, and Hite, 2012). In Shasta County, the loss in tree canopy cover resulting from development led to a $4,923 loss in average house value. In Placer County, loss in tree canopy cover from development led to a $3,127 loss in house value.

CHAPTER 3: Existing Policy

According to the California Department of Forestry and Fire Protection (CALFIRE)there are at least 90 state and federal laws that regulate the management of forest and range resources as well as at least 25 relevant executive orders and other initiatives implemented in the last decade (CALFIRE, 2003). In addition, statewide planning and zoning laws require that every city and county must adopt an open space zoning ordinance[2].

3.1 Zoning

While state agencies regulate land management at the state level, local governments also play a key role in influencing the use of lands with tree cover, particularly through zoning ordinances and land use policies. Local governments can impose restrictions on tree removal and are responsible for setting the minimum parcel size for forest classification. In El Dorado County, for example, the *General Plan* includes canopy retention standards that require discretionary projects located on parcels with oak woodland canopy cover of at least 10 percent retain or replace the existing canopy on an area basis. In addition, clustered development is emphasized to retain natural vegetation. Planned development projects, including subdivisions that create more than 50 new lots, must set aside at least 30 percent of the project area as open space, which can be used to meet canopy retention requirements.

AB32 Global Warming Solutions Act of 2006 has created new initiatives on the local and county level, where zoning and development decisions are primarily made, that address deforestation from development. At the state level, an interagency effort is underway to reduce California's greenhouse gas emissions, in part by changing land use policy.

The CA Department of Housing and Community Development (2009) has compiled a list of many of the city and county level policies that address climate change. Some of those policies are relevant to development of forest land. The cities of San Leandro and Santa Cruz both promote infill development opportunities in areas that are currently served by municipal services. The city of San Diego directs growth into dense patterns of development, in part to maximize availability of open space. The city of Yucaipa in San Bernardino County is rezoning sites for higher density use, increasing maximum density from 12 to 24 dwelling units per acre on 59 acres, all located near existing commercial districts. Finally, Sacramento County implements several programs aimed at promoting infill in a manner consistent with the County's sustainable community strategy. The programs include incentives for infill

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[2] CA Governor's Office of Planning and Research. 2009. Planning and Zoning Development Laws.

development including financial incentives; amending zoning codes to provide for a new mixed-use zone; and adoption of a new development code to enable medium and high density development along current commercial corridors.

3.2 Timberland Conversion

Specific to forest land, the timberland conversion process provides some opportunity for conservation of timberlands. However, in the past decade, the form of conversion of timberlands to other uses has changed with less area converted through direct permitting, and a relatively greater area converted through non-permitting processes. From 2003 to 2007 CALFIRE received on average 13 timberland conversion permit (TCP) applications per year totaling 416 acres. During this same time period, CALFIRE received an average of 13 *Notices of Exemption from Timberland Conversion for Subdivision Development* (Sub-Division Exemptions) per year totaling 1,157 acres of timberland conversion (Robertson, 2008).

As required under the 2008 Farm Bill, the 2010 assessment of California's forests and rangelands identified priority landscapes based on population growth and development impacts (CALFIRE, 2010). These areas were identified by an analysis of trends and conditions and are the focus of strategies and investments to enhance commodity production and the provision of ecosystem services. The assessment identified montane hardwood and blue oak woodland as being the forest habitat types in California with the most acres at risk from development statewide. The bioregions identified as having the highest proportion of acres at risk are the South Coast, Bay/Delta, and the central and northern foothill areas of the Sierras. The assessment also determined that the Bay Area, South Coast and Sacramento Valley bioregions are at the greatest threat for the loss of terrestrial carbon from development.

CHAPTER 4:
Policy Recommendations

Based on our findings and the feasibility of policy to address the impacts of deforestation for development with respect to climate change, we will focus on four potential policy options: promotion of appropriate location of development, including infill and urban growth boundaries; reduction of tree removal through cluster developments; incentive programs; and a revision of the timberland conversion process. Each of these four options is described below.

