IMPORTANCE OF FOREST BIOMASS UTILIZATION TO CALIFORNIA FOREST PROTECTION AND RENEWABLE ENERGY GOALS

California Department of Forestry and Fire Protection
April 12, 2012

Background

The California Department of Forestry and Fire Protection (CAL FIRE) is responsible for the protection and stewardship of over 31 million acres of privately owned wildlands (forest and rangelands). These lands provide critical environmental, economic and social benefits to California citizens. Recent development, historic management practices, effective fire suppression activities and other factors have resulted in modified forest structure, increased biomass in small diameter trees and understory vegetation, and vegetation species shifts. These factors have resulted in increased fuel loading, decreased forest health, and increased threat of extreme wildfire behavior.

Wildfires currently burn over 200,000 acres annually (five year average) on CAL FIRE responsibility areas, costing over $200 million per year in suppression and resulting in over $100 million annually in damages to property and resources[1]. More than 7,000 wildfires burn over 900,000 acres on average in California[2]. Total acres burned on state and federal responsibility lands have been increasing for several decades[3]. Recent climate change studies project 57-169% more wildfire by the end of the century, with a doubling of burned acres in northern California[4].

Fuel Treatment/Biomass Relationship

Wildfire risks and hazards can be reduced by thinning trees and removing brush. This restores forest conditions that are more resistant to wildfire damage. Treatments are very costly, however, and markets for harvested biomass currently provides little economic incentive to utilize biomass for production of energy. The USFS currently treats about 100,000 acres per year, but currently have a policy statement in-place calling for a four to fivefold increase in acreage treated. CAL FIRE provides cost-share and grant funds to treat about 15,000 acres per year. This is far less than the estimated one million acres per year[5] needed to protect natural resources and the public.

Quantification of Biomass Potential

Forest biomass residues (i.e. unused material from logging, thinning and fuel management, left to decay or burned in piles) constitute an underutilized feedstock for renewable energy generation. About 800,000 bone dry tons (BDT) per year of forest biomass is currently used for energy production[6]. CAL FIRE's priority for enhanced utilization is the untapped 2.8 million BDT of biomass, including brush, in targeted fire threat treatment areas that would be technically available if funding were available for

[1] (Upton)
[2] CAL FIRE 2010 Redbook
[3] Keithley and Bleier 2008; other sources?),
[4] (Westerling et. al, 2009)
[5] (CAS 2009; my personal communication with Max Moritz, I think)
[6] (2011 ? Collab paper)

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treatment. An additional 1.5 million BDT are technically available on an annual basis from current logging activities, for total of 4.3 million BDT per year statewide[7].

Challenges and Barriers

In order to use biomass projects as a tool, first there must be a biomass energy facility within reasonable proximity, making the biomass material economically available. Second, biomass material must be technically available. Areas that are inaccessible should be excluded as should areas where biomass is unavailable due to regulations or management direction.

Currently, extensive areas of technically available biomass are not served by operational biomass facilities. Factors that constrain investment in new facilities include:

1. Uncertainty in future energy prices which affects biomass value and transportation cost structure.
2. Uncertainty regarding supply to biomass from public lands.
3. Opposition to siting of new biomass facilities
4. Permitting barriers.
5. Public concerns regarding impacts and sustainability of increased biomass removals from forested landscapes.

Market Based Approach

The CAL FIRE 2010 Forest and Rangeland Assessment[8] analyzed how operational, idle and six proposed biomass plants could support fire prevention priorities for ecosystem restoration and community safety (Figures 2.1.5 and 2.1.9). It found that only 22% of high priority sites for maintaining ecosystem health and 14% of priority sites for community safety were within 25 miles of these plants (see Figure 3.4.6).
CAL FIRE estimates that the current cost of removing and hauling biomass 25-50 miles to a plant is about $35-50/BDT. About a third of that cost is for transportation. At current energy rates of approximately 8.5-10 cents/kw (depending on the contract), it is estimated that every additional 1 cent/kw could provide an additional $10/ton for biomass handling, provided this marginal increase is available to the landowner. A preliminary rough estimate suggests that an increase of 1-1/2 to 2 cents/kw (to 10.5-12 cents/kw) could significantly increase the private and public acreage accessible to biomass utilization and facilitate treatment of more areas critical to ecosystem restoration and community safety

Increasing the price for biomass energy to recognize both ratepayer and greater public benefit will increase the viability of existing biomass operations and encourage development of additional infrastructure. A robust biomass industry will increase the market for forest biomass and revenues for forest health and community fuel reduction treatments. It will also help meet goals for providing 33% of State energy from renewables in 2020 and 20% of that from biomass. Finally, it will produce additional environmental and social co-benefits of avoided air pollutants from open burning, diversion from landfills, reduced net greenhouse gas emissions, rural job development and others. Environmental benefits alone have been estimated at 5 to 20¢/kw.[9]

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[7] PIER – Rosenberg report 2005
[8] FRAPAssessment 2010
[9] Morris 2000.....

Goals for increased forest health and fire hazard treatments are included in recent State climate and energy policies and reports. Fuels reduction was identified as a mitigation strategy in the 2006 Climate Action Team, a risk to sequestered carbon in the AB 32 Scoping Plan, and an adaptation strategy in the 2009 California Adaptation Report. Fuels reduction and biomass goals are included in the Bioenergy Action Plan, developed by the Bioenergy Interagency Work Group on which CAL FIRE and the Board of Forestry and Fire Protection (BOF) participate. Actions include BOF development of policies supporting biomass utilization, fire hazard severity zone mapping, permitting tools to facilitate fuels reduction, and defining sustainable forest biomass utilization in conjunction with ARB and CEC.

In summary, CAL FIRE is interested in maintaining and expanding the utilization of forest biomass residues for energy in order to achieve the following benefits:

- Improved capacity of private landowners to thin forests and reduce hazardous fuels by providing a robust private market for utilizing forest treatment residues
- Improved ability to treat 2.8 million tons in targeted fire threat treatment areas, to reduce wildfire threat to life, property and resources, and to reduce fire suppression costs
- Climate mitigation to reduce GHG emissions by avoiding wildfires and providing an alternative to fossil fuel, and climate adaptation to make forests more resilient to wildfire and pests
- Achieve energy goals for 33% renewables and 20% of renewables from biomass
- Employment opportunities in rural communities

Current Biomass Strategic Approach from 2010 Assessment

The current strategic approaches of CAL FIRE are as follows:

1. Strategy 3.4.1-Facilitate development of sustainable biomass harvest practices to grow, collect and store forest and range biomass resources and deliver it as feedstock to biomass markets.
2. Strategy 3.4.2-Facilitate the expansion of biomass markets through improved infrastructure, monetization of external benefits, feedstock collection, and generation capacity.
3. Strategy 3.4.3- Support and conduct biomass research and development including life cycle analysis, best management practices, monitoring and sustainability.
4. Strategy 3.4.4-Support education and training and the development of curricula to inform citizens, consumers, and decision makers and develop a well trained biomass industry professional base in California.
5. Strategy 3.4.5-Address existing constraints and develop new policies, laws, and regulations that promote and facilitate the expanded use of biomass while protecting the state's environment.
6. Strategy 3.4.6-Support the development of voluntary and compliance carbon markets.

Strategy: 3.4.3. Support and conduct biomass research and development including life cycle analysis, best management practices, monitoring and sustainability.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support and conduct biomass research and development including life cycle analysis, best management practices, monitoring and sustainability	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced; rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.4. Support education and training and the development of curricula to inform citizens, consumers, and decision makers and develop well trained biomass industry professionals in California.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support education and training and the development of curricula to inform citizens, consumers, and decision makers and develop well trained biomass industry professionals in California	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced; rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.5. Address existing constraints and develop new policies, laws and regulations that promote and facilitate the expanded use of biomass while protecting the state's environment.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Address existing constraints and develop new policies, laws and regulations that promote and facilitate the expanded use of biomass while protecting the state's environment	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced; rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.6. Support the development of voluntary and compliance carbon markets.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support the development of voluntary and compliance carbon markets	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Climate Change	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Carbon tonnes traded annually in the voluntary and compliance markets.	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Forest Biomass Resources

Including Timber Harvest and Fire Threat Reduction Potentials

California Biomass Collaborative

April 5, 2011

Mark Rosenberg
California Department of Forestry and Fire Protection
Fire and Resource Assessment Program (FRAP)

Visit our web site at: http://frap.cdf.ca.gov

Background

Sources of Forest Biomass include logging slash, lumber mill wastes, small non-merchantable logs and shrubs

Policy Issues	Public Benefits
Reduced wildfire impacts to public health and safety (Public Resources Code, CA Fire Plan)	Improve air quality (fewer fire emissions)
Renewable Energy from Biomass Resources (RPS - SB107, 2006 and SB1078, 2002)	Reduce net carbon emissions
Carbon sequestration - for mitigating global climate changes (AB32, 2006; AB1504, 2010)	Create fire safe communities
	Promote healthy, resilient forests
	Produce lumber, energy and other products

Biomass Energy in CA

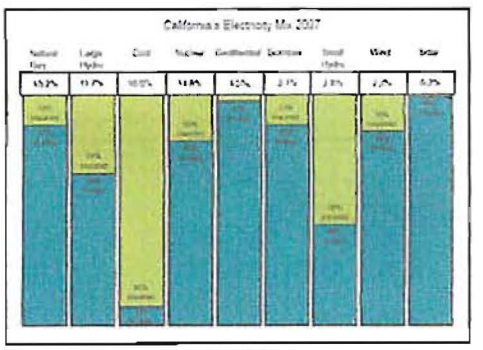

Figure 3.4.1
California energy sources for electricity, 2007

- Biomass comes from Forest, Ag and Urban processing wastes
- Biomass provides about 2.1% of California's electricity.
- Forest biomass provides about 1% of California's electricity
- Forest biomass potential is thought to be much higher
- Economic barriers to increased biomass utilization
- Concerns over Long-term biomass supply and possible ecological and other impacts

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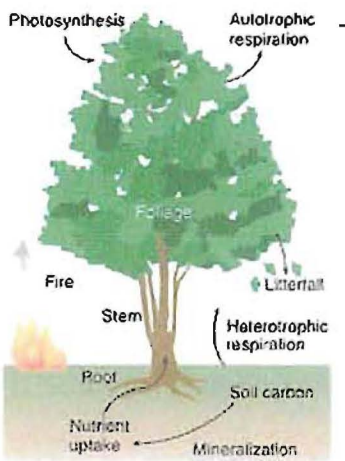
Carbon Cycle



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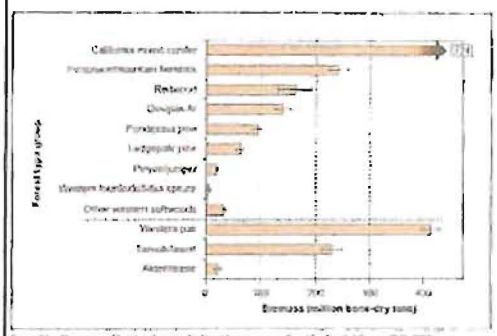
Forest Biomass Pools

- Bole (trunk)
- Branch and Leaf Foliage
- Roots
- Down Woody Debris
- Soil Organics

Forest Biomass Sources

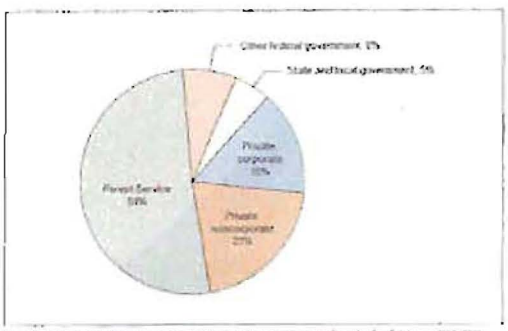
- Logging Slash
- Mill Wastes
- Forest Thinning operations
- Fire Threat Reduction Treatments (Forest and Shrub biomass potential)

Biomass In CA



- FIA (2005) estimates
  - over 2 billion tons of biomass in live trees 1" DBH and greater
  - 1.5 billion tons on Timberlands (FIA 2005).
- Softwood forests:
  - 2x the biomass of Hardwood types
  - Mostly in trees larger than 21" DBH.
- Hardwood biomass
  - Concentrated in trees with 9"-12" DBH.
- National Forest Service lands
  - 50% of Forest Biomass
  - 1/4 of this is reserved
- Down Woody Material (DWM)
  - Approximately 500 million tons

Growing stock, Removals and Growth



- Key indicator of forest sustainability
- Growth was equal to or exceeded mortality/removals for public and private lands (Christensen et al., 2008)
  - Largest increase on National Forest lands
  - Corporate owned "industrial" timberland removals exceed growth (estimate has high uncertainty)
- Improved estimates available in the next few years

Timber Harvest in CA
(FRAP 2010 Assessment)

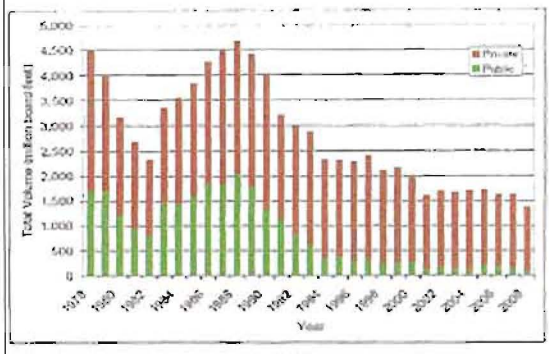
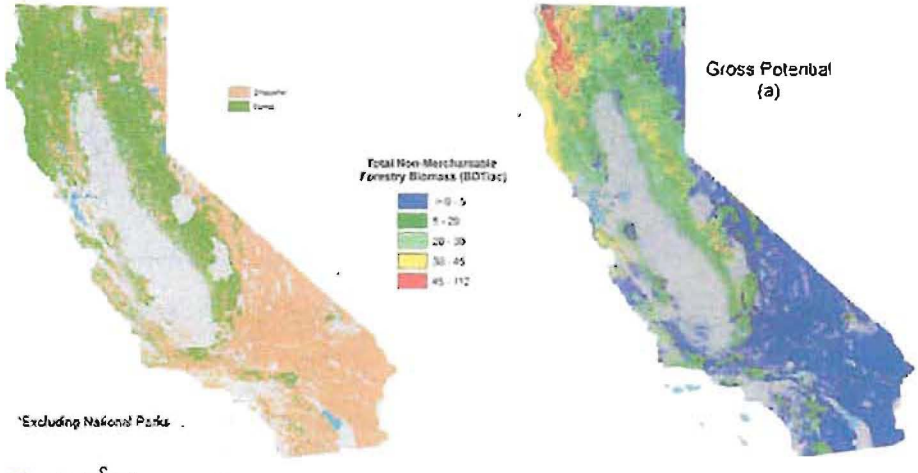


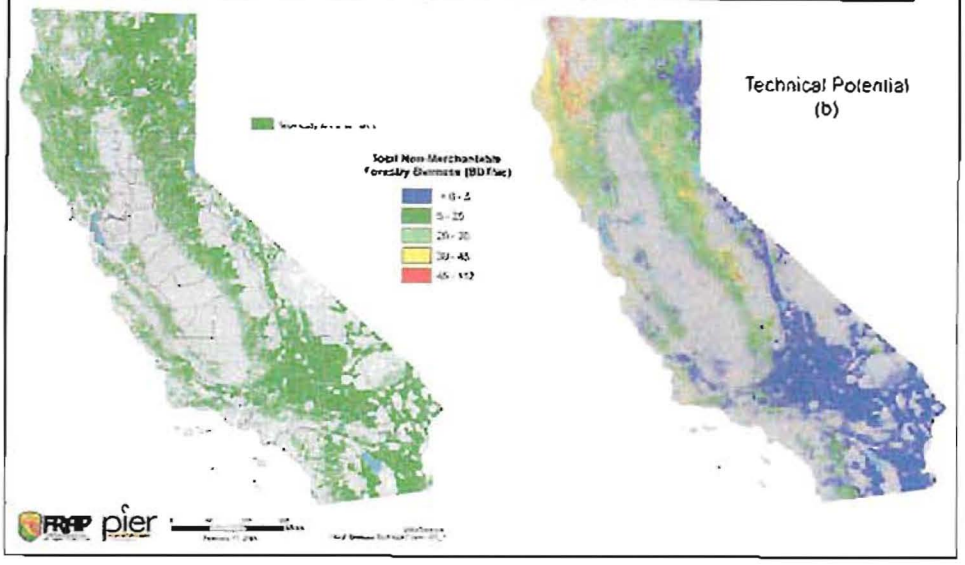
Figure 1.2.4
Annual timber volume from private and public lands.
Data Source: Timber Tax Program, California State Board of Equalization, 2009

- Timber harvesting by-products:
  - logging slash
  - mill wastes
- Harvest levels are declining.
- Annual Harvest covered 1.64 % of private timberland acres
- Private land harvest levels indicate a 61-year rotation.
- Relatively little harvesting has taken place on federal lands.

