5.4 Response of Program/Alternatives to Climate Change

This section summarizes the impacts of implementing the Proposed Program and Alternatives on climate change. An analysis of the effects of the Program and Alternatives on climate change, and of the effects of a changing climate on vegetation and treatment combinations, is warranted as a result of the approval of AB 32, the Global Warming Solutions Act, Executive Order S-3-05 issued on June 1, 2005 and the requirements of CEQA.

5.4.1 Significance Criteria

In 2005, in recognition of California's vulnerability to the impacts of climate change, Governor Schwarzenegger issued Executive Order S-3-05, which set forth a series of target dates by which statewide Greenhouse Gas (GHG) emissions would be progressively reduced, as follows:

- By 2010, reduce GHG's to 2000 levels
- By 2020, reduce GHG's to 1990 levels; and
- By 2050, reduce GHG's to 80% below 1990 levels.

In 2006, California passed the California Global Warming Solutions Act of 2006 (Assembly Bill 32; California Health and Safety Code, Division 25.5, §38500, et seq., or AB 32), which requires CARB to design and implement emission limits, regulations, and other measures such that feasible and cost-effective statewide GHG emissions are reduced to 1990 levels by 2020 (representing an approximately 25% reduction in emissions; COE, 2008). In January of 2010, the office of Attorney General released a set of 60 mitigation measures that local agencies and project proponents can take to mitigate the impacts of climate change from their projects and polices. These mitigation measures cover a broad set of possible measures including two that particularly apply to forestry:

- Preserve forested areas, agricultural lands, wildlife habitat and corridors, wetlands, watersheds, groundwater recharge areas and other open space that provide carbon sequestration benefits
- Protect existing trees and encourage the planting of new trees. Adopt a tree protection and replacement ordinance.

The 2020 target reductions are currently estimated to be 174 million metric tonnes/year of CO_2 equivalents. In total, the 44 recommended early actions described by the Attorney General in January, 2010 have the potential to reduce GHG emissions by at least 42 million metric tonnes/year by 2020, representing about 25% of the estimated reductions needed by 2020. CARB staff is working on 1990 and 2020 GHG emission inventories in order to refine the projected reductions needed by 2020 and identify the additional reduction measures required to meeting the 2020 target.

On March 18, 2010, the final CEQA Guidelines for GHG emissions analysis in CEQA documents went into effect as a result of rulemaking required under SB97. These significance criteria and determination thresholds for GHG emissions are described below. In December 2010 ARB adopted regulations for a cap and trade program under AB 32. These incorporate protocols for measuring carbon benefits from forest management, avoided conversion and reforestation projects for use as carbon offsets. Thus, current regulations recognize the potential GHG benefits of forest

management activities and their value in mitigating climate change.

Based on Appendix G of the CEQA Guidelines, GHG impacts would be considered significant if the Program and Alternatives would:

a) Generate greenhouse gas emissions, either directly or indirectly that conflict with the State goal of reducing GHG emissions in California to 1990 levels by 2020, as set forth in AB 32, California Global Warming Solutions Act of 2006.
b) Conflict with an applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases.

5.4.2 Determination Threshold

The CARB has not set thresholds for GHG emissions. The Natural Resources Agency instructs the lead agency for a project/program to set determination thresholds. Both the Bay Area Air Quality Management (BAAQM) District and the San Joaquin Valley Air Pollution Control District have developed thresholds for greenhouse gas emissions. The BAAQM threshold states that non-stationary projects create significant effects if they are a) not in compliance with a qualified GHG reduction strategy, or b) emit more than 1,100 metric tonnes of CO_{2E}/year, or c) emit more than 4.6 metric tonnes of CO_{2E}/year/service population (the service population is the total number of residents plus employees within an air quality management district). The San Joaquin Valley Air Pollution Control District threshold states that a stationary project's GHG emissions must have been reduced or mitigated by at least 29%, as compared to Business-as-Usual in order for there to be a less than significant effect. The ARB scoping plan and most recent emissions inventory (May 12, 2010 - http://www.arb.ca.gov/cc/ inventory/data/data.htm) shows net forestry emissions of –3.98 million metric tonnes of CO_{2E}/year. That is forests and rangelands in the state of California are a net sink for carbon emissions. For the purposes of this EIR and consistent with AB32, the Program and Alternatives will have a significant effect if treatments:

a) Result in CO_2 levels by 2020 that are in excess of those established by the State Air Resources Board.

5.4.3 Data and Assumptions

CAL FIRE Fire and Resource Assessment Program's 2010 Forest Resource Assessment (CAL FIRE, 2010) documents several important trends associated with the effects of climate change including (see page 252 of CAL FIRE report)

- *The results [of climate modeling] show an expected increase in temperature among all ecological units, but the magnitude of the increase varies with ecological units. For all ecological units, average annual temperatures are expected to increase within the range of 0.8 degrees Celsius (1.4 °F) in 2039 to 2.7 degrees Celsius (4.9 °F) in 2099.*
- *Maximum daily temperatures during summer months showed the greatest increase in interior ecological sections including: Northwestern Basin and Range, Modoc Plateau, Mojave/Sonoran/Colorado deserts, Sierra and the Sierra foothill ecological sections. Temperature changes alone are expected to result in declining snowpack, affecting water resources and related environmental services.*