These options may be addressed at the state and/or county level, although they would need to be tailored to local circumstances. While there are some regional similarities in zoning and development, it became clear through discussions with planning offices that differences between counties are significant enough that development practices should be defined by county rather than by region, and policy solutions should also be addressed at this level. County plans may be a good vehicle for such regulations/incentives, and some counties, such as El Dorado and Sacramento, already have some such provisions in place.

4.1 Location of Development

The first policy option is to enact measures such as zoning or tax structures that concentrate development in areas where the resulting greenhouse gas emissions are minimized. Cities and counties can establish urban growth boundaries with a requirement that most development must occur within those boundaries. Depending on the structure and location of such boundaries, they will result in reduced emissions from development. However, this method is more commonly used to reduce sprawl, as well as emissions from the energy and transportation sectors.

Another method that can be used to concentrate development is to promote infill, with development focused on vacant or underutilized land within existing areas of development. Somewhat similar to infill is brownfield development, which is the redevelopment of previously developed areas. Both of these approaches can minimize urban tree removal, conserve open space and forest land, and avoid development of land with continuous forested cover. As described above, many cities within California already have in place means to encourage infill, which has additional advantages, such as the ability to use existing public services and transportation corridors, rather than requiring the development of new infrastructure. Current zoning regulations such as minimum lot size, setback requirements, and minimum land coverage may present difficulties for the use of infill practices. In addition, there is a limit to the amount of land available for infill, and some homeowners prefer to live in less dense areas.

A third method is to enact measures which ensure that development occurs in areas with low carbon stocks. Infill and brownfield development will likely fit this description. Additionally, development could be allowed primarily on certain land cover types, for example forests with minimum tree cover, or non-forested areas. If this method is used, it is necessary to consider unintended consequences, and ensure that development is not concentrated in critical habitat or threatened non-forest ecosystems, and that it does not impact other ecosystem services.

All of these measures to locate development in a manner that minimizes emissions from changes in land use and land cover would need to be designed and implemented at the local or county level. While state policies can allow for and encourage such practices, there are unique situations in municipalities and counties that make it unreasonable to enact prescriptive state policies.

4.2 Cluster Development

The second policy option is to plan the location of houses within a development or single parcel in such a manner that terrestrial emissions are reduced.

For larger developments this can be achieved through cluster development or density bonuses. This is currently allowed under the California Planning and Development laws[3]. Such a practice encourages developers to cluster development in a certain percent of the total project area, leaving the remaining area as forest land or open space. Developers using cluster development are often allowed to build a greater number of units than would be permitted in a traditional, dispersed development. For example, if under current zoning the minimum lot size in a certain area is 2.5 acres, then a 50 acre project would allow for 20 units. If, however, the developer were allowed to cluster projects, 30 units could be allowed with lot size reduced to 0.5 acres and 35 acres would be conserved. An option somewhat similar to cluster development, but with additional conservation safeguards is the transfer of development rights, under which landowners sell their right to develop land, and the development right is then transferred to areas where higher density is more appropriate.

For smaller development projects, particularly single homes, policy could encourage or require building in a location where tree removal is minimized. Most counties already have street tree ordinances that limit removal of certain species of trees in certain locations. These could be expanded to include all trees over a certain size, regardless of species. Additionally, provisions could be made to incentivize location of remaining trees on the west side of buildings where possible, as this affords the greatest energy benefits (and/or the south side where trees are deciduous and the north side in colder climates where trees are coniferous). It should be noted,

[3] CA Governor's Office of Planning and Research. 2009. Planning and Zoning Development Laws.

however, that building location must be determined in conjunction with the need for other infrastructure such as septic systems and driveways. If not planned carefully, reduction in tree removal for the main building may lead to an increase in tree removal for other purposes.

4.3 Incentives

Each option described above can be addressed using incentives as well as regulatory mechanisms. In fact, in some cases, where there is little appetite for additional regulations or change in zoning classification, incentives may be preferable and more successful.