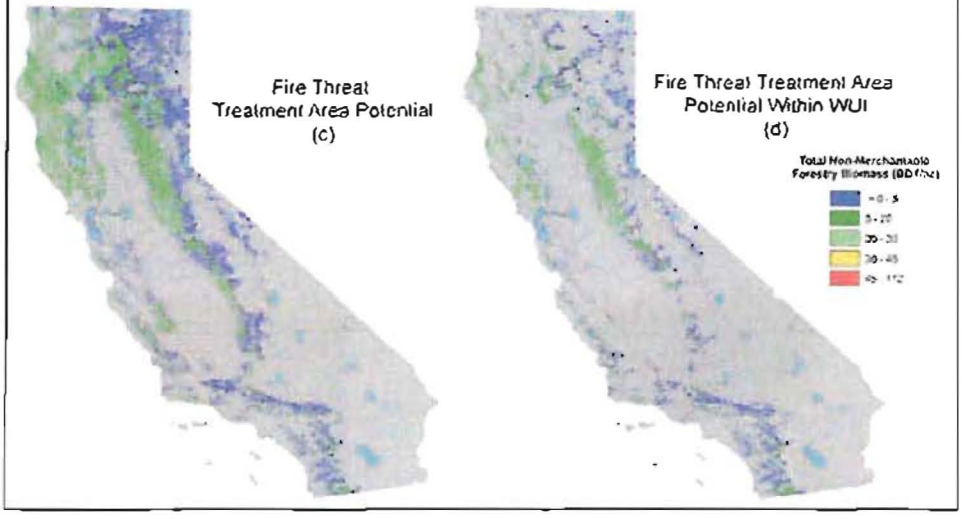
Total "Non-Merchantable" Biomass Potential



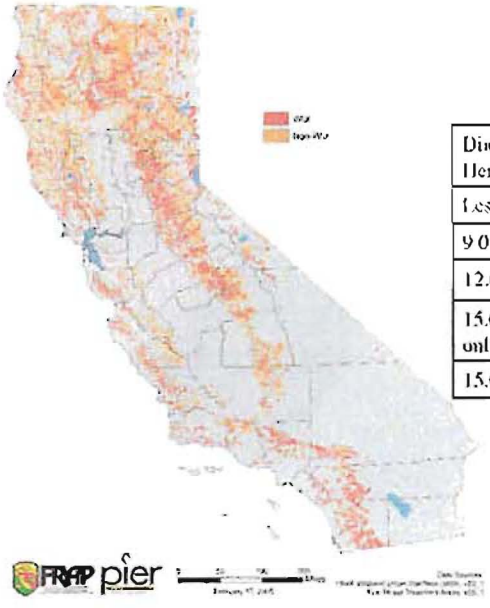
CA Forest and Shrub Biomass Areas Available for Management Activities



Fire Threat and Wildland Urban Interface (WUI) Areas



Modeled Fire Threat Treatments



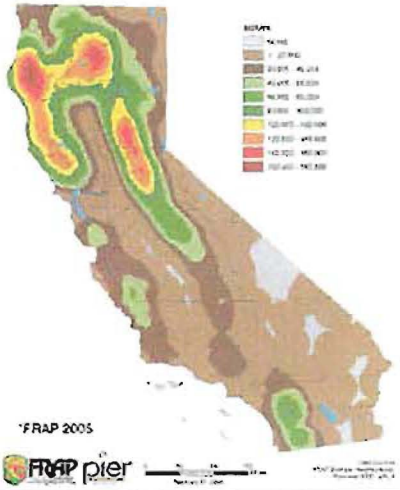
Diameter (inches) at Breast Height	Tree Volume Removed[6]
Less than 9.0	90%
9.0 - 11.9	50%
12.0 - 14.9	20%
15.0 and greater (private land only)	5%
15.0 to 29.9 (national forests)	5%

- Example Fire Threat reduction treatment (above) modeled every 25 years on private lands and 50 years on Federal lands

Estimated Annual Biomass Potential from Fire Threat reduction and Average Timber Harvest Volume in California*

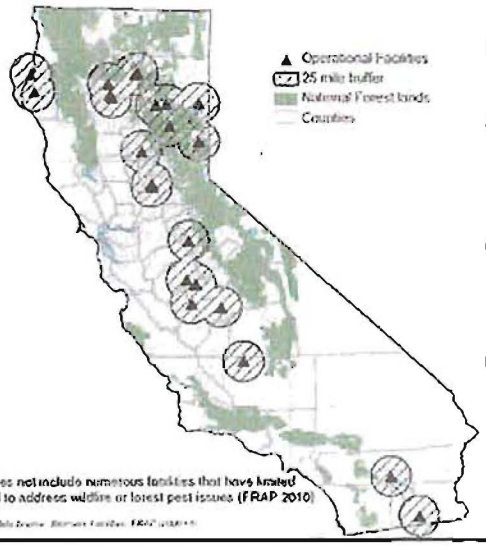
Yellow and Red areas represent greater than 100,000 BDT/y within the 25 mile search window

Annual Electrical Capacity (MWe) of slash and thinning from Fire Threat Treatment Area and average annual Harvest (1999-2003)



*FRAP 2005

Operational* Biomass facilities in California with potential to address wildfire or forest pest hazards



*This does not include numerous facilities that have limited potential to address wildfire or forest pest issues (FRAP 2010)

- Proximity to operational biomass facility key to economics
- California had 49 operating biomass plants in the mid-1990s; in 2010 there were 33
- Only 20% of high threat communities and forests are near biomass facilities (FRAP 2010)
- FRAP assessed 12 idle or proposed facilities (FRAP 2010)

Proposed and Idle Biomass Facilities

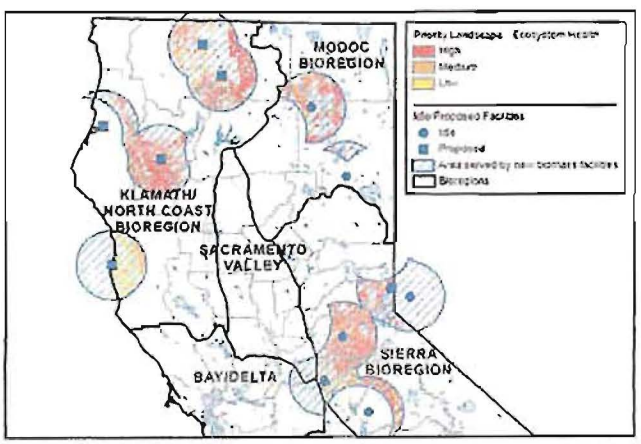


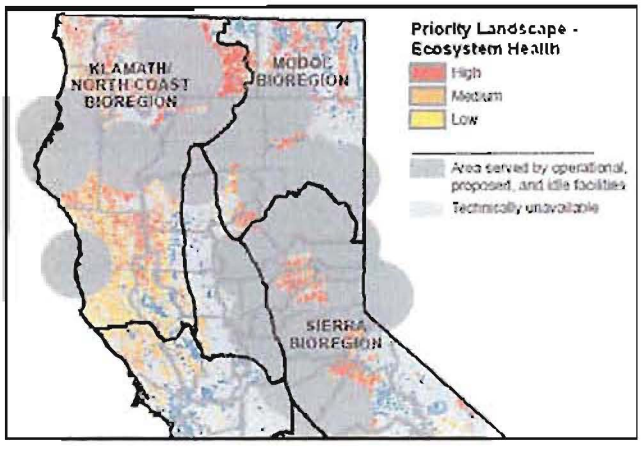
Figure 3-4.3
Priority landscapes for ecosystem health with potential for new biomass facilities. Priority landscapes that are technically unavailable (e.g., steep slopes, stream buffers, wilderness areas) or have too little biomass to be economically available (less than 50,000 bone dry) are excluded in the map. Map shows only the portion of the state that is affected by making the 12 idle or proposed biomass facilities operations

FRAP 2010

Adding 12 facilities will

- Reach forest health priorities in
  - Klamath
  - North Coast
  - Modoc
  - Sierra
- 11 new high priority communities.

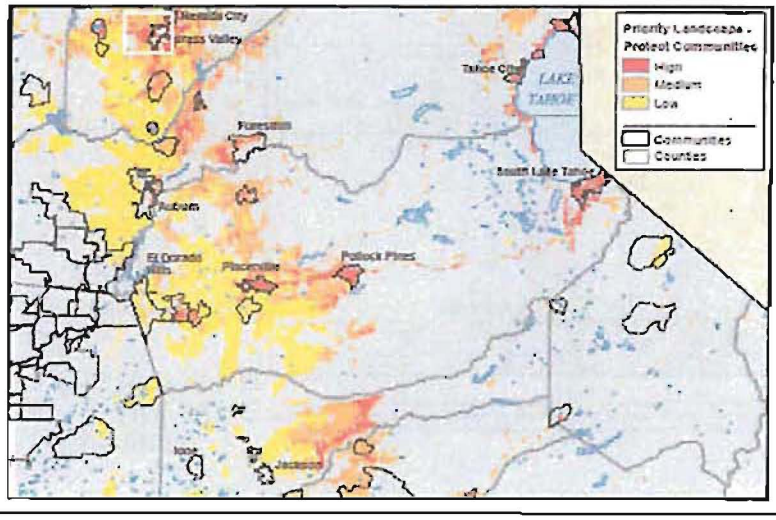
Proposed and Idle Biomass Facilities



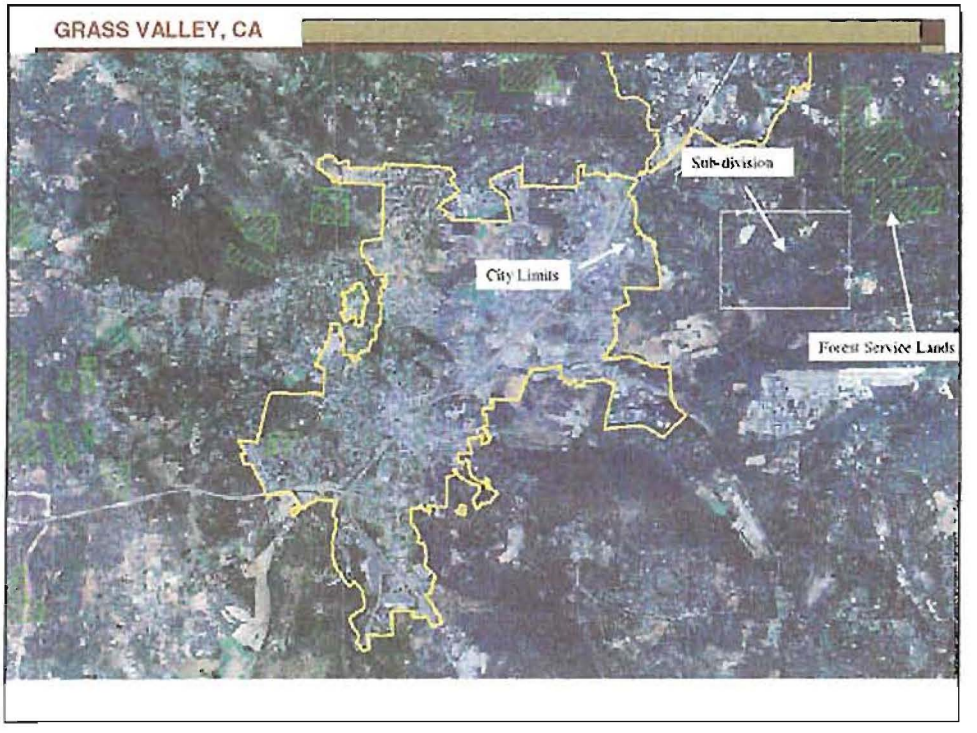
- Only ~ 20% of high priority areas near operational biomass facility.
- Adding 12 facilities would increase this number to ~40%
- Over 50% high priority areas on U.S. Forest Service lands
- Coordination across agency boundaries is critical.

California's Forests and Rangelands: 2010 Assessment

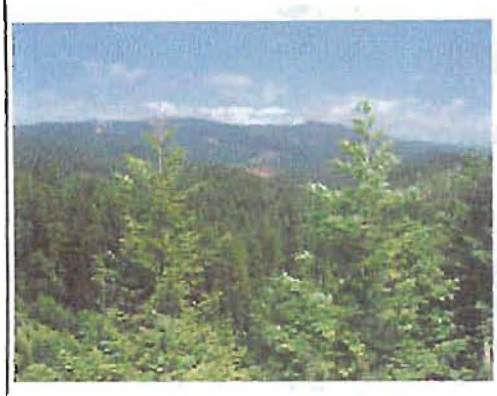
Wildfire Threats to Communities



GRASS VALLEY, CA


GRASS VALLEY, CA
Sub-division
City Limits
Forest Service Lands

Challenges



- Strategically link fire threat reduction and other public benefits to biomass utilization strategies
- Reduce economic barriers to speed forest biomass utilization
- Improve monitoring activities and use adaptive management to address ecological and other impacts

Thank You

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Chapter 3.4
Emerging Markets for Forest and Rangeland Products and Services

Assessments should identify forest landscape areas where there is a real, near term potential to access and supply traditional, non-timber, and/or emerging markets such as those for biomass or ecosystem services. These might be areas where necessary infrastructure currently exists, is planned or developing, where group certification of landowners has created market supply aggregation potential, or where retention and management of forest cover presents a money saving alternative to an engineered fix – such as a water filtration facility. Strengthening and developing new market opportunities for forest products and benefits provide incentives for forest stewardship and conservation (excerpted from the U.S. Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

KEY FINDINGS

Emerging markets for renewable energy, ecosystem services and niche products are impacting how forest and rangelands are managed. Developing appropriate policies requires a better understanding of the benefits and environmental impacts of these emerging markets and how society values the various market and non-market products and services provided by forests and rangelands.

Renewable Energy Overview

- In the Mojave and Colorado Desert bioregions the number and size of proposed solar and wind power generation sites has engendered controversy over potential impacts to wildlife habitat. The science-driven Desert Renewable Energy Conservation Plan is intended to become the state road map for renewable energy project development that will advance state and federal conservation goals while

facilitating the timely permitting of renewable energy projects in these desert regions.

Biomass Energy – Current Status and Trends

- Biomass energy from forestlands provides about one percent of California's electricity, while having the potential to provide nearly eight times this amount. Biomass also has unutilized potential for heating homes, businesses and schools and for conversion to liquid transportation fuels (as conversion technology evolves).
- Capturing energy from biomass that would otherwise decay, be disposed of by pile and burn or potentially consumed by wildfire, provides numerous economic and environmental benefits, which are not captured as an actual economic return for operators of facilities that utilize woody biomass material. Case studies confirm that fuels treatment activities involving biomass removal can mitigate wildfire behavior (Cone Fire, 2002).
- The various benefits and environmental impacts of forest biomass removal are complex and further research is required to guide appropriate policies and practices. Questions of long-term biomass supply (especially from public lands), as well as possible ecological and other impacts of biomass removal on forest sustainability, are key issues in California.
- The future of the biomass energy industry in California, at least as it relates to the forestry sector, is uncertain. California had 49 operating biomass plants in the mid-1990s; today there are 33.
- The California Energy Commission, working through the Bioenergy Interagency Working Group, has produced a comprehensive strategy for sustainable development of biomass in the state. The first Bioenergy Action Plan was released in 2006, and the goal is to adopt an updated plan by the end of 2010.

Biomass Energy – Ecosystem Health Analysis

Benefits of making six idle and six proposed biomass facilities operational are derived in terms of treating priority landscapes for ecosystem health from the wildfire and forest pests analyses articulated in previous chapters.

- Currently, 22 percent of high priority landscapes are within 25 miles of an operational biomass facility. Adding 12 facilities would increase this number to 39 percent, and would primarily benefit the Klamath/North Coast, Modoc and Sierra bioregions.
- Even with the additional facilities, 61 percent of high priority landscapes are farther than 25 miles from a facility. Since 57 percent of the high priority landscapes are on U.S. Forest Service lands, coordination across agency boundaries will be critical.

Biomass Energy – Community Safety Analysis

Building upon the wildfire and forest pests community safety analyses presented in previous chapters, this analysis determines the benefits of making six idle and six proposed biomass facilities operational in terms of treating priority communities.

- Currently, only 14 of the 66 priority communities are within 25 miles of an operational biomass facility. Adding the new facilities would reach eleven additional priority communities. Of the remaining 41 priority communities, 31 are in the South Coast bioregion.

- Developing a biomass industry in the South Coast bioregion that addresses the significant wildfire and forest pest threats will be challenging. In the bioregion, there are large acreages in shrub species that are difficult to recover and utilize as biomass, and much of the forestland is in public ownership.

Carbon

- Carbon sequestration is an ecosystem service for which markets are emerging; as part of these markets, the value of the service is quantified, prices determined and dollars generated for carbon credits.
- Markets are emerging for both voluntary exchange between parties (voluntary markets) and in response to the need to reduce carbon impacts as part of regulatory requirements (compliance markets).
- Demand for forest and range-related carbon is projected to be very significant in such markets and other venues.
- Carbon credit supply is constrained by economics, risk and other factors. It is estimated that one to two million metric tons a year will be available to the compliance market from California forests, which is only 10–25 percent of demand.
- Protocols already have been developed for forest and range-related carbon. The development of additional project type protocols for forests and rangelands could promote activities with ecological and economic co-benefits and increase the supply of carbon credits.
- California has large acreages of forest stands that with additional investment, could provide larger, future benefits in terms of forest products, jobs and carbon storage and sequestration. Opportunities also exist on rangeland, but the markets and necessary technologies to capture carbon are not sufficiently developed to quantify these opportunities.