- *A variable pattern of annual precipitation is expected; increasing through 2069, then followed by a large decrease by 2099.*

In addition CAL FIRE's 2010 assessment predicted that:

- *Carbon stocks were found to be mostly stable through 2050 and then declining substantially through 2100.*
- *Below ground carbon pools showed less variation than aboveground carbon pools.*
- *The expected loss of carbon sequestration from wildfire, insects and disease was much more extensive than from development.*
- *Threats to the loss of terrestrial carbon (forest and range) from development were greatest in the San Francisco Bay Area, and the South Coast and Sacramento Valley bioregions. The current amount of medium and high priority landscapes are two to three percent in 2010 expanding to 10 to 14 percent by 2100.*
- *The results show a mixed response among tree species, with some species showing an expansion in range and some species contracting in range by 2080.*
- *The two climate models used to estimate future conditions were reasonably consistent in predicting the shift in a species range. For several of the indicator species both GCMs predicted gains or losses in range that were within 10 percent of each other. Although for one species, giant sequoia (Sequoiadendron giganteum), the estimated extent of gain in species range varied by 58 percent between the two climate models.*
- *Many tree species showed a shift toward higher elevations and towards northern latitudes.*

CAL FIRE also reported that (pg 254):

> *Although GCMs (General Climate Models) are fairly consistent in their predictions of increasing temperature, there is less agreement among models forecasting precipitation patterns. While models show variation in wetter or drier trends, the seasonal distribution of rainfall is still typical of Mediterranean climate, with most precipitation occurring during the winter months. In general, the climate models show little or no change in annual precipitation, but they do show substantial interannual and decadal fluctuations in precipitation (Cayan et al., 2006).*
>
> *Wildfire risk will continue to be highly variable across the state. Research suggests that large fires and burned acreage will increase throughout the century (Westerling and Bryant, 2006; Lenihan et al., 2008), with some declines after mid-century due to vegetation type conversions. Recent research estimates that the wildfire area burned is expected to increase by at least 100 percent in the forests of Northern California (Westerling et al., 2009). This estimate was consistent for the three GCMs that were used in the analysis.*
>
> *Recent research suggests that regardless of the climate model or emissions scenario an increase in wildfire is expected (Westerling et al., 2006). By mid-century the frequency of large wildfires is expected to increase by 30 to 50 percent, and could reach as high as 94 percent by 2085 under the A2 emissions scenario (Westerling, 2009).*

Section 4.4, *Climate Change in California* contains the baseline to be used to determine if implementing the Program or the Alternatives would have a significant effect on the environment. Portions of Chapter 4 are reproduced here to provide context for the determination of significance.

> *Currently, forests in California are thought to operate as a net sink for CO_2. However, estimates of carbon sequestration rates have varied substantially. As part of the Global Warming Solutions Act*

(AB32) the Air Resources Board has reported forests to operate as -5 MMT CO_2eq. More recent reports by CAL FIRE and USFS estimate carbon sequestration on forest lands to be on the order of -25 to -30 MMT CO_2eq.

In addition to the amount of carbon sequestered in forestlands the trend or likelihood of future storage must also be considered. The Scoping Plan for implementing The Global Warming Solutions Act estimated that forests were currently sequestering approximately -5 MMT CO_2eq, but that the sequestration rate was declining and would become negligible by 2020 (CARB, 2008). A USFS study estimated that national forests in California were currently operating as a substantial sink, but that over the next several decades there were great risks to carbon storage depending on disturbance and management regimes (Goines and Nechodom, 2009). Using the MC1 vegetation model CAL FIRE estimated that carbon stocks were relatively stable through 2050, but then declines would occur through 2100 (CAL FIRE, 2010). In addition, there were substantial acres of forestland, with high carbon storage, that are at risk from wildfire and mortality from forest pests (Table 4.4.5 and Figure 4.4.8).

Indirect effects of the trend in climatic change include an increase in the frequency and intensity of wildfires in several vegetation types, which is likely to play a role in the expansion of grasslands. A warmer, drier climate will likely increase the number of days of severe fire danger. The fire season in California and elsewhere seems to be starting sooner and lasting longer, with climate change being suspected as a key mechanism in this trend (Flannigan et al., 2000; Westerling et al., 2006). The rolling five-year average for acres burned by wildfires on all jurisdictions increased in the past two decades from 250,000 to 350,000 acres (1987–1996) to 400,000 to 600,000 acres (1997–2006) (2006, California Wildfire Activity Statistics). In addition, the three largest fire years since 1950 have occurred this decade, with both 2007 and 2008 exceeding the previous five-year average.

Wildfire risk will continue to be highly variable across the state. Research suggests that large fires and burned acreage will increase throughout the century (Westerling and Bryant, 2006; Lenihan et al., 2008), with some declines after mid-century due to vegetation type conversions. Recent research estimates that the wildfire area burned is expected to increase by at least 100 percent in the forests of Northern California (Westerling et al., 2009). This estimate was consistent for the three GCMs that were used in the analysis. This is likely to have adverse effects on air quality, especially during summer and fall months. Another study used data from three CDF ranger units (Santa Clara, Amador, and Humboldt) to model potential effects to vegetation and wildfire under differing climate change scenarios (Fried et al., 2004). When interpolated to most of northern California's wildlands, these results translate to an average annual increase of 5,000 hectares (12,355 acres) burned by contained fires. Fire suppression was simulated using CFES (California Fire Economics Simulator). Across all SRA lands in northern California the model predicted 114 additional escapes per year. This is roughly a doubling of the number of escapes under current conditions.