Potential incentive options include direct financial assistance, tax breaks for developers, technical assistance, and increased allowance for number of development units. Direct financial incentives could be provided to land owners or developers who would incur increased upfront costs as a result of a conservation development project. This could take the form of government assistance, private investment, or a public-private partnership. Tax breaks can be offered for developers who retain a certain number of trees on a project or ensure long term conservation of a specified percentage of forest in the project area. Technical assistance would entail no or low cost support during the development process, to ensure that best practices are known and followed. Finally, density bonuses allow an increased total number of units, provided a larger area is conserved as forest. As described in Chapter 3, such practices are already in place in some counties in California.

4.4 Timberland conversion

As described above, timberland conversion has increased significantly over the past decade, and oversight of the conversion process is divided among many state and local agencies, with no primary oversight by CALFIRE. An issue paper on timberland conversion (Robertson, 2009) has identified six issues related to timberland conversion that need to be addressed:

1. Increased litigation and controversy over timberland conversions
2. Complications with concurrent review of timberland conversion permits (TCP) and timber harvest plans (THP)
3. Conversion of timberland occurs without CALFIRE oversight
4. Complexity and workload have increased substantially
5. Confusion over lead agency role on conversions
6. There are no standard mitigations for loss of timberland

For each of these issues, alternative approaches are proposed for consideration by the Board of Supervisors. Some of these alternatives include

1. Require more rigorous determination as to whether conversions should require an Environmental Impact Report (EIR) under the California Environmental Quality Act (CEQA).

2. Reduce concurrent reviews of TCPs and THPs by creation of a "conversion THP," exemption of requirement of THP for timberland conversions, or requirement for TCP approval prior to THP submittal.
3. Grant CALFIRE "Trustee Status" regarding protection of the state's forests and watersheds, eliminate subdivision exemption for timberland conversion, or require that lead agencies make findings as to the potentially significant impacts of conversion of timberlands.
4. Raise TCP application fee based on relevant criteria, such as proposed area or project value.
5. Ensure that CALFIRE always has primary permitting responsibility in any proposed change of timberland, allowing for it to tier this responsibility to another lead agency, if appropriate.
6. Require landowners to offset the loss of timberland, restore unproductive timberland, or establish a system for mitigation banking with fees paid by landowners proposing conversion.

Additional regulatory and non-regulatory options exist for reducing emissions from development. One valuable non-regulatory option is the use of conservation easements. Many land trusts exist across California and the country, and have a great deal of experience in implementing conservation easements for a wide range of land use objectives.

CHAPTER 5: Potential for Project Methodology

It could be possible to develop a carbon offset project methodology for reduced emissions from conversion for development (RECD) that could in many ways look somewhat similar to an existing avoided forest conversion methodology. There are, however, many issues that would still need to be addressed for such a method to be achievable. These issues are discussed in detail below.

5.1 Baseline

One of the key requirements of a carbon offset project is that it reduces greenhouse gases that would have otherwise been emitted to the atmosphere. This is determined by establishing a baseline scenario, representing business-as-usual emissions. Because the baseline reflects a hypothetical situation, it can be difficult to define with accuracy. There are two primary approaches to establishing a baseline, project-specific baselines and performance standards.

Project-specific baselines determine the emissions that would have been created for each individual project. This can be time intensive, and places a high burden of proof on the landowner and/or project developer, which could result in a disincentive to develop projects. However, it may be more feasible for a RECD project in California, as there is no state-wide trend in the level of emissions from development projects.

Performance standards, on the other hand, are based on the average practice and emissions for a project type. Well-designed performance standards ensure, across a portfolio of projects, that the average project is providing additional carbon credits above the baseline due to a balancing of projects that will be over-credited and those that will be under-credited. Where a balance is not achieved, a standard leads to more over-crediting than under-crediting, and there are no real emission reductions. Performance standards are best applied when emissions or sequestration can be defined relative to a unit of production and where little variability in emissions or sequestration occurs from one location to another. Performance standards function accurately only across a portfolio of similar project types. A proportion will be over-credited relative to the actual project-specific baseline and at least a balancing proportion should be under-credited.