Niche Markets

- There is potential for niche markets to stimulate rural economies through certified products, micro-biomass or landowner collaboratives to produce and market timber using small scale or portable milling technologies.

Ecosystem Services

- In many cases, market mechanisms for exchange of values from ecosystem services in California are still limited. Despite this, substantial investments have been made in the state that support ecosystem services. Typically, these investments involve protecting areas that provide unique or high levels of desired services, or restoring areas impacted by past events.
- These investments come through a variety of programs, agencies and stakeholders. Involvement of landowners and the development of partnerships and cooperation have been key factors. To a large degree, the underlying funding comes from public sources, such as ballot initiatives or agency budgets. Augmenting this with emerging market-based solutions could enhance the ability to sustain these important services into the future.

RENEWABLE ENERGY OVERVIEW

Current Status and Trends

Through legislation and executive orders, California has focused on increasing use and development of renewable energy. For example, one of the goals of the Renewables Portfolio Standard (RPS) (SB 107, 2006 and SB 1078, 2002) is to help reduce greenhouse gas (GHG) emissions. Another example is AB 32 which, in large part, is devoted to GHG reduction.

Related executive orders include:

- Executive Order S-06-06 (2006): established a biomass target of 20 percent within the established RPS goals for 2010 and 2020.
- Executive Order S-14-08 (2008): established accelerated RPS targets (33 percent by 2020) as recommended in the Energy Action Plan II. The order also called for the formation of the Renewable Energy Action Team, comprised of the California Energy Commission (CEC), Department of Fish and Game, U.S. Bureau of Land Management and U.S. Fish and Wildlife Service. Through the team, the Energy Commission and the Department of Fish and Game are to prepare a plan for renewable development in sensitive desert habitat.
- Executive Order S-21-09 (2009): directs the Air Resources Board (ARB) to work with the California Public Utilities Commission, the California Independent System Operator, and the Energy Commission to adopt regulations increasing California's RPS to 33 percent by 2020. The ARB must adopt these regulations by July 31, 2010.

The Air Resources Board's Scoping Plan points to achieving the RPS and 33 percent renewable as a key strategy for reducing greenhouse gases. The California Public Utilities Commission, California Energy Commission and Governor Schwarzenegger have sanctioned the Energy Action Plan, requiring that renewable energy sources increase to 33 percent of the state supply by 2020.

As of 2007, California was deriving 11.9 percent of its electricity from renewable energy sources (geothermal, biomass, small hydro, wind and solar) (CEC, 2007). Figure 3.4.1 shows that in 2007, 2.1 percent of the state's energy sources for electricity were derived from biomass, or 18 percent of the total renewable resources. Not all of this can be attributed to forests and rangelands, as biomass energy sources include urban and agricultural waste along with forest biomass.

Potential for Meeting the Renewables Portfolio Standard

Table 3.4.1 shows current and potential future renewable energy infrastructure by bioregion, derived from various sources. The Mojave bioregion has the most existing, and by far the most potential, solar and wind sites. Current sites occupy about 50,000 acres; if potential projects were actually implemented this could grow to well over a million acres, with 1,155 miles of new or updated transmission lines. The Colorado Desert and Modoc bioregions are also candidates for extensive development of renewable energy infrastructure.

Applications for Renewable Energy Projects

As of December 2009, there were 57 U.S. Bureau of Land Management (BLM) applications for solar projects in the California desert district and 93 applications for wind projects in California, many in the desert (BLM, 2010). Two of the more active areas for applications are shown in Figure 3.4.2. A significant portion of public lands are prohibited from renewable energy development due to environmental concerns (ecological reserves, wildlife refuges, national parks, wilderness and roadless areas, etc). Nonetheless, over 1.45 million acres of public lands in California are under consideration for alternative energy production (California Desert Council (CADC), 2009). Renewable energy development raises a new set of concerns, particularly related to impacts on wildlife habitat, and this creates controversy (CADC, 2009; LA Times, 1/23/09). The science-driven Desert Renewable Energy Conservation

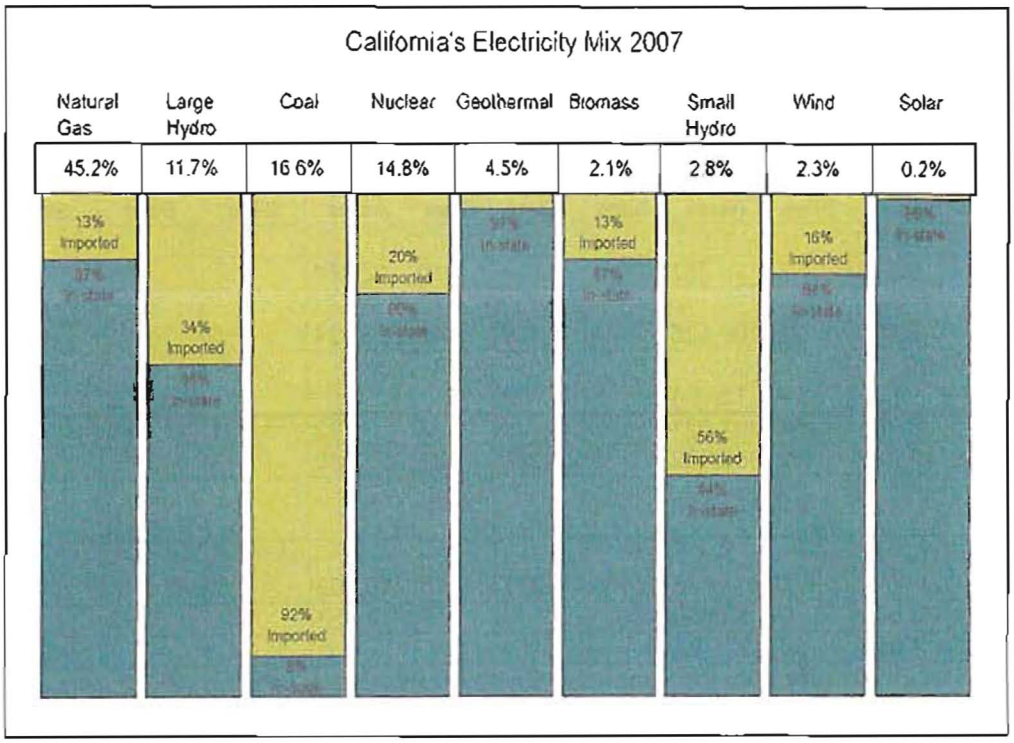


Figure 3.4.1.
California energy sources for electricity, 2007.
Source: California Energy Commission, Gross System Power Report, 2007

Plan is intended to become the state road map for renewable energy project development that will advance state and federal conservation goals while facilitating the timely permitting of renewable energy projects in these desert regions (Integrated Energy Policy Report, 2009).

While BLM has been the primary agency affected by emerging renewable energy markets in the state, the U.S. Forest Service has conducted a suitability study that identifies numerous areas within national forests in California that are potentially suitable for wind, solar or geothermal energy development (Karsteadt et al., 2005).

Revenue from Lease of Public Lands

Lease of public lands for renewable energy development provides a potential revenue source. For example, a recent competitive auction of lease parcels for geothermal energy resources on federal lands in California, Nevada and Utah generated $9,098,304 in revenue for 255,347 acres, an average of about $35 an acre (BLM, 2009). The California portion amounted to 11,392 acres for $131,126, about $12 an acre. Revenue is shared by the state (50 percent), county (25 percent), and BLM (25 percent).

Impact on Rural Economies

Developing renewable energy sources has the potential to create jobs for initial construction of infrastructure and for ongoing maintenance. Job creation for different types of renewable energy development is provided in Table 3.4.2.

Wind Energy

Wind power plants generate mechanical energy, which is converted to electrical energy. Ninety-five percent of California's wind generating capacity is located in three areas: Altamont Pass (Alameda County), Tehachapi (Kern County) and San Gorgonio (Riverside County) (CEC, 2009). The cost of wind power generation has decreased by nearly four-fold since 1980, primarily due to improved technology (American Wind Energy Association, 2009), and

Table 3.4.1. Current and potential future[1] renewable energy infrastructure by bioregion

	Wind				Solar				Geo-thermal	Biomass[2]		Transmission Lines
	Existing		Potential		Existing		Potential		Existing	Existing	Potential	Potential New or Updated
Bioregion	Sites	Acres	Sites	Acres	Sites	Acres	Sites	Acres	Sites	Sites	Sites[3]	Miles
Bay/Delta	9	28,090										297
Central Coast	1	9,544	2	20,787			10	12,774				58
Colorado Desert	1	5,420	37	109,125	4	11,127	42	222,224	5	2		758
Klamath/North Coast			4	12,006						2	5	36
Modoc	1	8,761	54	307,521			2	723	1	5	2	96
Mojave	9	42,918	112	666,822	5	6,260	132	457,180	1			1,155
Sacramento Valley										5		303
San Joaquin Valley			1	38	1	1,277	15	19,809		5		601
Sierra	4	22,630	9	53,666			7	8,953		3	5	200
South Coast	2	4,053	13	27,787								809

[1] Potential future sites includes those from the Renewable Energy Transmission Initiative (RETI), plus current applications on BLM lands.
[2] Current and potential biomass facilities are based on data assembled from various sources by FRAP, and only includes facilities with the potential to reduce wildfire or forest pest threats on forests and rangelands.
[3] Includes six proposed facilities, five that are currently idle, and one operational facility in Carson City, Nevada that under current conditions gets minimal material from California.
Data Sources: RETI, California Energy Commission (2009); Biomass Facilities, FRAP (2010), Renewable Energy Applications, BLM (2009)

Table 3.4.2. Average employment for different energy technologies normalized to the amount of energy produced (or saved in the case of energy efficiency)

Technology	Total Job-Years per GWh
Biomass	0.22
Geothermal	0.25
Solar Photovoltaic	0.91
Solar Thermal	0.27
Wind	0.17
Carbon Capture and Storage	0.18
Nuclear	0.15
Coal	0.11
Natural Gas	0.11
Energy Efficiency	0.38

Data Source: Kammen and Engel, 2009

wind is becoming more competitive with energy sources such as coal and nuclear.

However, wind power requires large tracts of land, impacts visual quality, creates noise, typically operates at only 25 to 40 percent of capacity, and facility construction and maintenance can have extensive environmental impacts through vegetation clearing and soil disruption. There are significant concerns related to bird and bat mortality due to collisions with turbines and wires. A five year research effort at the Altamont Pass Wind Resource Area found that 1,766 to 4,721 birds are killed annually, including 40 different species, 881 to 1,300 of which are raptors (Smallwood et al., 2004). Newer, larger turbines installed in groups seem to cause fewer bird fatalities per megawatt (MW) than the smaller, older, lattice-style turbines (National Academy of Sciences, 2007; Smallwood et al., 2004).

The California Energy Commission and California Department of Fish and Game have developed guidelines for reducing impacts to birds and bats from wind energy. These include methods to assess bird and bat activity at proposed wind energy sites, design pre-permitting and operations monitoring plans, and develop impact avoidance, minimization and mitigation measures. The U.S. Fish and Wildlife Service

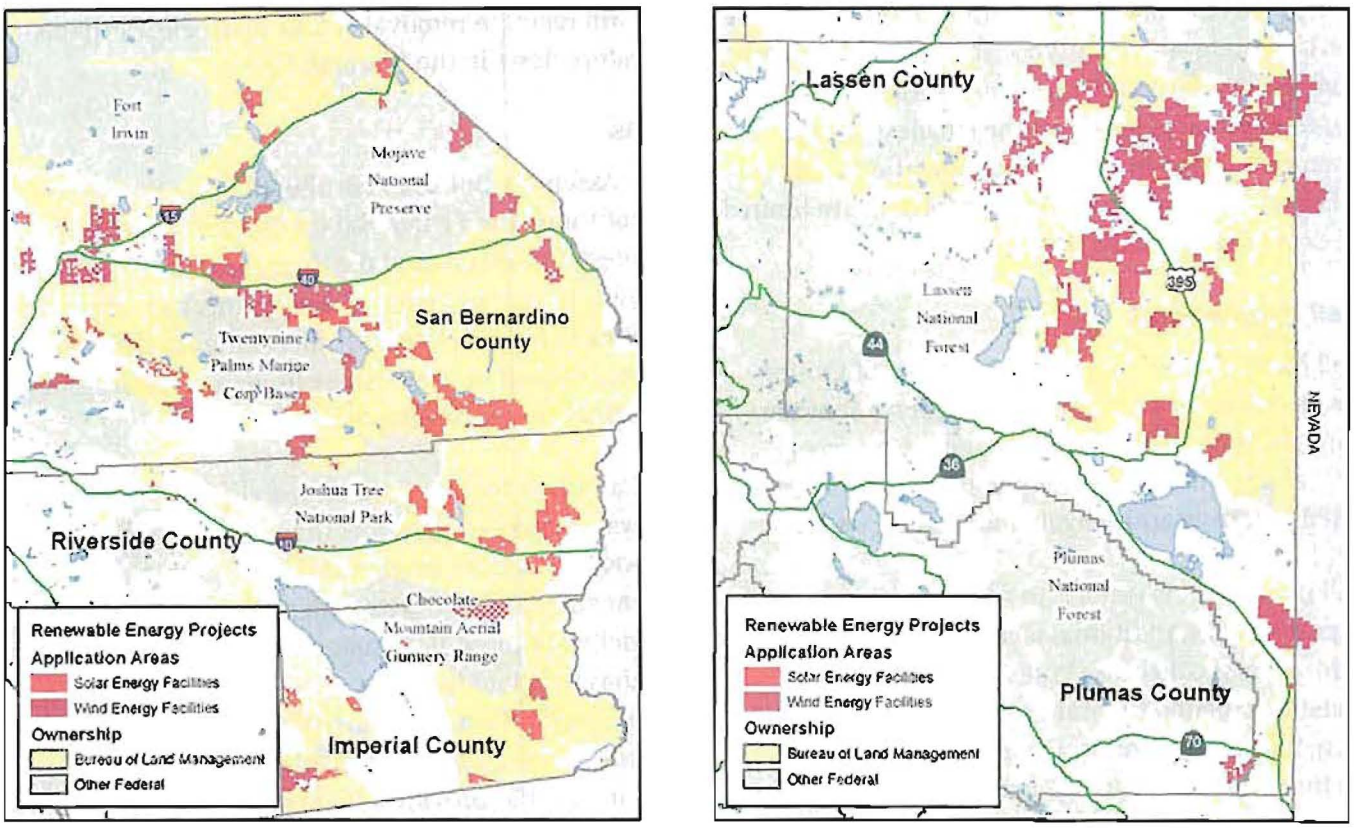


Figure 3.4.2.
Application areas for wind and solar energy development on BLM lands, for two of the more active regions of the state.
Data Sources: Renewable Energy Project Applications in California, BLM, (2008), California Protected Areas Database (CPAD), GreenInfo Network (2009)

also has released voluntary guidelines (National Academy of Sciences, 2007).

Solar Energy

Solar energy converts solar radiation to electricity. There are basically two types of systems that use solar to generate energy. Solar photovoltaic generates electricity directly from sunlight, while concentrated solar thermal panels use light to create heat and steam to drive turbines. A cursory review of BLM applications indicated a fairly equal mix of the two technologies.

Although California has an abundance of solar technical potential, in 2007 only 0.2 percent of total electricity generation was derived from solar, much less than other commercially available technologies such as wind, geothermal or biomass (CEC, 2007).

Some challenges for solar energy development are that the technology can be costly to install, is more appropriate for sunny locations, and its energy production varies seasonally and can drastically fluctuate within minutes due to cloud cover. Also, remote solar energy infrastructure development can require new transmission lines and may cover a large area (see photo on following page) which necessitates extensive permitting processes.

Geothermal Energy

Geothermal power requires thermal aquifers, primarily available where hot magma finds its way close to the surface and heats ground water to usable temperatures above 212°F. California contains the largest amount of geothermal generating capacity in the United States (CEC, 2009), because two tectonic plates meet under its surface, creating a large amount thermal activity.

The majority of California's geothermal plants have been operating since the 1960s in Napa and Sonoma Counties. In addition to operating virtually emission-free, geothermal plants have the smallest land requirements of any major power generation technology. However, suitable sites for geothermal are limited and expensive to establish.

Small Hydroelectric

Small hydroelectric supplied 2.8 percent of California's electricity in 2007, or about 24 percent of the state's electricity from renewable energy sources (CEC, 2007), and the majority of these plants are located in forests and rangelands (Figure 3.4.3).

Small hydroelectric (under 30 megawatts) has limited potential for additional facilities, in part due to environmental concerns (Wall Street Journal, 2009). Regulations related to minimum water flows are likely to reduce production from some existing facilities, such that even maintaining current output levels is uncertain (Clay Brandow, personal communication). It is certain that some hydroelectric dams will be removed; for example, recent agreements were signed that will result in removal of four hydroelectric dams to restore flows in the Klamath River.