California is losing forestland at increasing rates: 35,000 to 40,000 acres of private forestland is converted annually to non-forest uses (Stewart, 2005), which could contribute as much as 12 million tons of CO_2 emissions annually. Policies designed to minimize or prevent forestland conversion to non-forest uses could provide significant benefits by 1) preventing or minimizing climate change emissions that are associated with increasing forestland conversion in California and 2) maintaining the opportunity to increase forest carbon stocks on these lands through additional sequestration over time. Forest conservation can also enhance and protect biodiversity, water quality, and habitat resources that the state will increasingly seek to protect from the negative effects of climate change.

The California Energy Commission (CEC) has completed substantial work over the last several years on the sources and amounts of CO_2 in California. In addition, a fair amount of research has been conducted by the USDA Forest Service on the carbon content and the carbon emissions of forest and rangeland in the US. However, neither the CEC nor the USFS work on CO_2 has developed carbon-specific information based on research for California plant species. Most of the work by the CEC on baseline quantities of CO_2 (Brown, et al., 2004a) and updated baseline quantities of CO_2 (Petrova, et al., 2006) utilizes work from Smith et al., (2003), which describes carbon stocks for the entire US. Brown's (2004a) work for the CEC converted DFG's 57 WHR types in the State into eight Smith vegetation types, which were then aggregated into the eight WHR lifeforms described in Table 2.2. Based on Brown's work, CO_2 stocks for the major WHR lifeforms of the State were calculated. Brown's work also addresses CO_2 recruitment (sequestration) due to vegetation growth as well as CO_2 emissions from wildfires and from timber harvest and conversion of forest and rangeland to development. Only the emissions from wildfires and the accretion in sequestered (stored) CO_2 due to plant growth are considered here, since the Proposed Program and Alternatives are not expected to result in direct changes to the patterns of timber harvest or development. As stated in the Program description, only about 10% of the annual acreage treated mechanically is expected to produce biomass where the GHG emissions would be different than if the material were left on site. The removal of this material to biomass plant represents about 2% by acreage of all treatments.

CO_2 sequestration due to plant growth described by Brown (2004b) is based on using USDA Forest Service Forest Inventory and Analysis plots to determine annual increases in biotic vegetation converted to tons and then converted into annual CO_2 accretion. California forestlands typically increase (sequester) CO_2 stocks at a rate of approximately ½ metric ton of CO_2 per acre per year. The annual increase in CO_2 stocks due to sequestering of atmospheric CO_2 by woodlands, shrublands and grasslands is (based on Browns 2004 work):

- Annual increase in CO_2 stocks for timberlands is about 0.50 tons per year
- Annual increase in CO_2 stocks for woodlands is about 0.42 tons per year
- Annual increase in CO_2 stocks for shrublands is about 0.11 tons per year
- Annual increase in CO_2 stocks for grasslands is about 0.04 tons per year.

CO_2 emissions from wildfire were calculated based on assumptions about the percent of the vegetation volatilized by wildfire as described by Brown (2004b) and then using those percentages to estimate the amount of CO_2 stocks, by lifeform, that would be depleted.

The benefits of treatments were based on comparison of projected increases in vegetative biomass over time due to treatment compared to no treatment. Typical increases due to treatment were in the range of a 15% increase in biomass over 10 years, which is a 1.5% increase in vegetative biomass per year.

Finally, much modeling of long-term vegetation trends in California has been completed describing the likelihood of changes in vegetation occurrence as a result of global warming. Many researchers predict that forest and shrublands at low elevations will gradually change to grasslands as a result of global warming. At high elevation, conifers forests are predicted to move up in

elevation displacing high elevation alpine shrub forests. Because the VTP is a program to treat vegetation types and is not being analyzed spatially, changes in vegetation over time favoring one type over another as a result of global warming are not likely to affect the environmental consequences described below. Treating grasslands today with treatments described below is not likely to be different than treating grasslands in the future that were formerly forest or shrublands, particularly given the landscape constraints, minimum management requirements and mitigation measures in effect at the programmatic level as well as the practices employed at the project level.

5.4.4 Direct Effects Common to all Bioregions From Implementing the Program and Alternatives

Section 4.4 provides the context for describing the consequences on climate of implementing the Proposed Program and Alternatives. The Proposed Program potential treatment acreage by bioregion is described in Tables 5.0.1, 5.0.4, 5.0.5 and 5.0.7. Total acreage treated over a ten-year period is projected to be approximately 2.16 million acres, which represents about 5.1% of the total acreage of CAL FIRE jurisdiction lands that might be treatable in any ten-year period.

Table 5.4.1 summarizes the information from the balance of this chapter on the effects of implementing the Program across the state by bioregion in terms of effects to climate, specifically CO_2.