If a performance standard is to be adopted for RECD projects, the business-as-usual scenario should be defined regionally. If this is possible with a reasonable degree of certainty, this method may attract more projects than project-specific baselines and so may be preferred. However, our analysis indicates significant variation between developments, such that a single or even a set of default emissions per parcel or area of parcel cannot be established even when stratified by development type and region within California. Instead, a performance standard could perhaps set a standard emission per area of canopy cover lost through development by forest type. A standard area of building footprint by development type could also be created. Projects would then pair the two default factors with current canopy cover to give baseline emissions. Significant additional work is needed to develop such a standard even for a single region within the State.

5.2 Additionality

In order for an offset project to generate a real positive impact on the atmosphere in terms of reduced GHG emissions, the project must be additional. This is to say that the project must prove that reduced emissions or increased sequestration occurred as a direct result of the economic incentive of carbon financing. To be additional, project activities must not be required by law, and projects must not be financially viable in the absence of additional funding.

Where a performance standard exists additionality is given when the applicability for using the standard is met. In other cases it will be necessary to show why the baseline approach would have been followed in the absence of a carbon project.

For project developers, the burden of proving the additionality of individual projects could be a barrier to participation in carbon markets

5.3 Leakage

Preventing residential development in areas with forest cover could lead to leakage because of high demand for real estate. For example, a project may reduce emissions from deforestation by creating fewer residential lots and designating part of the project area as green-space, but result in conversion of forest elsewhere by another development project undertaken to fill the deficit in available housing units. A clustered approach to development could reduce potential leakage if the number of lots created by a given development is maintained by reducing the minimum allowable lot size. However, reducing the minimum allowable lot size through clustering could create an incentive for the development of large residential subdivisions in areas where they are not usually a common practice. It is important for any RECD project to address leakage in a comprehensive manner. Policies, as discussed Chapters 3 and 4 will act to minimize risk of leakage.

5.4 Carbon credit ownership

Various actors participate in the development process, making it difficult to accurately determine ownership of carbon credits. For example, while the developer might be responsible for site plans and site preparation for construction, the homeowner could be responsible for building decisions and landscaping the developed property. For a carbon project developer to be able to sell carbon credits, they must be able to prove sole ownership of the rights to them. In the case of a RECD project, this could be defined as the entity responsible for making decisions regarding the removal or retention of vegetation during the housing development process.

While it may be possible for a RECD methodology to be created, at present projects outside of the carbon market may be the most feasible option due to the issues described above. To encourage such projects, policy changes and incentive programs as described in Chapter 4 could be undertaken.

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ANNEX A:
Desk Study

See Attached:

Swails, E, T. Pearson, K. Goslee, S. Petrova, and S. Brown. 2009. Desk Study: Deforestation in California: a poorly understood GHG emission source and emission reduction opportunity. Report to PIER under #PIR-08-008.

ANNEX B:
Spatial Analysis

See Attached:

Pearson, Timothy, S. Grimland, K. Goslee, and S. Brown. (Winrock International). 2011. Spatial Analysis: Deforestation in California - a poorly understood GHG emission source and emission reduction opportunity. California Energy Commission. Report to PIER under #PIR-08-008.

ANNEX C:
Emissions Analysis

See Attached:

Goslee, K, T. Pearson, S. Petrova, and S. Brown. (Winrock International). 2012. Emissions Analysis: Deforestation in California - a poorly understood GHG emission source and emission reduction opportunity. California Energy Commission. Report to PIER under #PIR-08-008.

ANNEX D:
Economic Analysis

See Attached:

Sohngen, B., D. Hite, and L. Marzen. 2012. Economic Analysis: Deforestation in California - a poorly understood GHG emission source and emission reduction opportunity. California Energy Commission. Publication number: CEC-PIR-08-008.

ANNEX E:
Economic Case Study

See Attached:

Sohngen, B., S. Petrova, and D. Hite. 2012. The Impact of Tree Loss During Development on House Values and Carbon Storage: A Case Study from Two Counties in California. California Energy Commission. Publication number: CEC-PIR-08-008.

ANNEX F:
Indirect Emissions Analysis

See Attached:

Goslee, K. and T. Pearson. 2012. Indirect Emissions: Deforestation in California - a poorly understood GHG emission source and emission reduction opportunity. California Energy Commission. Publication number: CEC-PIR-08-008.