Tools

State Assembly Bill 1890 (Brulte, Chapter 854, Statutes of 1996) and Senate Bill 90 (Sher, Chapter 905, Statutes of 1997) created the Energy Commission's Renewable Energy Program. Under this legislation, portions of funds collected from customers through investor-owned utilities can be used as incentives for renewable energy development.

The California feed-in tariff allows eligible small renewable energy generators (as amended by SB 32 in 2009, up to three megawatts) to enter into 10 to 20 year standard contracts with their utilities to sell electricity at time-differentiated market-based prices (Database of State Incentives for Renewable Energy, 2010). The California Public Utilities Commission is currently developing a Renewable Auction Mechanism, in order to provide a more efficient pricing mechanism for renewable energy providers up to 10 megawatts (Local Clean Energy Alliance, 2010).

Solar energy facility occupying an entire square mile of land southeast of California City, San Bernardino County

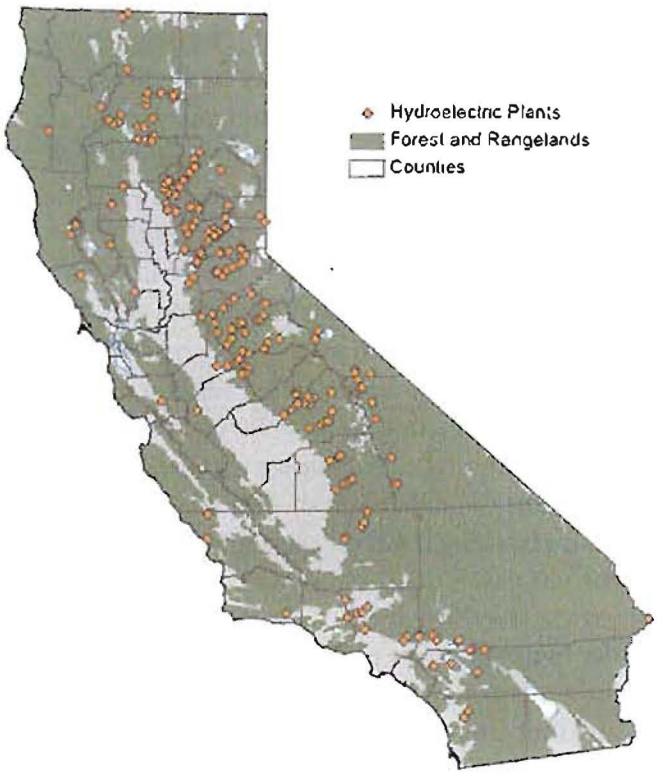


Figure 3.4.3.
Hydroelectric power plants in California.
Data Source: Hydroelectric Power Plants (derived from U.S. Army Corps of Engineers (1979), and Bulletin 160-93 Volume 2, DWR (1989)), FRAP (2002)

The California Energy Commission's Geothermal Program was created in 1981 (Assembly Bill 1905 (Bosco)) to promote geothermal energy development in California by offering financial and technical support for planning and mitigation projects and research and development to private entities.

The Renewable Energy Transmission Initiative (RETI) was created to facilitate meeting the Renewables Portfolio Standard goals. California currently does not have the transmission infrastructure to move the electricity generated by renewable resources to consumers, so extensive improvements and expansion are needed to reach the renewable energy goals. RETI is meant to be a transparent, inclusive stakeholder driven process. The goals are to identify needed transmission projects, support future energy policy, facilitate transmission corridor designation and transmission, and project siting and permitting. The Conceptual Transmission Planning Group is using RETI's conceptual planning as a starting point to develop a California statewide transmission plan to meet the 33 percent by 2020 Renewables Portfolio Standard (California Transmission Planning Group, 2010).

There are federal government incentives to produce wind electricity through tax credits of 1.5 cents per kilowatt-hour. The federal Energy Improvement and Extension Act of 2008 extends tax credits to clean, renewable energy, solar and energy improvement projects.

BIOMASS ENERGY

Current Status and Trends

The Governor's Bioenergy Action Plan states that biomass-fueled electricity generation constitute 20 percent of the Renewables Portfolio Standard by 2010 (BAP, 2006). As of 2007, biomass energy derived from forests, farms, landfills and other urban wastes provided 2.1 percent of electricity use, or almost 18 percent of all renewable energy (CEC, 2007). Biomass energy from forestlands provides about one percent of California's electricity use (USFS, 2009; California Biomass Collaborative, 2007), while having the potential to provide nearly eight times this amount (Morris, 2002). Biomass also has unutilized potential for heating homes, businesses, and schools, and for conversion to liquid transportation fuels (as conversion technology evolves). Biomass power has been a part of the state's power generation portfolio for over 25 years, and has facilitated the treatment and restoration of thousands of forested acres (Mason, 2010).

There are benefits from utilizing biomass energy beyond reduced reliance on fossil fuels. A recent intensive study looked at the long-term (40 year) impact of implementing biomass projects in a Northern California test area, and confirmed the following (USFS, 2009; California Biomass Collaborative, 2007):

- Reduction in greenhouse gas emissions

- Reduction in acres burned by wildfires, as well as severity of fires, with an associated reduction in damages to human infrastructure, economic values from working landscapes, and fire suppression costs
- Negligible impact on habitat suitability
- Minimal cumulative watershed impacts

Numerous studies indicate that the societal benefits derived from biomass removal and utilization are significant (USFS, 2009; California Biomass Collaborative, 2007). Biomass energy displaces the need to burn fossil fuels, and efficiently disposes of materials that would otherwise release methane emissions through decay, pile and burn disposal or wildfire (Reese, 2009). From an air quality perspective, five of six regulated emission categories are reduced by over 95 percent by burning material for biomass versus in open piles or by wildfire (Reese, 2009). Case studies (Cone Fire, 2002) confirm that fuels treatment activities that involve biomass removal can in fact mitigate wildfire behavior. Biomass energy can create jobs in rural economies that have been dependent on traditional resource-based industries. A 50 megawatt (MW) biomass plant can employ about 50 people, and also generate 125 indirect jobs (Reese, 2009). A 1999 study (Morris, 1999) found that 4.9 full time jobs are created for each MW of biomass power generation capacity.

However, there are public concerns about the environmental impacts of biomass removal. The various benefits and environmental impacts of forest biomass removal are complex and further research is required to guide appropriate policies and practices. Questions of long term biomass supply (especially from public lands), as well as possible ecological and other impacts of biomass removal on forest sustainability, are key issues in California (Heinz and Pinchot, 2010).

Other states also are challenged with balancing the need to reduce fire and forest pest risk, stimulate rural economies and expand renewable energy use while minimizing environmental impacts. Oregon passed legislation in 2005 (Oregon SB 1072) to promote the health of forests and rural economies through active forest management. The State Forester is directed to prepare a report every three years summarizing the effect of biomass removal on plants, wildlife, air and water, and identify changes that are necessary to encourage biomass energy use and avoid negative effects on the environment. The first report emphasized changes to insure that adequate downed wood and snags are left on site. The need for scientific input to help establish appropriate removal/residual policies for forest slash in thinnings and fuel reduction treatments by forest cover type, and continuing to encourage logger certification programs to include woody biomass harvesting techniques training (Oregon Department of Forestry, 2008).

In order to use biomass projects as a tool, first there must be a biomass energy facility within reasonable proximity, making the biomass material economically available. Biomass facilities operational in California that have the potential to address wildfire or forest pest issues are shown in Figure 3.4.4. A 25 mile buffer zone around facilities illustrates a gross estimate of the area where biomass material is economically available, given current costs and returns to landowners and energy producers. A more realistic zone would require an analysis of travel costs, road networks, and energy prices.

Secondly, biomass material must be technically available. Areas that are inaccessible, for example steep slopes, are excluded as are areas where regulations or management direction preclude biomass harvesting, wilderness areas or stream and lake protection zones. This second consideration can be complex, in that some areas may be accessible only under certain conditions, for example when a Zone of Infestation for forest pests is formally declared, or after a wildfire. Finally, this definition excludes materials that are likely to be used for higher-value products, for example wood that is suitable for lumber.

Currently, extensive areas of technically available biomass are not served by operational biomass

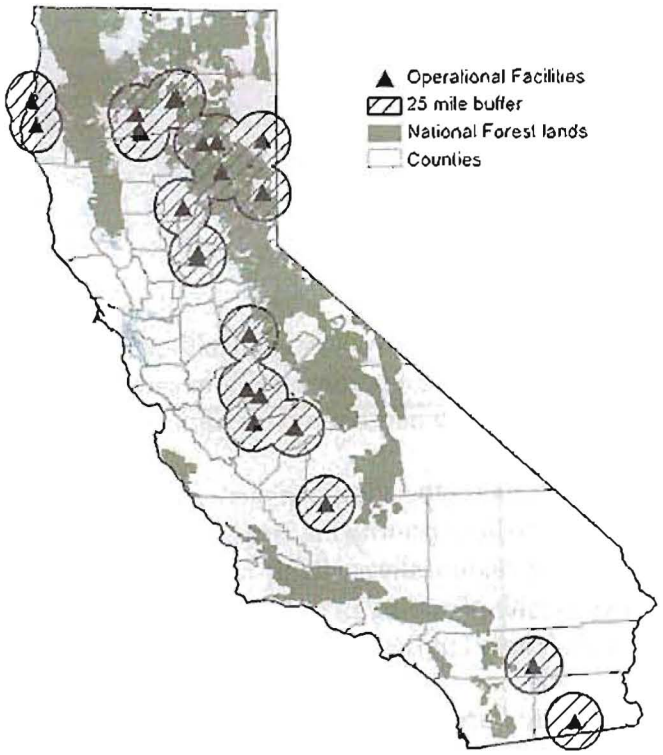


Figure 3.4.4.
Operational biomass facilities in California. This does not include numerous facilities that have limited potential to address wildfire or forest pest issues, for example those that primarily utilize biomass from landfills, urban waste, or agriculture. Exception – the two Southern California facilities shown on the map currently utilize primarily urban or agricultural wastes.
Data Source: Biomass Facilities, FRAP (2009 v1)

plants. Factors that constrain investment in new facilities include:

- Uncertainty in future energy prices, affecting biomass value and travel costs (Reese, 2009)
- Uncertainty over access to biomass on public lands
- Local opposition to the existence or proposed location of biomass facilities (SDN, 2009)
- Barriers related to permitting (CBC, 2006)

There are currently six idle biomass facilities that potentially could address wildfire and forest pest issues in California (including one in Nevada). The primary reason for closure is a reduction in timber harvesting associated with the current economic downturn (Sierra Pacific Industries, 2009). The Northern Nevada Correctional Facility biomass plant near Carson City, Nevada currently has minimal impact for biomass removals in California, and is included as an idle plant since under certain future conditions it could service areas in need of treatment in the Lake Tahoe area.

In addition, at least six new biomass facilities have been proposed across the state, which could address wildfire and forest pest issues. It remains to be seen which, if any of these will actually become operational. The optimal scale of new standalone grid energy biomass facilities in the Pacific Coast region, including California, appears to be small to medium (5 to 15 MW). The size of projects involves variables such as fossil energy prices, emerging technologies for liquid fuels, heat and power needs, carbon credit values, energy policy, and local forest conditions (Heinz and Pinchot, 2010).

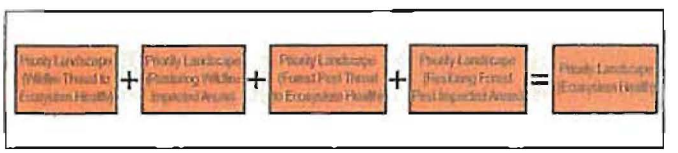
Given current trends, government action may be required if woody biomass utilization is to make a greater contribution towards meeting Renewables Portfolio Standard targets, or facilitate treatment of more areas at risk or damaged by wildfire and forest pests. Government action may also be warranted given that use of biomass for energy generation competes with other renewable energy sources or uses of biomass that are subsidized or otherwise encouraged through various government policies. Example policies include the diversion credit for use of green biomass as daily cover in landfills (BPA, 2009).

Analyses

The potential for biomass projects to play an increasing role in threat reduction and restoration efforts related to ecosystem health and community safety was analyzed, drawing on the analytical results presented in previous chapters. This involved simulating the effects of adding six proposed biomass facilities and making six idle facilities operational. However, a specific strategy to implement this scenario could require actions on multiple issues and a variety of options for addressing them, including changes to policies, programs or practices and funding sources.

Ecosystem Health

The potential for biomass projects to reduce threats and facilitate restoration efforts related to ecosystem health was examined. Each of the four priority landscapes in the following diagram represents priority areas where biomass projects could be applied. For example, biomass projects that thin overstocked stands and remove ladder fuels can reduce wildfire and forest pest threat. Restoring impacted areas often requires removal of dead, dying or infected trees.

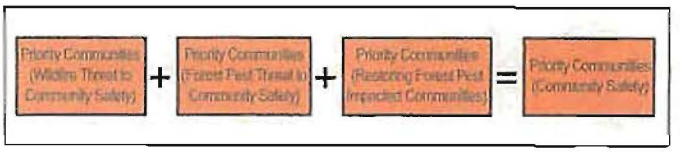


These four priority landscapes were combined to create a single priority landscape for ecosystem health, by assigning the maximum of the four component ranks. An area that is ranked high for any of the four inputs is also ranked high in the output. The resulting ecosystem health priority landscape represents areas most in need of treatments, such as biomass projects to reduce threats or restore impacted areas. The analysis involved determining which ecosystem health priority landscapes potentially become economically available as a result of adding the 12 facilities, and summarizing the results by county and bioregion.

Community Safety

A second analysis examined reducing wildfire and forest pest threats to community safety, or restoring impacted communities. Wildfire poses a direct threat to human infrastructure, while forest pests cause tree mortality that leads to indirect impacts from falling trees on roads, power lines and houses.

The analysis determined which priority communities that are currently not economically available due to distance from operational facilities, are within 25 miles of the added facilities.



Results

Ecosystem Health

Figure 3.4.5 shows the ecosystem health priority landscapes that might become economically available as a result of the 12 new biomass facilities.

Table 3.4.3 shows the additional acreage by county of high plus medium priority landscapes that potentially become economically available for biomass projects as a result of adding 12 facilities. A significant portion of these lands are federally owned.

Community Safety

Table 3.4.4 shows communities identified as priorities for protection or restoration in terms of which are potentially served by operational biomass plants, or idle/proposed plants. Southern California is currently not served by facilities that utilize a significant amount of biomass from forests and rangelands and these individual communities are not listed.

Discussion

Ecosystem Health

Proposed and idle biomass facilities potentially can make large areas of priority landscapes economically available for treatment in counties such as Siskiyou, Trinity, Modoc, Lassen, El Dorado, Amador and Placer. This would facilitate treatments to reduce threats from wildfire and forest pests and to restore impacted areas.

However, extensive areas of priority landscapes are not served by either existing, proposed or idle facilities. The first map in Figure 3.4.6 shows priority landscapes for ecosystem health that are not within 25 miles of operational, idle or proposed facilities. This map does not show the extensive areas of high priority landscapes in Southern California, since

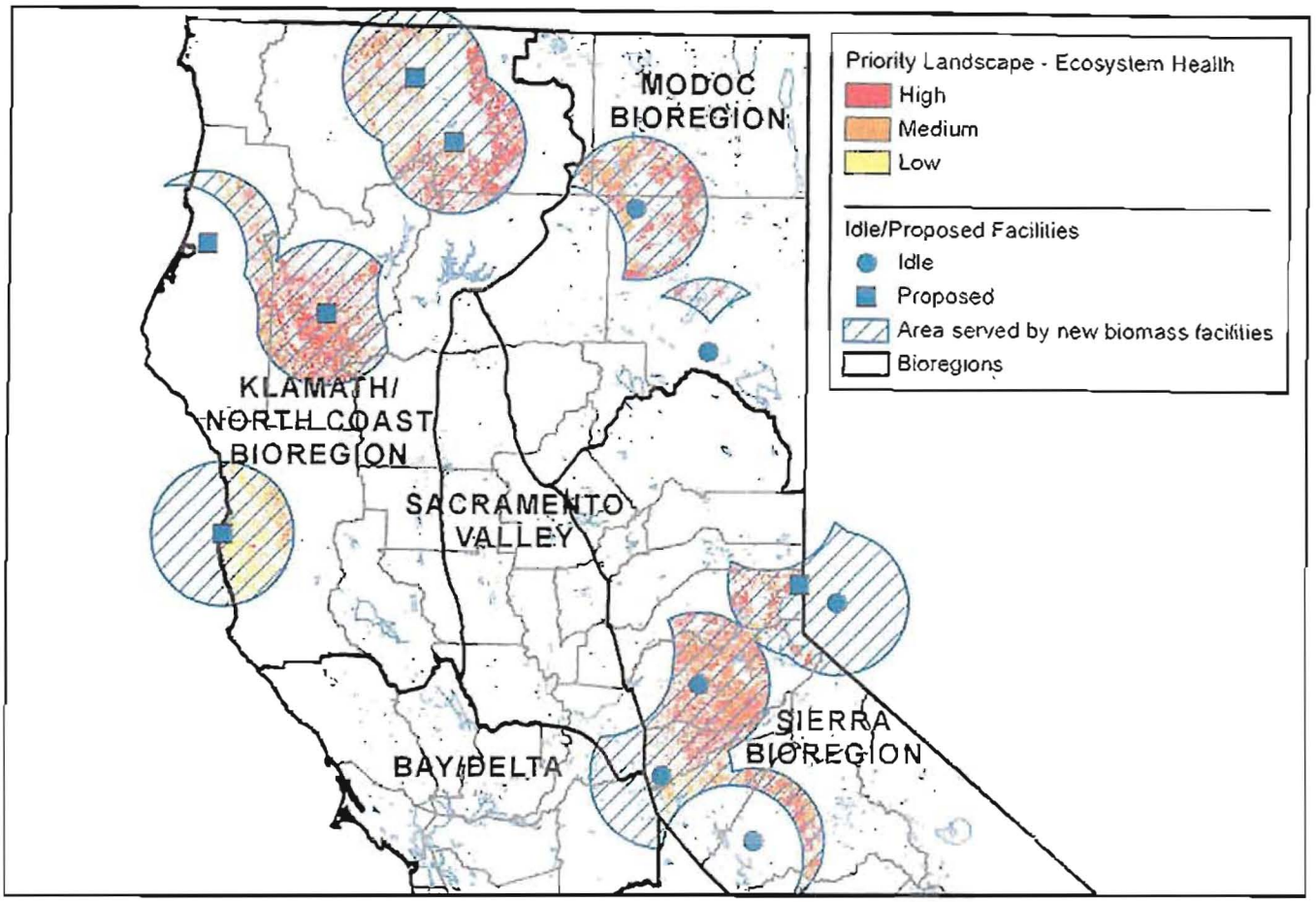


Figure 3.4.5.