Table 5.4.1
Summary of Effects 1/ to Climate from CO_2 Due to Implementing Treatments by Treatment Type and Bioregion

Bioregion	Prescribed Fire	Mechanical	Hand	Herbivory
Klamath/North Coast	MA	NB	NB	NB
Modoc	MA	NB	NB	NB
Sacramento Valley	MA	NB	NB	NB
Sierra	MA	NB	NB	NB
Bay Area	MA	NB	NB	NB
San Joaquin	MA	NB	NB	NB
Central Coast	MA	NB	NB	NB
Mojave	MA	NB	NB	NB
South Coast	MA	NB	NB	NB
Colorado Desert	MA	NB	NB	NB

1/ Key to effects; adverse effects are those effects which degrade the diversity, structure, size, integrity, abundance or number of; or are outside the natural range of variability, for the resource at issue. Beneficial effects are those effects that improve the diversity, structure, size, integrity, abundance or number of; or are within the natural range of variability, for the resource at issue. SA/SB – significant adverse or beneficial effects are those effects that are substantial, highly noticeable, at the watershed scale; and often irreversible. MA/MB - moderately adverse or beneficial effects - those effects that can be detected beyond the affected area, but are transitory and usually reversible. NA/NB - negligible adverse or beneficial effects - those effects that are imperceptible or undetectable.

Landscape Constraints and Minimum Management Requirements That Reduce Climate Effects

Although there are standard practices in the Proposed Program that reduce the effects of prescribed fire on air quality, there are no specific minimum management requirements or landscape constraints designed to reduce the effects of implementing the Program on climate, specifically on CO_2 emissions in California.

Proposed Program and Alternatives Non-CO_2 Greenhouse Gas Emissions

Prescribed herbivory using ruminants can produce CH_4 as a by-product of the digestion process in cows, goats, etc. However, the Proposed Program is not expected to lead to an increase in the number of cows, goats, or other ruminants in the state. Instead, a small number of the existing stock of cows, goats, etc. in California would likely be moved to VTP project areas in lieu of traditional feeding and grazing regimes. For these reasons, the impact of prescribed herbivory on CH_4 emissions in the state are not considered further.

Emissions of non-CO_2 gases, including methane (CH_4) and nitrous oxide (N_2O) may exacerbate global warming. Methane has 28 times the global warming potential of CO_2, so even small volumes of methane might be important. Brown (2004b) has estimated that wildfires on California forest and rangelands produce emissions of 0.011 million metric tonnes of N_20 per year (about 0.27% of total equivalent CO_2 emissions/year and 0.096% of total CO_2 sequestered/year). Brown also estimates that California wide wildfires and timber harvest produce about 0.15 million metric tonnes of CH_4 per year (4.7% of annual equivalent CO_2 emissions and 1.3% of annual sequestrations of CO_2). The Proposed Program and Alternatives

would only treat about 0.2% of the State's forest and rangelands per year, which would result in CH_4-equivalent generation of no more than 0.0037% of total California forest and rangeland CO_2 emissions per year. Total Program or Alternative N_2O emissions would represent about 0.002% of total CO_2 sequestered per year in California. Because the amounts of non-CO_2 gases produced on forest and rangelands from wildfire and timber harvest are so small compared to total CO_2 emissions and sequestrations, they are not further analyzed here.

Proposed Program CO_2 Emissions

Carbon dioxide is one of the five most important greenhouse gases, which act to retain heat in the atmosphere by allowing short –wave radiation (light) to pass through, but act as a barrier to long wave radiation (heat). While carbon dioxide is not the strongest greenhouse gas (methane is 30 times more effective at trapping heat), next to water vapor it is by far the most prevalent (Harmon, 2006).

At the global scale, deforestation and fire create the second-largest source of human caused CO_2 emissions to the atmosphere (Salwasser, 2006). According to the U.S. Environmental Protection Agency, carbon sequestration by U.S. forests currently offsets about 12% of annual U.S. greenhouse gas emissions from all sectors (Salwasser, 2006). On the other hand, the U.S. continues to lose forests to development at a rate of about one million acres per year, and is projected to lose 23 million acres by 2050 (Stein, et al., 2005). And, as noted in Chapter 4, California forestland is being lost at a rate of 35,000-40,000 acres per year, which is the equivalent of a loss of about 12 million tons of CO_2 that would normally be sequestered annually (Cal EPA, 2006).

The options available to mitigate carbon accumulation in the atmosphere via measures taken within the forest and range sector include 1) Increasing or maintaining forest area by avoiding deforestation, including within urban areas; 2) Increasing carbon sequestration using management practices that accelerate forest regeneration and growth, slow decomposition at the stand level, or use longer rotations, and 3) Increase product substitution using forest-derived materials to replace material with higher fossil fuel requirements (Krankina and Harmon, 2006).

CO_2 emissions produced by land use and forestry practices can cause CO_2 atmospheric concentrations to increase. The total contribution to California's carbon emissions from forest and rangelands, due to timber harvest, mortality from fire and insects, etc., was estimated at 5.12 million metric tonnes/year (based on data from 1987 to 2000 and extrapolated to the entire state - Winrock, 2004). Of the 5.12 million metric tonnes/year of CO_2 emitted by forest and rangelands, about 42% (2.12 million metric tonnes) was due to wildfire. The California Energy Commission estimated forest and rangeland emissions at 4.7 million metric tonnes in 2002 (Bemis and Allen, 2005).