Priority landscapes for ecosystem health with potential for new biomass facilities. Priority landscapes that are technically unavailable (e.g., steep slopes, stream buffers, wilderness areas), or have too little biomass to be economically available (less than 50,000 lbs/ha) are excluded in the map. Map shows only the portion of the state that is affected by making the 12 idle or proposed biomass facilities operational.

Data Sources: Biomass Facilities, FRAP (2009 v1); Burn Severity, USFS (2009), California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Aerial Detection Surveys, USFS FHP (2008 v1); Forest Pest Risk, USFS FHP (2009 v1); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002)

in this region of the state there are currently no facilities that utilize significant biomass from forest or rangeland. The second map shows that since so much of these priority landscapes are on federal lands, access to a stable flow of material, especially from national forests, will be a critical factor in terms of whether these areas will ever be served by facilities.

Community Safety

Currently, only 14 of the 66 priority communities are within 25 miles of an operational biomass facility. Adding the 12 new facilities would reach 11 more priority communities. Of the remaining 41 communities, 31 are in Southern California.

Bioregional Findings

Ecosystem Health

Adding the idle and proposed facilities potentially would facilitate treatment of extensive priority landscape areas for ecosystem health in the Klamath/North Coast, Modoc and Sierra bioregions.

However, even if all idle and proposed facilities are made operational, there will still be extensive areas of priority landscapes that are not served by bio-

Table 3.4.3. High plus medium priority landscape (HMPL) acres (rounded to the nearest hundred) for ecosystem health by county that are potentially economically available as a result of making 12 proposed or idle biomass facilities operational

County	HMPL Acres*	Percent Federal
Amador	89,900	9
Calaveras	64,600	14
El Dorado	377,000	53
Humboldt	104,400	49
Lassen	163,900	60
Mariposa	4,000	97
Mendocino	53,600	2
Modoc	166,300	47
Nevada	4,300	16
Placer	141,300	68
Shasta	48,300	54
Siskiyou	485,300	47
Tehama	8,500	87
Trinity	415,700	78
Tuolumne	108,200	78
State Total	2,235,600	54

*counties with less than 1,000 HMPL acres excluded.

mass facilities in these same bioregions, though the majority of this is federal lands.

Community Safety

As a result of adding idle and proposed facilities, 11 additional priority communities could potentially be treated using biomass projects, six of these are in the Lake Tahoe area. Numerous additional communities could be served, primarily in the Klamath/North Coast and Sierra bioregions.

About half of the priority communities identified occur in the South Coast bioregion where biomass projects currently are not a viable treatment tool due to lack of biomass facilities.

Tools

California had 49 operating biomass plants in the mid 1990s, today there are 33 (Reese, 2009). The current environment does not seem conducive to bringing new plants that rely on forest biomass online, or in some cases even keeping existing plants operational. The challenge is to develop strategies that capture the array of benefits provided by biomass energy in terms of incentives for sustainable

Table 3.4.4. Priority communities for protection or restoration for forest pests and wildfire, that are potentially serviced by an operational biomass facility, or idle/proposed facility

County	Priority Community (F = Wildfire; P = Forest Pests)	Biomass Facility (O = Operational; I = Idle/ Proposed)
Alameda	Oakland (F)	-
Alpine	Kirkwood (P)	-
Butte	Magalia (P)	O
	Paradise (P)	O
Calaveras	Arnold (FP) [1]	I
	Mountain Ranch (P)	I
El Dorado	South Lake Tahoe (P)	I
Humboldt	Willow Creek (P) [1]	I
Marin	Inverness (P)	-
Mono	Mammoth Lakes (P)	-
Monterey	Aromas (P)	-
Nevada	Grass Valley (P)	-
	Truckee (P) [1]	I
Placer	Dollar Point (P)	I
	Foresthill (P)	I
	Kings Beach (P)	I
	Sunnyside–Tahoe City (P)	I
Plumas	Bucks Lake (P)	O
	East Quincy (P)	O
	Graeagle (P)	O
	Iron Horse (P)	O
	Johnsville (P)	O
	La Porte (P)	O
	Meadow Valley (P)	O
	Mohawk Vista (P)	O
Shasta	Lakehead–Lakeshore (P)	O
	Redding (F)	O
Siskiyou	Mount Shasta (P)	I
	Weed (P)	I
Sonoma	Guerneville (P)	-
	Healdsburg (P)	-
	Occidental (P)	-
	Monte Rio (P)	-
Tehama	Mineral (P)	O
Tuolumne	Groveland–Big Oak Flat (P)	O
Southern California [2]	23 Communities (F) 7 Communities (P) 1 Community (F;P)	-

[1] Community is just inside the 25 mile buffer of an operational facility, but would be better served by a closer proposed/idle facility.

[2] San Diego, Orange, Los Angeles, San Bernardino, and Ventura counties.

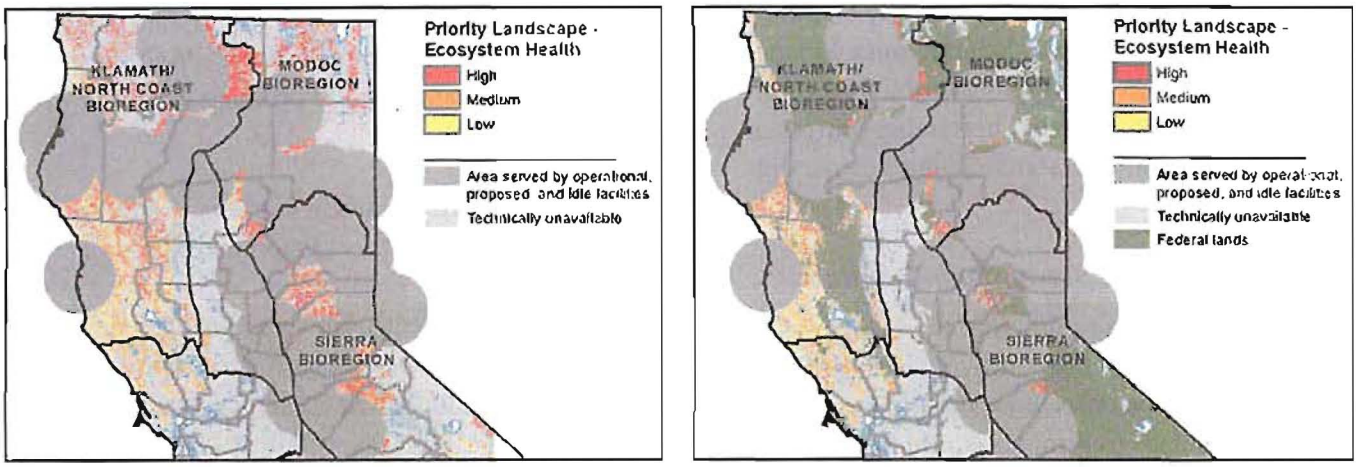


Figure 3.4.6
Priority landscapes for ecosystem health that are not within 25 miles of operational, proposed, or idle biomass facilities.
Data Sources: Biomass Facilities, FRAP (2009 v1); Burn Severity, USFS (2009); California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Aerial Detection Surveys, USFS FHP (2008 v1); Forest Pest Risk, USFS FHP (2009 v1); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002)

development of this technology (California Biomass Energy Alliance, 2006), while monitoring potential environmental impacts and adapting policies and regulations as needed. Transparent and inclusive stakeholder involvement is important in decisions about biomass. Collaborative processes, planning and long-term stewardship contracts are critical for determining and realizing supply from federal lands (Heinz and Pinchot, 2010).

Road Map to the Future

The California Energy Commission, working through the Bioenergy Interagency Working Group, has produced a comprehensive strategy for sustainable development of biomass in the state. The first Bioenergy Action Plan (CEC, 2006) was released in 2006, and the goal is to adopt an updated plan by the end of 2010. There are recommended actions in five areas:

- Resource access and feedstock markets and supply
- Market expansion, access, and technology deployment
- Research, development, and demonstration
- Education, training and outreach
- Policy, regulations, and statutes

Coordinated Resource Offering Protocol (CROP)

In response to the uncertainty for access to biomass from public lands, the U.S. Forest Service and BLM have launched a series of Coordinated Resource Offering Protocols (CROP) pilot projects, including one in the Lake Tahoe region in California (USFS, 2009). For the Lake Tahoe pilot project, a key concern is that 50 percent of CROP resource offering (acreage for biomass removal) has not started in the National Environmental Policy Act (NEPA) process.

The key tenets of CROP projects are to (USFS, 2009):

- facilitate coordination of biomass removal between public agencies;
- facilitate the use of long-term multi-agency stewardship contracts to achieve biomass removal;
- increase the certainty of levelized biomass supply offerings from public agencies;
- invite investment back into a sustainable forest management landscape and
- heighten public trust and support for biomass removal from public lands operating within a transparent process.

CROP projects are of limited application however

due to the fact that they are focused only on biomass material sourced from federal lands. Financial institutions that provide funding for biomass utilization projects are interested in reliable sources of woody biomass material across all land ownership categories.

Integrated Resource Stewardship Contract

A promising contracting tool that the U.S. Forest Service and BLM have been utilizing in recent years is the Integrated Resource Stewardship Contract, which is focused on treatments conducted over three to ten years. Stewardship contracts have proven to facilitate forest fuels reduction and restoration activities at the landscape level. There are numerous examples of these contracts in place or proposed in California for fuels reduction projects to protect communities, endangered species habitat, key watersheds for anadromous fish and for ecosystem restoration (http://www.forestsandrangelands.gov/stewardship/ca.shtml).

Biomass Crop Assistance Program

Biomass Crop Assistance Program (BCAP) provides financial assistance to producers or entities that deliver eligible biomass material to designated biomass conversion facilities for use as heat, power, bio-based products or biofuels (USDA Farm Service Agency, 2009). For example, in Butte County BCAP funds made it economically feasible to convert 15,500 dry tons of charred timber into clean energy, and enabled Bamford Company to keep 37 people employed (timberbuysell.com).

CARBON

Carbon sequestration is an emerging market that quantifies and helps pay for an ecosystem service. Terrestrial carbon sequestration is considered in policy and at the project level. The role of carbon in compliance markets along with the economics of carbon and the opportunities in California for forest and rangeland carbon are explored here while the sequestration of carbon by trees and other plants is described in Chapter 3.7.

Carbon accounting may use "on-site" to describe carbon stored in the forest or soil while "off-site" refers to the pool of carbon in wood products, either in-use or in a landfill.

There are two kinds of carbon markets: voluntary and compliance. Voluntary carbon markets are generally unregulated by government, with transactions usually occurring directly between the buyer and seller. Specific systems, protocols and registries exist for the voluntary market. Compliance markets occur under regulatory schemes, usually cap-and-trade, where offsets are sold to emitters. These usually involve contracts between buyer and seller, but are regulated by the trading system so that offsets meet the system criteria, are properly credited, and are not used more than once. Entities may operate in both voluntary and compliance markets to assemble multiple landowners into projects for economies of scale.

Standards and guidelines are necessary to quantify greenhouse gas benefits from forestry and range-related activities. For example, protocols are the rules for carbon accounting that a project developer must follow to quantify reductions, while registries function like carbon credit banks where ownership may be tracked.

Two general approaches to protocol development are project specific (i.e., Clean Development Mechanism) and programmatic (i.e., Climate Action Reserve (CAR)). Project types that relate to forestry include reforestation, avoided conversion, urban forestry and forest management. Range-related project types include manure management systems and soil sequestration. Currently, the most likely forestry protocols to receive near-term adoption under AB32 or Western Climate Initiative (WCI) cap-and-trade systems would be CAR forestry protocols, the CAR manure management protocol and the Alberta Offset System soil sequestration protocol (WCI, 2010).

The State of California has supported the CAR forestry protocols for use in the voluntary market. It is expected that these protocols, or modifications of them, will be used for forestry offsets under a

cap-and-trade compliance market under the Global Warming Solutions Act of 2006, WCI, or a national cap-and-trade program. Other protocols will also likely participate.

Reductions are the metric tons of carbon dioxide equivalent (CO2e) attributed to a project and may be referred to as credits in general or a more specific name associated with a specific protocol or registry. The quality of credits varies according to many factors, such as the nature of the carbon reduction, the extent to which the carbon removed will stay out of the atmosphere, and the ability to accurately measure and verify the amount of carbon saved.

An "offset" is the term generally used in conjunction with a cap-and-trade program where credits are generated outside of the capped sectors. Offsets are used in lieu of emission allowances. The use of offsets has been controversial, with critics questioning the effectiveness and proponents emphasizing the near-term necessity of offsets.

Within California, the amount of offsets to be allowed under cap-and-trade systems is still unknown. By one estimate, which proposed that four percent of annual GHG emissions in California could be met by each entity with offsets, total annual use of offsets could be about 7.7 million metric tons in 2012–2014, over 16 million metric tons in 2015–17, and over 15 million metric tons each year from 2018–2020 (ARB, 2009). Proposed federal legislation would allow upwards of one billion metric tons of domestic offsets a year with another billion metric tons of international offsets.

The apparent demand for offsets far exceeds the supply, at least in the near term (Sikorski, 2010). Estimates and potential value in markets that are emerging can be made for forest-related supply in California. Live tree carbon stored in California forests is estimated to be 5.1 billion metric tons (teragram, Tg) (see Chapter 1.2); the sequestration rate was 30 million metric tons (gigagram, Gg) per year. The estimate for private timberlands was 1.4 Tg; the sequestration rate was five Gg per year. A widely held 2020 auction allowance price range for AB 32, WCI and national programs is $15–$25 per metric ton (Economic and Allocation Advisory Committee, 2010; Point Carbon, 2010; PEW, 2010). For illustration, applying a $15 and $20 per metric ton value to offsets under a compliance market, the theoretical values if all carbon were monetized are:

- Total California forest carbon storage (live trees): $77–102 billion
- Total California forest carbon sequestration: $450–600 million/year
- California private timberland forest carbon storage (live trees): $21–28 billion
- California private timberland carbon sequestration: $75–100 million/year

Potential market revenue based on the $15–20 per metric ton assumption for offsets in a compliance market under AB32 is as follows:

- First Compliance Period (2012–2014): $116–155 million/year
- Second Compliance Period (2015–2017): $246–328 million/year
- Third Compliance Period (2018–2020): $226–301 million/year

These estimates are for all offset project types. Sikorski (2010) estimates that about two-thirds of nationwide domestic offsets will be supplied by forestry project types to 2020. This would reduce the potential revenues to the forestry sector accordingly.

In the case of range-related carbon, no estimates have been made on the supply from manure management; there is lack of information on the impacts of technology and other obstacles. Soil sequestration from forests and rangelands was not estimated; the associated protocols are unclear at this point.

The type of forest project is a critical factor when considering possible offset supply to 2020. For example, urban forestry and reforestation project types rely on carbon accruing in young trees, which will be minimal before 2020 although important for

later years. In contrast, the avoided conversion and improved forest management project types could generate substantial credits in the next ten years.

The following assumptions were used in the estimates of credits generated from the avoided conversion and improved forest management project types. The stocking and sequestration estimates are from Chapter 1.2.

- One-half of the 139 metric tons per acre average stocking on forestlands are credited on average on avoided conversion projects
- Avoided conversion projects are 10,000 acres a year
- Sequestration rate is 0.746 metric tons per acre on forestland
- Sequestration rate is 1.244 metric tons per acre on timberland
- Non-industrial forestland owners will participate in the improved forest management projects at 10 to 20 thousand acres a year while industrial timberland owners will participate at 20 to 40 thousand acres a year.
- Improved forest management projects that have initial inventories above common practice are 11 to 23 thousand acres a year and result in immediate credits of 35 metric tons per acre.