California's annual forest and rangeland emissions of 4.7 to 5.12 million metric tonnes of CO_2 is offset by the amount of carbon that is annually sequestered by California's forest and rangelands, which was estimated by Winrock (2004) to be 14.14 million metric tonnes/year. However, more recent work by Brown (2004b) suggests that the total amount of CO_2 that is

currently being sequestered by forests and rangelands in California is approximately 8.76 million metric tonnes/year. As Section 4.4 points out, ARB figures suggest that the net sequestration of CO_2 by California's forest and rangelands is –5 million metric tonnes/year, yet more recent research by CAL FIRE and the USFS suggests that sequestration of CO_2 by California's forestlands alone is around –25-30 million metric tonnes of CO_{2E} per year.

Total CO_2 production associated with mechanical treatments due to heavy equipment operation is based on information developed by ENSR International (2005) for the Bureau of Land Management's Programmatic Environmental Report (USDI BLM, 2005b). Based on the ENSR report, the production of CO_2 by heavy equipment used in tractor piling and burning, masticating, chaining etc., is considered too small, at 0.029 tons of CO_2/acre treated, to be considered further. Even the alternative with the largest number of acres to be treated mechanically (~ 48,000 acres in Alternative 3) would only generate about 1,220 tons of CO_2 per year or 0.03% of the four million metric tonnes emitted by various other forest and rangeland sources such as wildfire, conversion, etc.

The effect of implementing the Proposed Program or the Alternatives treatments on California CO_2 emissions is based on reducing the severity of wildfire in treated areas, and thus reducing the amount of CO_2 emitted, and increasing the growth of treated forest and rangelands in order to sequester more CO_2. The reduction in CO_2 due to reducing the severity of wildfire is both due to reducing hazardous fuels within the burn area as well as reducing the extent of area burned by wildfire in watersheds when more than 30% of the area has been treated. Offsetting these benefits are the CO_2 emissions from prescribed fire use within the Program. (As previously noted, the CO_2 emissions from mechanical equipment and the CH_4 emissions from prescribed herbivory are considered to be too small to have a significant effect on California's total carbon emissions.)

Increased Sequestration of CO_2 due to Growth of Vegetation from Proposed Program Treatments

Table 5.4.2 shows total acres burned by major WHR lifeform category (from Section 4.2) and the number of acres likely to be treated by lifeform category by bioregion.

Table 5.4.2
Average Annual Acres Burned by Wildfire and Proposed Treatment Acres by WHR Major Lifeform

Bioregion	Timberland	Woodland	Shrubland	Grassland	Total
	Average Annual Acres Burned 1996 -2005				
Klamath/North Coast	2,267	2,975	998	1,206	7,446
Modoc	1,188	81	287	259	1,815
Sacramento Valley	4,570	8,478	16,759	6,017	35,824
Sierra	1,505	2,344	5,025	4,785	13,659
Bay / Delta	12	1,673	2,330	4,453	8,468
San Joaquin Valley	16	754	1,226	14,470	16,466
Central Coast	17	247	4,456	2,162	6,882
Mojave	283	13	16,708	5,747	22,751
South Coast	2,127	3,379	35,328	1,877	42,711
Colorado Desert	0	0	0	0	0
Total	**11,985**	**19,944**	**83,117**	**40,976**	**156,022**
Proposed Annual Program Treatment Acres by WHR Major Lifeform					
Klamath/North Coast	17,600	1,900	3,100	2,700	25,300
Modoc	13,000	3,300	4,900	1,100	22,300
Sacramento Valley	2,200	13,700	1,100	14,200	31,200
Sierra	19,800	8,100	4,700	10,200	42,800
Bay / Delta	5,800	3,400	2,100	4,400	15,700
San Joaquin Valley	100	1,400	1,200	9,000	11,700
Central Coast	1,100	11,200	9,500	16,200	38,000
Mojave	500	400	800	300	2,000
South Coast	700	1,700	14,900	3,300	20,600
Colorado Desert		500	6,600	100	7,200
Total	**60,800**	**45,600**	**48,900**	**61,600**	**216,900**

All treatments except for herbicide application are expected to result in increased growth rates of forest and rangelands. Most herbicide treatments are expected to retard growth of target species, which will likely offset any corresponding increase in growth of non-target species. Thus, there is no expected change to GHG emissions from herbicide treatments, along with the fact that herbicide treatments are limited to 10% of all treated acreage annually.

Mechanical treatments are expected to result in only a small increase in overall carbon stored in forests and rangelands due to increased growth of residual vegetation, as treatments are likely to reduce overstory canopy levels by 10-40% in surface fire ecosystems and up to 75% in crown fire ecosystems (see Chapter 5 for description of surface and crown fire ecosystems elements). Mechanical treatments can increase growth and therefore the amount of sequestered carbon compared to no treatments, but such treatments can also result in the gradual release of CO_2 as treated fuel left on site (e.g., crushed or left in windrows/piles) degrades. Mechanical treatments that include pile burning or broadcast burning result in immediate impacts to air quality and to atmospheric CO_2, as discussed below. Also, increases in growth are not immediate. It can take as long as 10 years before treated vegetation achieves increased growth rates above those of untreated vegetation. "Natural" accretion of CO_2 on forest and woodland surface fire regime

vegetation is expected to sequester about 0.4-0.5 tonnes/acre/year of CO_2. Treating vegetation in surface fire regimes is expected to improve accretion rates by about 1.2% – 1.5% per year.

Mechanical (and hand) treatments in crown fire ecosystems, such as in chaparral, often result in temporary conversion of vegetation on the site to mixed grassland/chaparral. Chaparral stands remove CO_2 from the atmosphere at a rate of approximately 0.1 tons of CO_2 per year, adding to the existing stocks of 7-12 tons/acre of CO_2 already stored in the chaparral. Mechanical (and hand) treatments that temporarily change chaparral stands into mixed grassland/chaparral likely result in stored carbon levels dropping from around 7 –12 tons of CO_2 per acre to around 1-3 tons per acre. In addition, the dead vegetation created by mechanical (and hand) treatments degrades over time and gradually emits CO_2 as well.

Hand treatments in surface fire regimes include such actions as thinning understory fuels, removing small trees and shrubs, etc. These hand treatments are expected to increase growth and therefore the biomass of the remaining forest and range vegetation at rates of around 1.5%/year over untreated vegetation. These growth-inducing impacts are somewhat offset by the gradual CO_2 emissions resulting from degradation of the treated vegetation left on site (Petrova, et. al, 2006). As noted earlier, growth increases are not immediate and can often take 5-10 years before improvements from treatment are fully realized. Hand treatments that include pile burning have direct air quality and CO_2 emission effects. Few hand treatments are expected in crown fire regimes, but where they do occur they are expected to result in a reduction in CO_2 being sequestered on an annual basis compared to the sequestration that occurs within untreated crown fire regimes.

Prescribed burning in surface fire regimes (e.g. conifer and hardwood forests, etc.) (see Table 5.0.2) is expected to result in improved growth of the residual vegetation. As in other treatments, growth increases are expected to take up to 10 years before becoming fully effective. Prescribed fire results in immediate CO_2 emissions, albeit at lower rates compared to wildfire. In addition to the immediate increase in CO_2 emissions, there is also a gradual release of CO_2 from vegetation that is killed immediately after treatment and not volatilized during the actual treatment itself. Prescribed fire in surface fire regimes is expected to result in increased biomass, compared to no treatment, resulting in an additional 1.2% to 1.5% CO_2 being sequestered per year compared to no treatment, after the 5-10 year lag period.

Prescribed burning in crown fire regimes (shrub and grasslands) is not expected to result in improved growth nor in additional CO_2 accretion as up to 75% of the carbon stocks are expected to be converted to CO_2 during burning, some portion is retained in char and burned chunks and the balance slowly degrades over time as a result of prescribed fire-induced mortality over time. As these crown fire regimes recover, they begin sequestering CO_2, but given treatment maintenance, which requires periodical reburning, it is assumed that these crown fire ecosystems do not sequester sufficient CO_2 to offset the CO_2 given off by wildfire.

Table 5.4.3 summarizes the annual additional amount of CO_2 removed from the air by bioregion due to treatment. The approximately 38 million acres of jurisdiction land sequester an annual net (after removals) volume of about 6.35 million tonnes of CO_2 annually. For comparison, Brown (2004b) estimated that the state's approximately 68 million acres of forest and rangelands

annually sequester about 13.05 million metric tonnes of CO_2 per year, and after removals (e.g. fires, harvest, etc.) the net sequestration is about 8.76 million metric tonnes annually.

Table 5.4.3
Additional Annual CO_{2E} Accretion on Program Lands Due to Treatments

Bioregion	Additional Metric Tonnes of Carbon Sequestered Annually Due To Treatments Improving Growth and Biomass				
	Timberland	Woodland	Shrubland 1/	Grassland 1/	Total
Klamath/North Coast	486	535			1,021
Modoc	359	471			830
Sacramento Valley	61	658			719
Sierra Nevada	547	905			1,452
Bay Area / Delta	160	329			489
San Joaquin	2	247			249
Central Coast	30	802			832
Mojave	14	42			56
South Coast	19	435			454
Colorado Desert	1	153			154
Grand Total	**1,679**	**4,578**			**6,257**

1/ Both shrubland and grassland are considered crown fire regime vegetation types; treatments tend to result in replacement of the vegetation negating potential growth of "remaining" vegetation.

Prescribed herbivory is expected to have impacts on surface fire regimes similar to hand treatments, though fuels removed are not a source of CO_2 emissions as they are instead converted to emissions of CH_4. Nonetheless, in surface fire regimes, prescribed herbivory is expected to result in an additional 1.2% to 1.5% more CO_2 being sequestered per year compared to non-treated areas (after the 5-10 year lag period). In crown fire regimes, prescribed herbivory is not likely to be a common treatment, though goats are being used to treat a 4,000-acre area of short chaparral in Tehama County. Prescribed herbivory in these crown fire ecosystems is not expected to result in an increase to existing carbon stocks; instead, carbon stores are likely to be reduced from 3-7 tons/acre to 1-3 tons/acre, with accretions being similarly reduced due to removal of the chaparral and replacement by grass ecosystems.