Avoided conversion projects would produce 0.7 million metric tons per year. Improved forest management projects, by the CAR protocol, may produce credits in two ways: to incrementally as forests grow and as an avoided emissions type credit for exceeding common practice. Based on analysis of avoided conversion and improved forest management, estimates of annual forest carbon offsets available to a California compliance market for the three compliance periods results in the following:

- Compliance Period 1 (2012–2014): 1.17 to 1.67 million metric tons per year
- Compliance Period 2 (2015–2017): 1.25 to 1.83 million metric tons per year
- Compliance Period 3 (2018–2020): 1.33 to 2.00 million metric tons per year

If these estimates are approximately correct then the forestry sector in California will meet 10–25 percent of the potential offset demand through 2020. Fulfilling the demand for offsets to 2020 will require more landowner participation, other sector offsets, the development of other project types such as soil or avoided emissions from fire, or the use of forestry offsets from outside of California.

Carbon credits will be in demand for both the voluntary and compliance markets. Protocols are in place for many project types. The price of carbon, however, is generally low relative to the value for high quality timber products. A thousand board feet of Douglas-fir that is worth $400 is approximately four metric tons of CO2e, which is $80 at $20 a metric ton. This value discrepancy combined with the risk associated with a 100-year commitment to maintain the sequestered carbon, which is required for CAR projects, will likely keep supply low. If credits become widely used for mitigating climate impacts identified in the California Environmental Quality Act (CEQA) analyses of development projects, then prices in the voluntary market could possibly exceed prices in the compliance market, further constraining cap-and-trade supply.

Investments in working landscapes could bolster terrestrial carbon inventories and reduce risk of loss. Priority landscapes for carbon are identified in Chapter 3.7. Significant acreages on private and public lands could benefit from management. Carbon management must, however, be considered in the context of the multiple benefits that forests and rangelands provide. Quantities of carbon should be considered in combination with the risk of emission and long-term ecosystem health. Investments in restoring stands converted from either conifer or hardwood cover should be made soon to address ecological restoration and carbon contributions in future decades.

NICHE MARKETS

Definition

Natural Resources Canada defines niche products as "specialty, higher-value, non-commodity wood products that are directed at specific markets that value the unique appearance/quality of a product that has a limited production supply. Niche products are usually produced by smaller manufacturing plants that focus on producing a unique, high quality product in limited volumes. These are usually products that an end-user believes has an added-value component due to unique appearance/quality, end-use, etc. Many niche products have the same number of competitors as established commodity products but niche products have the advantage of being able to create brand or product loyalty to separate themselves from competitors, are more regional in market focus, are more attuned to market/demand changes and trends, and are quick to adapt to changes in market demand." (Natural Resources Canada, Canada Wood, 2003)

Niche Markets for Certified Products

Niche products are differentiated based on the nature of the process used to create them, in terms of being a more environmentally and socially responsible option for consumers. This typically involves a certification process by third-party entities such as the Forest Stewardship Council (FSC) or Sustainable Forest Initiative (SFI) for wood products, or the USDA National Organic Program for agricultural products. There are also various programs for certification of "natural" beef and grass-fed beef, which are generally less restrictive standards than organic.

"An on-product label that says a product is certified to a program such as SFI or FSC delivers assurance you are making a choice that represents conservation of biological diversity, protection of special sites, sustainable harvests, respect for local communities, and much more" (Larry Selzer, President and CEO, The Conservation Fund).

The demand for certified wood products can be driven by higher level certification programs, for example the trend towards "green building" and certification programs such as Leadership in Energy and Environmental Design (LEED®) (http://www.usgbc.org/DisplayPage.aspx?CategoryID=19).

In some cases, major retailers have endorsed certified products to the point of excluding or limiting selection of non-certified products. For example, Home Depot began endorsing certified wood products in 1999, and now sells more FSC certified wood than any retailer in America (http://corporate.homedepot.com/wps/portal/Wood_Purchasing).

Advantages of Niche Products

The mass marketing business model involves intense competition based on standardized product lines and fierce price competition (Hacker, 2006). Niche markets involve a unique business model that can often command higher prices by competing to meet a unique need for custom products.

Niche products sometimes utilize materials that would otherwise be discarded, or even incur a disposal cost. Eric Oldar of the California Department of Forestry and Fire Protection pioneered a project to utilize urban trees that would otherwise end up in landfills, by investing in portable sawmills and kilns which are loaned to municipalities (Hacker, 2006). The City of Lompoc, which was faced with a tree disposal problem and landfill regulations, was able to meet a need for higher quality park benches, flooring, and other wood products (Gamstetter, 2009). The number of municipalities now using portable sawmilling is widespread throughout the country in response to landfill regulations (Hacker, 2006).

Examples of Niche Products

Niche products are vast and diverse, a list of some of the more interesting or promising in California includes:

- West Coast Arborists, Anaheim: Utilizing the latest technology for urban forestry inventory, planning, and management (http://www.wca-inc.com/Introduction.aspx).

- California Hardwood Producers, Auburn: Utilizing tree removals from urban forests and orchards for high quality flooring, cabinets, beams, countertops, etc. (http://californiahardwood.com/).
- Humboldt Woodworkers Guild, Humboldt County: Collective marketing of unique high quality, environmentally and socially responsible wood products (http://woodguild.com/).
- Calaveras Healthy Impact Product Solutions, San Andreas: In response to local sawmill closures and fire hazard from small trees, this community organizing effort, funded by a $96,500 USDA grant, implemented a chipping station for landscaping and heating. One customer uses wood chips to heat a four acre greenhouse that supplies fresh organic local produce.
- Sierra Nevada Geotourism: The Sierra Business Council has partnered with the National Geographic Society and the Sierra Nevada Conservancy to develop a website to capture the history, heritage and attractions distinctive to the Sierra Nevada Region, to promote tourism that can conserve the region's historic towns and heritage sites, restore and protect the landscape, and sustain local businesses and communities (http://www.sbcouncil.org/Projects/Sierra-Nevada-Geotourism).
- There are many examples of California ranches that produce organic, natural or grass-fed animals and meat products.
- Numerous California livestock operators fill niche markets for various specialty products and services, ranging from beef jerky to ranch tours.

Opportunities for Niche Markets in California

There is a strong potential for niche markets to increase economic activity and employment in the state.

California hardwoods have historically received a lot of attention, since they are an underutilized resource. California is a major consumer of hardwood lumber (20 percent of nation's production) but the hardwood lumber production industry in the state is almost non-existent; this is in spite of a sizable hardwood tree resource (12 billion cubic feet of timber growing stock) (http://ucanr.org/delivers/impactview.cfm?impactnum=196). Although California producers have been unable to compete in traditional high-volume markets, the potential exists for utilizing this resource to fill additional niche markets.

As California loses more sawmills, many landowners will be unable to sell their timber. Portable sawmills provide an opportunity for these landowners to process their own logs, and sell their timber as finished products, commanding a higher price. This will require innovation in terms of forming landowner cooperatives for processing and marketing their products.

While this chapter deals extensively with opportunities for additional large biomass facilities, there is also potential for utilizing small or micro-biomass power generation, particularly for heating homes, businesses and schools. Examples include the U.S. Forest Service State and Private Forestry's Fuels for Schools program being initiated in six western states.

The various certification programs for rangeland products provide an opportunity for some ranchers to increase profitability. This could become especially important if food safety concerns become an emerging issue. For example, grass-fed beef avoids potential food safety concerns that could arise from sending animals to feedlots.

ECOSYSTEM SERVICES

Forests and rangelands provide a number of values which historically have not been captured easily in traditional markets. Examples are: carbon sequestration (until recently), watershed services, wildlife habitat and biodiversity, scenic and related values. Often these are viewed as "public goods" which are provided as benefits to the public at little or no cost. Since landowners are generally not compensated for providing these services, they may not receive

adequate consideration in decisions related to keeping lands in production, or in how they are managed.

Markets have been slow to emerge for a number of reasons, such as the difficulty of defining market units and price, few buyers, and limited support in the investment community. However, a growing recognition of the importance of these services is leading to efforts to quantify their value, which could lead to market-based solutions. At the national level, for example, the Food, Conservation, and Energy Act of 2008 directs states to identify high-value areas for providing various ecosystem services and to delineate threats to those areas. The Act also seeks to facilitate landowner participation in emerging markets for ecosystem services. The Secretary of Agriculture must develop technical guidelines that measure the environmental services benefits from conservation and land management activities. These guidelines will facilitate measurement and reporting protocols and registries. A verification process and guidelines for reporting conservation and land management activities must also be developed (http://www.fs.fed.us/ecosystemservices/).

Across the country, some market-based frameworks can be found in the area of ecosystem services. These can include private payments, public payments or incentives and trading schemes. For example, in the case of preserving wildlife and plant diversity, payments for specific areas or programs can come from non-governmental organizations, pharmaceutical, agricultural or other companies, and even the eco-tourism industry. In some cases regulatory frameworks have fostered a way to do market transactions, such as the emergence of conservation and mitigation banking in California and the U.S. Other investments are made in an effort to comply with or lessen cost of regulatory compliance, such as flood control structures or better road design to improve water quality.

Local or regional districts can also serve a quasi-market function. Examples include the East Bay Regional Park District, the Mid Peninsula Open Space District and the Marin Open Space District. These districts have programs that support ecosystem services directly or indirectly. They utilize property taxes, assessments, fees/rents/other charges, grants, interest and other funding sources. Programs relate to what the voters want and for which they will pay.

Some programs can influence market opportunities for ecosystem services. An example of this is the Private Lands Wildlife Habitat Enhancement and Management Area (PLM) Program administered by the Department of Fish and Game. The program was first authorized in 1983 and has undergone several revisions. The goals of the PLM are to encourage private landowners to manage for the benefit of fish and wildlife. In exchange for developing a management plan and adopting specific wildlife habitat improvements, landowners receive incentives that allow them to better realize the recreational value of wildlife. Incentives can include more flexible seasons and quality hunting experiences. Landowners gain by charging fees for hunting, fishing and other uses, such as photography and observing wildlife. (DFG, 2008). There are now 90 PLM properties that encompass almost 900,000 acres of wildlife habitat (http://www.dfg.ca.gov/wildlife/hunting/plm.html).

Conservation easements are another mechanism widely used in California. Many examples exist such as efforts by organizations including the Trust for Public Land, the Nature Conservancy and the California Rangeland Trust. Under a conservation easement, a landowner voluntarily donates or sells certain rights related to their property, such as the opportunity to develop to a private organization or public agency. This entity is willing to hold the right to enforce limitations agreed to by the landowners. Often landowners retain rights to manage the property for ongoing agricultural, rangeland or forestry uses, together with associated habitat, watershed and open space values. These easements are legally recorded agreements and conditions continue with the land when the land is sold. Compensation to the landowner can take several forms, such as direct payments or tax credits. Credits come from various sources. One example of a tax credit is the Natural Heritage Preservation Tax Credit (2000).

Administered by the Wildlife Conservation Board, the Tax Credit Act allows state tax credits for donations of qualified land (fee title or conservation easement) and water rights.

Still another example is the Oak Woodlands Conservation Act (2001). Under the Conservation Act, the Wildlife Conservation Board established a grant program designed to protect and restore oak woodlands utilizing conservation easements, cost-share and long-term agreements, technical assistance, public education and outreach.

In addition, state law provides for tax and zoning approaches that encourage landowners to maintain land in agriculture, ranching and timber production. The two key frameworks are the California Land Conservation Act, better known as the Williamson Act, and the Timberland Production Zone under the Forest Taxation Reform Act. Under both these laws, properties are taxed in a manner that supports continued use of the land for resource production with its related ecosystem service benefits (such as wildlife habitat and watershed health).

The provision of ecosystem services in California has benefited greatly from development of partnerships and cooperation among landowners, governmental agencies, non-profit organizations and other stakeholders. Forms of the partnerships vary, but can be seen in the abundance of watershed groups, Fire Safe Councils and community or neighborhood based organizations. Agencies, landowners, and non-governmental organizations all play key roles. These efforts have facilitated watershed and habitat planning, restoration, management and acquisition, and efforts to improve forest health.

Support for such activities comes from different sources. The main contributors are property owners, non-profit organizations, public agencies and the public. By far, the largest funding sources for projects and for ongoing program support for environmental services comes in the budgets of federal, state and local agencies. Funding comes from general taxes, special taxes and dedicated funds, user fees, and other sources.

Especially important to support and enhancement of ecosystem services in California has been voter support of four ballot initiatives in the last decade. These are Proposition 40 (2002), Proposition 50 (2002), Proposition 84 (2006), and Proposition 1E (2006). Funds from these initiatives are being used for many aspects of ecosystem services. These includie such things as assessment and planning for watersheds, fish and wildlife, infrastructure and habitat restoration and enhancement, habitat acquisition, improving forest health and conservation and technical assistance.

Federal initiatives have also been important. Examples include funding and programs related to: improved water quality; restoration and enhancement of ecosystems, wildlife and fish habitat; and fuel reduction and improved forest health. Some federal programs focus on specific areas and issues such as Lake Tahoe or the forests of Southern California.

Planning for and determination of projects, as well as management and ongoing support that relate to ecosystem services, take many forms. Much depends on enabling legislation and direction in agency budgets of governmental agencies. In addition, program focus and even type or location of projects can be written as part of state or local ballot measures. Goals of landowners, contributors and non-governmental organizations also play a role.

One example is that the importance of forested and rangeland watersheds to water quality and supply has been recognized in various ballot initiatives, related legislation, the CALFED Program and, most recently, in the draft California Water Plan. Public funding has been the primary source of investment in these watersheds. For example, under CALFED, millions of dollars have been invested for watershed assessment, watershed management and technical and staff assistance. A number of agencies, but especially the State and Regional Water Quality Control

Boards and the Department of Fish and Game, have worked with stakeholders to carry out such efforts.

The same is true for investment in forests and rangelands critical to providing biodiversity, habitat and open space. Funding has come from a variety of sources, again largely public in origin. Conservancies, such as the Coastal Conservancy and the Sierra Nevada Conservancy, have been established to provide facilitation, coordination, project focus and management. Several state departments have worked with stakeholders to guide these investments. Key among them is the California Department of Fish and Game, especially the Wildlife Conservation Board (WCB).

Many policies, programs, agencies and stakeholders are involved with making decisions over where to make investments that affect ecosystem services. This typically involves protecting areas that provide unique or high levels of desired services, or restoring areas impacted by past events. Augmenting this with emerging market-based solutions could enhance our ability to sustain these important services into the future.

Total Forest Inventory, Growth and Mortality

Table 1.2.9 Total live tree stocks and estimated annual change from tree growth and mortality									
		Stocks				Change, Net of Mortality			
Landbase	Acres	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees
All Forestlands	32,114,317	5,099,162,048	113,695,755	447,709,621	10,058,521,955	40,046,799	1,419,806	5,764,470	-58,328,612
Public Forestland	19,467,566	3,343,515,541	76,368,749	340,794,682	5,685,834,310	30,611,051	751,107	3,438,690	-38,089,971
Private Forestland	12,646,761	1,755,647,124	37,327,502	106,914,068	4,372,687,646	9,438,766	668,726	2,325,853	-20,237,568
Private Timberland	7,647,009	1,418,463,058	31,054,447	103,118,272	4,364,675,374	9,516,486	591,411	2,242,743	-17,094,787

Per Acre Live Trees and Annual Change

Table 1.2.10. Per acre live tree stocks and estimated annual change from tree growth and mortality										
	Stocks					Change, Net of Mortality				
Landbase	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees	Stand Density Index	CO2e (metric tons)	Cubic Feet (thousands)	Board Feet (thousands)	Number of Trees	Stand Density Index
All Forestlands	158.8	3.5	13.9	313.2	214.1	1.247	0.044	0.179	-1.816	2.422
Public Forestland	171.7	3.9	17.5	292.1	225.1	1.572	0.039	0.177	-1.957	2.015
Private Forestland	138.8	3	8.5	345.8	197.1	0.746	0.053	0.184	-1.6	3.05
Private Timberland	185.5	4.1	13.5	570.8	258	1.244	0.077	0.293	-2.235	4.189

Strategy Report 3.4:
Emerging Markets for Forest and Rangelands Products and Services

Assessments should identify forest landscape areas where there is a real, near term potential to access and supply traditional, non-timber, or emerging markets such as those for biomass or ecosystem services. These might be areas where necessary infrastructure currently exists, is planned or developing, where group certification of landowners has created market supply aggregation potential, or where retention and management of forest cover presents a money saving alternative to an engineered fix – such as a water filtration facility. Strengthening and developing new market opportunities for forest products and benefits provide incentives for forest stewardship and conservation (excerpted from the US Forest Service State and Private Forestry Farm Bill Requirement and Redesign Strategies).

GOALS: The goals of these strategies are to facilitate the sustainable development of a biomass industry and to develop carbon and other ecosystem service markets as a way to achieve hazard reduction, improved ecosystem health and services, and lowered greenhouse gas emissions in California.