By the end of the first decade after implementation (2022), the Proposed Program treatment effects would just be kicking in, and total additional CO_{2E} stored due to 216,910 acres of treatments in 2012 would be about 6,250 additional tons of CO_{2E} stored. In implementation year 11, another 6,250 metric tonnes of CO_{2E} would have been sequestered on the 216,910 acres treated in 2012 and an additional 6,250 metric tonnes of CO_{2E} would have been sequestered from 216,910 acres of new treatments implemented in 2013. At 30 years into the program (2042) total additional CO_{2E} sequestered would be 1.57 million metric tonnes of CO_{2E} compared to the Status Quo.

Increased sequestration of CO_2 due to growth from treatments under implementation of Alternatives

Alternative 1, the Status Quo, would not sequester any additional carbon that isn't already

accounted for in the work by Brown (2004b), which established the baseline amount of CO_2 sequestered by forest and rangelands used for this analysis.

Annual sequestration by the other Alternatives is proportionately similar to the Program based on the number of acres treated by prescribed fire, mechanical, hand and herbivory in any one year. There are no discernible differences in the rates of sequestration from the growth-inducing treatments (prescribed fire, mechanical, hand and herbivory) by Alternative treatments; however, there are differences between treatments in terms of CO_2 emissions. The apparent differences in sequestered CO_2 by alternative is due to the differences in the number of acres treated in any one year rather than variations in treatment types. Thus, Alternative 2 would actually sequester slightly more metric tonnes of CO_2 than the Proposed Program because it treats about 13,000 more acres by hand and mechanical treatments (73,750 acres) that can increase growth (and therefore in total tons of biomass) compared to the Proposed Program, which only treats about 60,700 acres by non-prescribed fire treatments. Alternative 3 is expected to sequester about the same amount of CO_2 as the Proposed Program because treatment acreages are similar. Alternative 4 would only sequester about 42% as much CO_2 as the Proposed Program.

Emissions of CO_2 due to Program Treatments and Wildfire

The Proposed Program treats about 115,000 acres with prescribed fire. Both the BLM (USDI BLM 2005b) and Brown (2004b) present emissions data for wildfire and/or prescribed fire, as noted above. Calculating the CO_2 emissions from the expected change in wildland fire severity due to treatments is difficult.

Prior to treatment, about 12,000 acres of forest and rangelands are burned by wildfire at low severity; 20,000 acres burn at moderate severity, and 124,000 acres at high severity, based on historical trends. Based on the estimate by Brown (2004b) of 20%, 40% and 75% consumption of vegetation by low, moderate and high severity wildfire, total CO_{2E} emitted after wildfires on jurisdiction lands would amount to about 811,400 metric tonnes. Brown (2004b) estimates that wildfires emit about 2.4 million metric tonnes of CO_{2E} per year from all of California's forests and rangelands.

After treatment, CO_2 emissions due to wildfire would be expected to drop from 811,400 metric tonnes emitted annually to 638,400 metric tonnes emitted annually, due to treatments that reduce wildfire severity. It should be noted that for this analysis (and in Brown's 2004b analysis) high severity wildfire is projected to emit about 75% of total carbon stocks immediately as CO_2 while around 16% of carbon stocks are not volatilized but are instead turned into long-lived charcoal and soot which generally are not added to the overall CO_2 emissions from wildfires. Also, as much as 8-10% of total carbon stocks in severely burned wildfire areas are retained on site as dead wood which emits CO_2 as it decays over time.

Although a reduction of 173,000 metric tonnes of CO_2 from the atmosphere due to treatments is not trivial, it is somewhat offset by increased CO_2 emissions from 115,000 acres in the Proposed Program being potentially treated with prescribed fire. Prescribed fire treatments are expected to be considerably less intensive than wildfires. Based on the literature describing tons of CO_2 produced from prescribed fire by vegetation type and using Brown's fire intensity percentages for

the amount of carbon volatilized into CO_2, the Proposed Program would emit about 262,000 metric tonnes of CO_2, as shown in Table 5.4.4.

Table 5.4.4
Acres of Vegetation Treated Annually by Prescribed Fire and Tons Of CO_2 Emitted Annually

Bioregion	Timberland	Woodland	Shrub	Grassland	Total
	Acres of Prescribed Fire by Vegetation Type				
Klamath/North Coast	9,300	1,000	1,600	1,500	13,400
Modoc	6,900	1,700	2,600	600	11,800
Sacramento Valley	1,200	7,200	600	7,500	16,500
Sierra	10,500	4,300	2,500	5,400	22,700
Bay Delta	3,100	1,800	1,100	2,300	8,300
San Joaquin	0	800	600	4,800	6,200
Central Coast	600	5,900	5,000	8,600	20,100
Mojave	300	200	400	200	1,100
South Coast	400	900	7,900	1,700	10,900
Colorado Desert	0	300	3,500	0	3,800
Grand Total	**32,300**	**24,100**	**25,800**	**32,600**	**114,800**
Tons of CO_2 Stocks/Acre	**35.0**	**8.0**	**7.0**	**3.5**	
Volatilization Factor (See Table 5.0.2)	**10%**	**10%**	**40%**	**80%**	
Bioregion	**Metric Tonnes of CO2 Emitted Due to Prescribed Fire**				
Klamath/North Coast	32,550	800	4,480	4,200	42,030
Modoc	24,150	1,360	7,280	1,680	34,470
Sacramento Valley	4,200	5,760	1,680	21,000	32,640
Sierra	36,750	3,440	7,000	15,120	62,310
Bay Delta	10,850	1,440	3,080	6,440	21,810
San Joaquin	0	640	1,680	13,440	15,760
Central Coast	2,100	4,720	14,000	24,080	44,900
Mojave	1,050	160	1,120	560	2,890
South Coast	1,400	720	22,120	4,760	29,000
Colorado Desert	0	240	9,800	0	10,040
Grand Total	**113,050**	**19,280**	**72,240**	**91,280**	**295,850**