National Goals Supported. Enhance Public Benefits from Trees and Forests, Conserve Working Forest Lands, protect Forests from Harm

Montreal Process/BOF Policy Goal Supported:
MPC-6: Maintenance and Enhancement of Long-Term Multiple Socio-economic Benefits to Meet the Needs of Societies
MPC-2: Maintenance of Productive Capacity of Forest Ecosystems
MPC-3: Maintenance of Forest Ecosystem Health and Vitality
MPC-5: Maintenance of Forest Contribution to Global Carbon Cycles

State Assessment Theme: Emerging Markets for Forest and Rangeland Products and Services.

Defined Landscape Areas

Priority Landscapes:
Primary – Biomass potential for ecosystem health, biomass potential for community safety.

Secondary – Wildfire threat to ecosystem health, restoring wildfire impacted areas, forest pest threat to ecosystem health, restoring forest pest impacted areas, wildfire threat to community safety, forest pest threat to community safety, restoring forest pest impacted communities, sustainable working landscapes.

Priority Areas:
All bioregions except the Mojave and Colorado Desert. The Sacramento and San Joaquin Valley bioregions are lower priority than the more heavily forested bioregions.

Strategies Overview

Purpose of Strategies

Biomass energy is an underutilized resource and an expanded biomass energy industry would provide numerous public benefits including facilitating treatments to reduce wildfire and forest pest threat, restore areas impacted by wildfire and forest pests, and improve productivity of forestlands to sustain working landscapes. Biomass energy is also an important component for meeting the Renewable Portfolio Standard and reducing greenhouse gas emissions.

Ecosystem service markets are emerging in a number of areas including carbon, water, and habitat. Development of these markets provides a means to accomplish both societal and landowner objectives with efficient allocation of resources.

Statement of Need

Biomass energy provides at least a partial economic compensation for treatments that reduce wildfire or forest pest threat, or restore areas impacted by previous events. This is contingent on a biomass facility being within a reasonable distance such that the economic returns are not consumed by transportation costs. Currently, a majority of priority landscapes and priority communities for threat reduction and restoration are too far from existing biomass facilities to make biomass removal a viable option. Sustainable supply, access to markets and technology, as well as additional research, education and policies will be needed to guide development of the emerging biomass industry in California.

Carbon is the most developed ecosystem market and it is still in an early stage. A number of carbon registries and protocols have developed for the voluntary market, but California still lacks a mandatory compliance market where forest and range may participate. Voluntary carbon markets in California for forestry offsets thus far have used the Climate Action Reserve (CAR) forestry protocols, forest management project type. Compliance markets that use sequestration as an offset are in various stages of development at the local, state, regional, national and international levels. Additional experience with other project types such as avoided conversion, reforestation and urban forestry are needed. Soil sequestration and fuels reduction protocols may also be useful.

Other ecosystem services besides carbon can be market driven, such as water quality. Power producers have long recognized that energy conservation is much less costly than new plants. The same logic applies to water management versus costly new treatment options. For example, New York City spends billions of dollars on watershed improvement programs to avoid costly infrastructure improvements. Also, increased private market prices for water quality could encourage landowners to supply more of these public benefits.

Current market conditions offer virtually no incentives to land owners to adopt biodiversity and conservation related ecosystem services. Conservation benefits society

as a whole, but will not be adopted by landowners unless these markets are sufficiently high to make ecosystem services provisions financially competitive. Examples of conservation practices that benefit ecosystem services where private costs exceed private benefits include enhancing wildlife habitat and species conservation, maintaining or improving aesthetics and riparian habitat, forest and range land restoration, including oak woodland re-establishment and afforestation. Conservation banking and green tourism are examples of ecosystem services that have existing markets, but have room for growth. Both payment programs and markets for conservation practices that enhance ecosystem services are needed to achieve forest and range land conservation and the preservation of habitat to increase the flow of ecosystem services.

Cross-Cutting Issues

Priority landscapes identify areas for expanding the current biomass industry or maintaining current facilities. This includes all bioregions with areas of high wildfire or forest pest threat as well as areas already impacted. Carbon production depends on healthy forests for long-term production. There are a number of cross-cutting issues that include:

- Wildfire and Forest Pests Threats to Ecosystem Health – Forest management activities that improve stand health and increases tree growth also promotes wood fiber production and increases wood product flow for biomass facilities.
- Wildfire and Forest Pests Threats to Community Safety – Removal of dead, dying and diseased trees and thinning operations to address forest pests and to improve wildfire protection can also generate additional biomass.
- Sustainable Working Forests – The development of biomass and carbon markets could enhance long-term socio-economic benefits from working forests.
- Urban Forests – Maintenance of urban forests improves urban forest health and sustainability while simultaneously providing potential biomass feedstock to emerging markets.

Existing Supporting Plans and Programs

Supporting plans include:

- *A Preliminary Roadmap for the Future Development of Biomass in California* (CEC, 2006), California Fire Plan – California's strategic plan for reducing wildfire threats, National Fire Plan
- Executive Order S-06-06 (2006): Established a biomass target of 20 percent within the established RPS goals for 2010 and 2020.
- Executive Order S-14-08 (2008): Established accelerated RPS targets (33 percent by 2020) as recommended in the Energy Action Plan II. The order also called for the formation of the Renewable Energy Action Team, comprised of the Energy Commission, Department of Fish and Game, Bureau of Land Management, and U.S. Fish and Wildlife Service. Through the team, the Energy Commission and the Department of Fish and Game are to prepare a plan for renewable development in sensitive desert habitat.
- Executive Order S-21-09 (2009): establishes a target that all retail sellers of electricity shall serve 33 percent of their load with renewable energy by 2020

and directs the ARB to work with the CPUC, the California ISO, and the Energy Commission to adopt regulations by July 31, 2010.

- Global Warming Solutions Act of 2006, Scoping Plan, which identifies five strategies for forest carbon management and includes forest carbon as an offset under a cap-and-trade program; managed by California Air Resources Board.

Existing programs that support the emerging markets strategies include:

- The Sustainable Agriculture Research and Education Program(SAREP) provides leadership and support for scientific research and education in agricultural and food systems that are economically viable, conserve natural resources and biodiversity, and enhance the quality of life in the state's communities.
- California Forest Practices Rules – provides rules and procedures to avoid or lessen adverse effects on the environment from timber harvesting on local, state and privately owned timberlands.
- CAL FIRE Pest Management Program - forest pest specialists help protect the state's forest resources from native and introduced pests, conduct surveys and provide technical assistance to private forest landowners and promote forest health on all forest lands throughout the state
- California Forest Improvement Program (CFIP) – improve productivity of non-industrial private timberlands and includes the improvement of other forest resources, including fish and wildlife habitat, soil, and water quality.
- California Forest Stewardship Program – Designed to promote long-term stewardship of private forest lands.
- University of California Cooperative Extension (UCCE) – Serves forest and range land owners through outreach efforts and technical assistance.
- California Safe Harbor – Encourages land owners to conserve and manage land for endangered species and biodiversity conservation by removing the threat of financial penalties and violations.
- NRCS – Emergency Watershed Protection (EWP), Conservation Stewardship program (CSP), Environmental Quality Incentives Program (EQUIP), Wildlife Habitat Incentives Program (WHIP), Conservation Reserve Enhancement Program (CREP), Wetlands Reserve Program (WRP).
- Healthy Forests Restoration Act – To build-up the capacity to conduct hazardous fuels reduction projects on National Forest System lands and Bureau of Land Management lands aimed at protecting communities, watersheds, and certain other at-risk lands from catastrophic wildfire.
- Existing carbon protocols and registries - Climate Action Reserve (CAR), American Carbon Registry (ACR), Chicago Climate Exchange (CCX), Voluntary Carbon Standard (VCS), and others.
- Developing cap-and-trade systems that incorporate forest offsets: AB32 for California, Western Climate Initiative for regional program, and bills introduced in Congress.

Current Constraints
Relative to fossil fuels, biomass energy provides a wide variety of public benefits for which biomass energy investors are not economically and equitably compensated. Under current economic and policy conditions it is very difficult for biomass energy to compete with fossil fuels (e.g. natural gas).

Markets require adequate supply and demand. They also require transparency as to the quality of the goods for sale. Participation in a new market carries risk for both the producer and consumer of new commodities.

Key Stakeholders and Partners
California Energy Commission, California Biomass Collaborative, California Biomass Energy Alliance, California Air Resources Board, California Forestry Association (CFA), regional air quality districts, timber industry, landowners, local government and NGOs.

Strategies and Supporting Actions

The overall biomass strategy presented here is to support implementation of the California Energy Commission's roadmap for future biomass development (http://www.energy.ca.gov/2006publications/CEC-500-2006-095/CEC-500-2006-095-D.PDF). The first five strategies identified roughly outline steps detailed by this report. Additional details on strategies and actions can be found in the complete report entitled "A preliminary Roadmap for the Development of Biomass in California" (Jenkins, 2006). A strategy for developing carbon markets and a strategy for developing other markets is presented.

Strategy: 3.4.1. Facilitate development of sustainable biomass harvest practices to grow, collect and store forest, range and urban biomass resources and deliver it as feedstock to biomass markets.

Action A – Develop and apply best management practices for resource development, production, and extraction allowing both industry and state enforcement of standards. Where standards do not yet exist, new standards should be developed.

Action B – Determine the long-term biomass supply, if any, that is available from federal lands in or near to California. This will take collaborative processes, planning and long-term stewardship contracts/agreements (Heinz and Pinchot, 2010).

Action C –Establish a process for independent certification of sustainable practices.

Action D – Establish a biomass commodity market and commodity board or commission to facilitate biomass marketing, development of infrastructure, and coordination.

Action E – Develop production, collection, transportation, storage, and processing infrastructure.

Action F – Establish sustainable business certifications.

Action G – Credit sustainable suppliers of feedstock through tax incentives or subsidies in recognition of other costs avoided.

Action H – Provide initial state assistance in funding collection and processing efforts.

Action I – Provide access to extensive biomass resource and market information.

Strategy: 3.4.2. Facilitate the expansion of biomass markets through improved infrastructure (e.g., transmission lines), monetization of external benefits (e.g., hazard reduction), feedstock collection, and generation capacity.

Action A – Ensure adequate feedstock collection, separation, and harvesting equipment Infrastructure is available to all landowners.

Action B – Ensure adequate physical infrastructure is available, such as electricity transmission lines, interconnection, feedstock storage, transportation, and processing capacity.

Action C – Establish policies and enact necessary laws to monetize external benefits and stimulate needed investment through tax credits, price supports and loan guarantees, carbon markets, environmental credits, and other financial incentives.

Action D – Add new power generation capacity including distributed generation.

Action E – Encourage replacement of existing power facilities with more advanced systems such as biomass integrated combined cycles (BIGCC) and increasing use of combined heat and power (CHP) technologies.

Action F – Ensure that new and existing facilities utilize state of the science and technology to provide effective controls on smokestack emissions and other pollutants from biomass burning and conversion facilities.

Strategy: 3.4.3. Support and conduct biomass research and development including life cycle analysis, best management practices, monitoring and sustainability.

Action A – Conduct comprehensive life cycle assessments and health risk assessments systematically comparing waste and resource utilization alternatives.

Action B – Determine and maintain best management practices and conduct monitoring of environmental, health, and safety impacts from feedstock production, handling, processing, conversion, manufacturing, and utilization.

Action C – Conduct basic research to improve sustainability of biomass production systems, increase yields, reduce water and other agronomic inputs, increase resistance of biomass crops to disease and pests, and improve the conversion processes and product quality.

Action D – Conduct applied research and demonstrate commercial scale biomass conversion and biorefinery techniques.

Action E – Conduct market studies and other research to assess the effect of emerging carbon markets (LCFS and cap-and-trade) as drivers to utilize biomass for bioenergy/fuel production and the interplay between biomass, timber, and carbon markets and their impacts on supply and sustainability of forest and range land resources (including carbon sequestration) in California.

Action F – Develop or improve modeling, remote sensing, systems analyses, and systems optimization for land use monitoring, climate change impacts, economic impacts, feedstock production, acquisition logistics, and power plant siting and design.

Strategy: 3.4.4. Support education and training and the development of curricula to inform citizens, consumers, and decision makers and develop well trained biomass industry professionals in California.

Action A – Conduct outreach to local, state and federal government decision makers, schools, non-governmental organizations (NGOs), sustainability groups, and other public interest groups.

Action B – Provide outreach on biomass utilization and establish early dialog with affected communities where facilities are proposed to ensure environmental justice and direct public involvement, and to communicate the benefits of biomass to local communities.

Action C – Provide technical training by and for industry and expanding university curricula and programs to ensure the availability of adequate numbers of skilled professionals and technicians.

Action D – Augment existing cooperative extension programs to inform and educate farmers, producers, operators, investors, and others of results emerging from research and development efforts.

Strategy: 3.4.5. Address existing constraints and develop new policies, laws and regulations that promote and facilitate the expanded use of biomass while protecting the state's environment.

Action A – Align State and Federal energy and resource policies in the area of bioenergy so they compliment each other and enhance support for this emerging market, while maintaining and enhancing environmental and consumer protections.

Action B – Establish or augment financial incentives, including carbon markets, tax credits, production incentives, and access to capitol.

Action C – Revise waste management policies (e.g., alternative daily cover diversion credits), and practices.

Action D – Revise permitting requirements to enhance interagency communication and create a clear permitting pathway for applicants.

Action E – Establish new or invest in existing enterprise zones with responsibilities and opportunities to support biomass development including assistance identifying biomass power plant locations, local support, and environmental review.

Action F – Implement environmental justice review.

Action G – Enhance access to transmission lines, pipelines, and other infrastructure; and provide equitable policies for net metering, opening direct access, and other incentives intended to stimulate markets.

Strategy: 3.4.6. Support the development of voluntary and compliance carbon markets.

Action A – Encourage the use of registries to track both voluntary and compliance carbon credits. Use registry figures to track market progress.

Action B – Monitor the development of protocols related to forest and range lands to ensure quality and compatibility with laws and regulations.

Action C – Provide technical assistance to landowners, registries and buyers to encourage open and fair markets.

Action D – Facilitate landowner aggregation mechanisms to widen participation.

Action E – Promote funding mechanisms such as low interest loans for project development of high-yielding projects with co-benefits. Reforestation projects often fit this category.

Strategy: 3.4.7. Support the development of other emerging voluntary markets including water, habitat and green tourism.

Action A – Promote an understanding of the costs and benefits of watershed and other management.

Action B – Develop watershed approaches to permits and restoration activities that reward landowners for attaining socially desired future conditions.

Action C – Identify the need for government stimulus of registries, protocols or markets for non-carbon commodities.

Action D – Encourage trade credit systems for habitat provisions and pollution reductions.

Action E – Promote market incentives to encourage landowners to conserve forest and range working landscapes.

Action F – Promote local community and government efforts to acquire and manage additional open space and recreation lands.

Action G – Encourage relevant ecosystem services capabilities expansion on private land.

Action H – Focus on long-term plans and conservation easement conditions that clarify land tenure questions, are approved as alternatives under Forest Practice Rules and reduce compliance costs to landowners.

Action I – Examine use of systems of environmental management that depends on certified, insured and guaranteed operations rather than a permit with civil enforcement.

Strategy: 3.4.8. Support expansion of transmission infrastructure for emerging renewable energy generation from sources such as biomass, wind, hydro and solar in a way that minimizes environmental impact to forest and rangelands.

Action A – Avoid developing in areas that are environmentally sensitive or are prohibited from development by law or policy.

Action B – Support the findings and recommendations of the Renewable Energy Transmission Initiative (RETI) stakeholder steering committee to adopted energy policies that increases generation of electricity from renewable resources.

Action C – Support improvements needed for California's electric transmission infrastructure to get the electricity generated by new renewable power facilities to consumers with minimum impact to forest and rangelands.

Action D – Encourage a transparent, stakeholder based planning process that includes environmental organizations, regulatory and permitting agencies, major transmission providers and renewable energy generators.

Action E – Coordinate corridor designation in accordance with appropriate environmental protections by working with state and federal agencies, environmental groups, BLM Solar Energy Zones, Desert Renewable Energy Conservation Plan, NCCPs and Competitive Renewable Energy Zones (CREZ) defined by RETI.

Recommended Performance Measures

Note: Where appropriate, use one or more of the measures listed below to report on effectiveness. Extent of reporting is contingent on funding.

- Numbers of operational biomass facilities that utilize forest biomass.
- Acres treated to protect from wildfire/forest pest threat or restore impacted areas.
- Percent of total electrical generation obtained from biomass energy.
- Green tons from small diameter and low value trees removed from NFS lands and made available for bio-energy production.
- Carbon tonnes traded annually in the voluntary and compliance markets.
- Annual revenues to forest and range landowners from ecosystem markets.
- Number of rural jobs created.