Emissions of CO_2 due to Alternatives—Treatments and Wildfire

Alternative 1 would not result in any change to the amount of CO_2 emitted by wildfires and by prescribed fire, as these emissions are already included in the baseline CO_2 calculations by Brown (2004b). Alternatives 2 and 3 would generate slightly more CO_2 emissions (280,000 metric tonnes) than those associated with the Proposed Program (262,000 metric tonnes) due to prescribed fire treatments, and would release approximately the same amount of CO_2 emissions from wildfire as the Program.

Alternative 4 would have a substantially different effect on CO_2 emissions compared to the Proposed Program or the other Alternatives from both wildfire and prescribed fire, because Alternative 4 only treats about 7,400 annually acres with prescribed fire. As a result, Alternative 4 would only emit about 14,600 tons of CO_2 due to prescribed fire, an 18-fold reduction in CO_2 emissions. However, because only 43% as many acres are treated, and because the mechanical and hand treatments relied on by Alternative 4 are often less effective at reducing wildland fire effects, the amount of CO_2 emitted by wildfire could potentially be substantially higher under Alternative 4 compared to the Program. While implementation of Alternative 4 results in less CO_2 emitted by prescribed fire, it reduces wildfire severity on substantially fewer acres: about 119,000 acres burn at high severity in Alternative 4 after treatments, compared to 97,000 acres in the Proposed Program. In addition, many more acres burn at moderate severity compared to the Proposed Program. As a result, implementation of Alternative 4 would result in emissions from wildfires of about 788,750 metric tonnes of CO_2, compared to 638,400 metric tonnes of CO_2 under the Program.

5.4.5 Indirect Effects of Implementing the Program/Alternatives

Indirect effects to climate from implementation of the Program could be expected from emissions of CO_2 and other greenhouse gases. Indirect effects could include changes in health of individuals from poorer air quality and from more predicted temperature extremes. In addition, global warming from CO_2 emissions is expected to increase the wildland fire frequency in the state so that an additional 55,000 acres of forest and rangeland is expected to burn annually; however, most of this increase is not due to the Program or any of the alternatives (see Section 4.2). On the other hand, treatments can improve pest and wildfire resiliency resulting in fewer acres burning at high intensities, and improving forest conditions so that climate induced pest problems are less likely to create significant impacts. In addition, treatments may help forest stands in particular to resist conversion to shrublands as climate change increases temperature stress on forest lands throughout the state.

5.4.6 Determination of Significance

Implementation of the Program would initially result in an increase in CO_2 emissions over the status quo of about 295,000 metric tonnes per year due to treating 115,000 acres with prescribed fire. However, total CO_2 emitted from wildfires burning both treated and untreated forest and range jurisdiction lands would drop from about 811,000 tons to 638,200 tons of CO_2 emitted annually. The difference between the amount of CO_2 emitted by prescribed fire compared to the reduction in CO_2 emitted due to less wildfire is approximately a net increase in CO_2 emissions due to prescribed fire treatment of about 122,000 metric tonnes of CO_2 per year.

However, implementation of the Program would increase CO_2 sequestration at a rate of 6,250 metric tonnes/year due to increases in the growth of residual vegetation resulting from the treatments. As noted above, however, the additional sequestration will not "kick in" for about 10 years after treatments because of a 5-10 year lag in growth due to treatments. At the end of 30 years (2042) of treatments, an additional 1,500,000 metric tonnes of CO_2 would have been sequestered due to Program treatments.

Combining the additional sequestration of CO_2 resulting from growth increases against thirty years worth of net emissions of 3,660,000 metric tonnes of CO_2 from prescribed fire and wildfire results in a net emission of about 2,160,000 metric tonnes of CO_2 over the 30 year period or about 72,000 metric tonnes/year

Implementation of the Program would not result in a significant adverse change in air movement, moisture, temperature, or other aspects of climate, because jurisdiction forest and rangelands would continue to sequester about 6.35 million tons of CO_2 annually. As a result of Program implementation, a reduction in CO_2 emitted due to wildfires would be offset by an increase in CO_2 emitted by prescribed fire, resulting in approximately a net increase of 72,000 metric tonnes of CO_2 being produced per year above the status quo. However, due to sequestration by forest and rangelands, overall CO_2 sequestration would still remain positive at 6.36 million metric tonnes per year. Therefore, implementation of the Program would result in a less than significant impact to the environment because CO_2 levels associated with forest and rangelands under CAL FIRE jurisdiction in 2020 would not exceed the 1990 levels of such gases.

5.4.7 Similar Effects Described Elsewhere

The effects of Program implementation associated with air quality are described in detail in Section 5.6.