Strategy: 3.4.7. Support the development of other emerging voluntary markets including water, habitat and green tourism.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support the development of other emerging voluntary markets including water, habitat and green tourism	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Rural Economic Development	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA ;NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Annual revenues to forest and range landowner s from ecosystem markets.	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.8. Support expansion of transmission infrastructure for emerging renewable energy generation from sources such as biomass, wind, hydro and solar in a way that minimizes environmental impact to forest and rangelands.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support expansion of transmission infrastructure for emerging renewable energy in a way that minimizes environmental impact to forest and rangelands.	Entire state	Wildfire Threats Sustainable working landscapes Rural economic development.	BLM Solar Energy Zones, Desert Renewable Energy Conservation Plan, NCCPs, RETI	State, federal, NGO's, landowners	Bond Funding; Grants; State and Federal Programs	total energy produced, rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Chapter 3.4 - Emerging Markets for Forests and Rangeland Products and Services Analysis: Biomass Energy for Ecosystem Health

Priority Landscape by County (Thousands of Acres)

County	None	Low	Medium	High	Total
Alameda	0	0	0	0	0
Alpine	4	16	4	7	32
Amador	29	100	66	114	308
Butte	0	0	0	0	0
Calaveras	12	106	87	46	250
Colusa	0	0	0	0	0
Contra Costa	0	0	0	0	0
Del Norte	0	0	0	0	0
El Dorado	86	93	236	419	835
Fresno	0	0	0	0	0
Glenn	0	0	0	0	0
Humboldt	7	88	141	144	380
Imperial	0	0	0	0	0
Inyo	0	0	0	0	0
Kern	0	0	0	0	0
Kings	0	0	0	0	0
Lake	0	0	0	0	0
Lassen	60	46	80	440	626
Los Angeles	0	0	0	0	0
Madera	0	0	0	0	0
Marin	0	0	0	0	0
Mariposa	< 1	6	5	6	17
Mendocino	11	467	101	23	603
Merced	0	0	0	0	0
Modoc	26	40	87	279	432
Mono	0	0	0	0	0
Monterey	0	0	0	0	0
Napa	0	0	0	0	0
Nevada	< 1	2	2	9	14
Orange	0	0	0	0	0
Placer	70	58	100	201	428
Plumas	0	0	0	0	0
Riverside	0	0	0	0	0
Sacramento	83	96	4	0	183
San Benito	0	0	0	0	0
San Bernardino	0	0	0	0	0
San Diego	0	0	0	0	0
San Francisco	0	0	0	0	0
San Joaquin	165	91	< 1	0	257
San Luis Obispo	0	0	0	0	0
San Mateo	0	0	0	0	0
Santa Barbara	0	0	0	0	0
Santa Clara	0	0	0	0	0
Santa Cruz	0	0	0	0	0
Shasta	2	21	22	121	166
Sierra	0	0	0	0	0

Siskiyou	131	477	405	763	1,776
Solano	0	0	0	0	0
Sonoma	0	0	0	0	0
Stanislaus	< 1	13	< 1	0	13
Sutter	0	0	0	0	0
Tehama	< 1	7	10	14	31
Trinity	11	88	144	871	1,114
Tulare	0	0	0	0	0
Tuolumne	8	28	64	117	217
Ventura	0	0	0	0	0
Yolo	0	0	0	0	0
Yuba	0	0	0	0	0
Total	707	1,844	1,557	3,575	7,683

***Data Sources:** Aerial Survey Detection (ADS), USFS FHP (2008 v1); Biomass Facilities, FRAP (2009 v1); Burn Severity, USFS (2009); California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002); Forest Pest Risk data, USFS FHP (2006 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006); County Boundaries, FRAP (2009 v1)*

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Chapter 3.4 - Emerging Markets for Forests and Rangeland Products and Services Analysis: Biomass Energy for Community Safety

Priority Landscape by Community (Acres - Rounded to Nearest Hundred)

Community	None	Low	Medium	High	Total
Alpine Village	< 100	400	< 100	0	600
Amador City	300	0	0	0	300
Arnold	1,500	700	200	4,700	7,000
Carrick	< 100	< 100	< 100	< 100	< 100
Diamond Springs	200	2,700	800	< 100	3,800
Dollar Point	100	< 100	< 100	900	1,000
Dorrington	200	< 100	600	1,400	2,300
Dunsmuir	400	< 100	200	500	1,100
Edgewood	< 100	400	< 100	0	600
Elk Grove	5,100	0	0	0	5,100
Etna	400	0	< 100	< 100	500
Farmington	900	< 100	0	0	1,000
Foresthill	3,100	300	1,400	1,400	6,200
Fort Bragg	1,800	0	0	0	1,800
Fort Jones	300	0	< 100	100	400
Galt	3,400	0	0	0	3,400
Gazelle	< 100	400	< 100	0	400
Georgetown	300	< 100	1,300	200	1,800
Greenview	100	700	< 100	0	900
Grenada	300	0	0	0	300
Hayfork	88,400	1,900	8,200	1,100	99,600
Hornbrook	< 100	500	100	< 100	700
Ione	3,100	0	0	0	3,100
Jackson	2,300	0	0	0	2,300
Kings Beach	1,100	200	< 100	800	2,200
Laytonville	200	1,900	600	500	3,300
Lewiston	2,900	< 100	400	200	3,500
Linden	4,800	0	0	0	4,800
Lockeford	5,400	0	0	0	5,400
Lodi	7,400	0	0	0	7,400
McCloud	200	200	800	400	1,600
Mendocino	200	500	600	< 100	1,400
Mesa Vista	5,300	1,800	200	0	7,300
Mokelumne Hill	300	< 100	1,200	400	2,000
Montague	1,100	0	0	0	1,100
Morada	1,300	0	0	0	1,300
Mountain Ranch	5,100	2,000	12,200	< 100	19,300
Mt Shasta	1,100	< 100	600	500	2,300
North Woodbridge	1,800	0	0	0	1,800
Placerville	500	< 100	300	2,900	3,700
Plymouth	700	0	0	0	700
Pollock Pines	600	< 100	100	3,000	3,700
Rail Road Flat	12,300	1,200	5,300	< 100	18,700
Rancho Calaveras	< 100	1,600	3,500	200	5,400
Rancho Murieta	2,300	4,500	200	0	7,100
San Andreas	1,500	400	900	200	3,000

South Lake Tahoe	1,700	200	200	4,400	6,500
South Woodbridge	200	0	0	0	200
Stockton	200	0	0	0	200
Sunnyside-Tahoe City	700	< 100	< 100	1,400	2,200
Sutter Creek	1,000	0	0	0	1,000
Tahoe Vista	300	100	< 100	1,300	1,700
Truckee	< 100	0	< 100	< 100	< 100
Valley Springs	1,800	3,900	400	200	6,300
Vineyard	700	0	0	0	700
Wallace	1,000	1,800	< 100	0	2,800
Weaverville	15,500	1,300	4,800	1,100	22,600
Weed	2,300	400	300	< 100	3,100
West Point	200	< 100	2,000	200	2,400
Willits	1,600	< 100	< 100	0	1,600
Willow Creek	86,900	16,500	8,500	1,300	113,300
Wilton	16,700	2,300	< 100	0	19,000
Yreka	6,000	< 100	100	300	6,500
Total	305,400	49,500	56,400	30,000	441,200

Data Sources: *Aerial Survey Detection (ADS), USFS FHP (2008 v1); Biomass Facilities, FRAP (2009 v1); Burn Severity, USFS (2009); California Fire Regime Condition Class, FRAP (2003); California Tree Seed Zones, Buck, et al. (1970); Fire Threat, FRAP (2005); Fire Perimeters, FRAP (2009 v1); Fuel Rank, FRAP (2002); Forest Pest Risk data, USFS FHP (2006 v1); Statewide Land Use / Land Cover Mosaic, FRAP (2006); Communities, FRAP (2009 v1)*

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Strategy Matrix

Strategy: 3.3.1. Promote formation of Local Fire Safe Councils for priority communities.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Improve support for community wildfire planning.	Priority Communities and currently designated Communities at Risk	Fire suppression costs and losses; Firefighter safety	Fire Safe Councils, California Fire Alliance	Communities; Counties	Local Government	New funding sources	

Strategy: 3.3.2. Promote participation in the National Firewise/USA program.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Improve local fire planning process	Priority Communities and currently designated Communities at Risk	Need for a method to develop CWPP	Firewise, Current recognized communities	Communities	CFA, FSC	Firewise recognition; CWPP; Projects implemented/planned	

Strategy: 3.3.3. Establish a statewide comparative database of community wildfire planning.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Increase collaboration and knowledge sharing in community wildfire planning	Priority Communities and currently designated Communities at Risk	CWPP monitoring and evaluation	CFA Website	USFS, BLM, Counties	CFA	Improved monitoring, better statistics	3.1; 3.7

Strategy Matrix

Strategy: 3.4.1. Facilitate development of sustainable biomass harvest practices to grow, collect and store forest and range biomass resources and deliver it as feedstock to biomass markets.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Facilitate development of sustainable biomass harvest practices to grow, collect and store forest and range biomass resources and deliver it as feedstock to biomass markets.	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.2. Facilitate the expansion of biomass markets through improved infrastructure (e.g. transmission lines), monetization of external benefits (e.g. hazard reduction), feedstock collection, and generation capacity.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Facilitate the expansion of biomass markets through improved infrastructure, monetization of external benefits, feedstock collection, and generation capacity	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA: NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced; rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.3. Support and conduct biomass research and development including life cycle analysis, best management practices, monitoring and sustainability.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support and conduct biomass research and development including life cycle analysis, best management practices, monitoring and sustainability	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced; rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.4. Support education and training and the development of curricula to inform citizens, consumers, and decision makers and develop well trained biomass industry professionals in California.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support education and training and the development of curricula to inform citizens, consumers, and decision makers and develop well trained biomass industry professionals in California	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced; rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.5. Address existing constraints and develop new policies, laws and regulations that promote and facilitate the expanded use of biomass while protecting the state's environment.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Address existing constraints and develop new policies, laws and regulations that promote and facilitate the expanded use of biomass while protecting the state's environment	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Wildfire Threats Forest Pest threats Sustainable working landscapes Rural economic development.	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Number of facilities; Acres of Forestland Restored; Reduced wildfire/pest damages; total energy produced; rural jobs created	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

Strategy: 3.4.6. Support the development of voluntary and compliance carbon markets.

Long-term Strategy	Priority Landscape Area(s)	Secondary Issues Addressed	Existing Programs	Partners / Stakeholders	Resources Available	Measures of Success	National Objectives Supported
Support the development of voluntary and compliance carbon markets	Primarily Klamath/North Coast, Modoc, and Sierra bioregions. Secondarily Sacramento and San Joaquin.	Climate Change	CFIP, CFSP, UCCD, CFLP, HFRA, NFP, EWP, CSP, EQUIP, WHIP	USDA-APHIS; State; USFS; CFA; CDFA; NGO's; landowners; Other Forest industry	Bond Funding; Grants; State and Federal Programs	Carbon tonnes traded annually in the voluntary and compliance markets.	Protect Forests From Harm Primary: T2.2, Secondary: Enhance Benefits; T3.4, T3

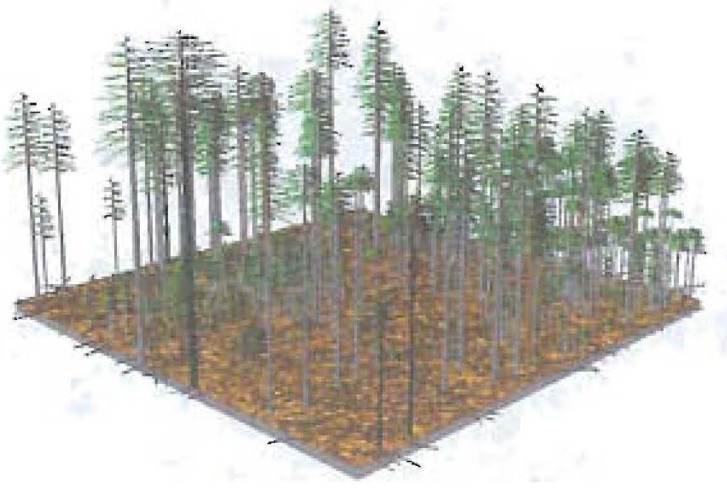
MTHP Fire Behavior Modeling

- White Fir Stand
- Extreme Fire Weather
- 30% Slope

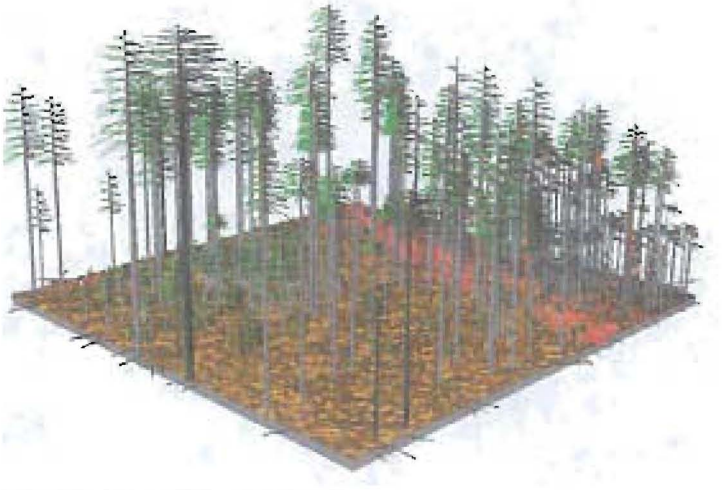
Scenario #1 – Untreated Stand

- Dense untreated White Fir stand
- Ladder fuels present (small trees)
- Moderate surface fuels (28 tons/acre).

Initial stand condition

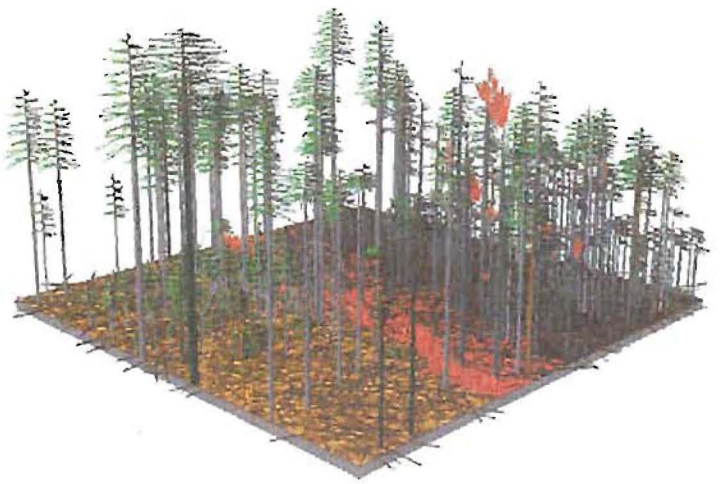


Beginning of Fire



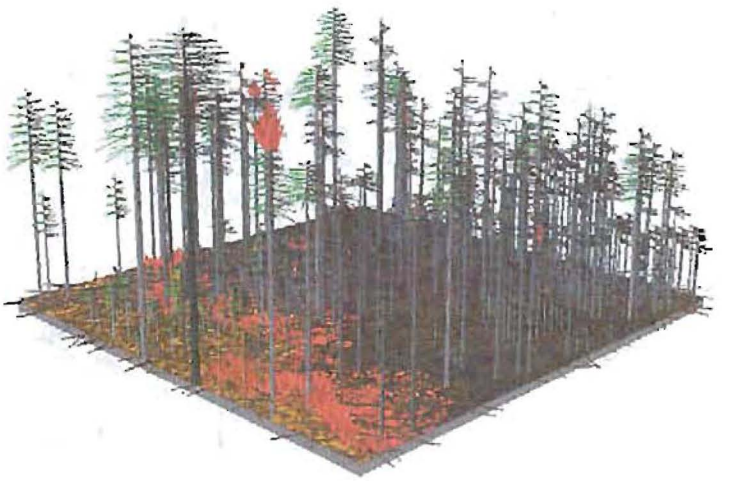
During the fire

Note the crowning fire behavior and flame lengths



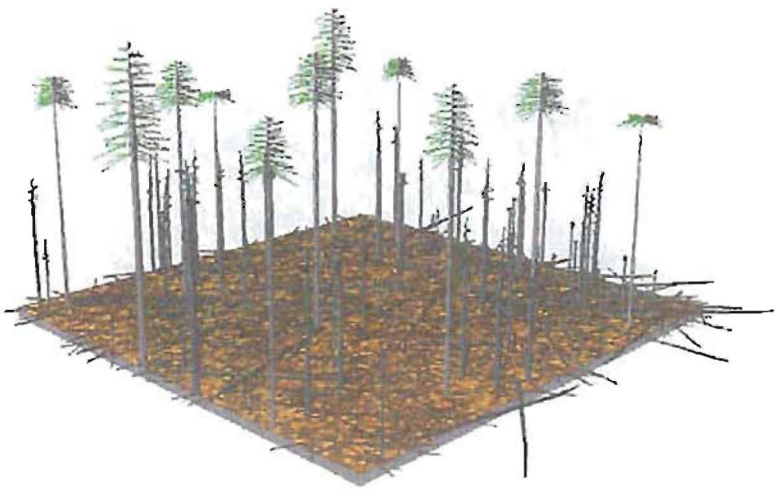
During the fire

Note the high mortality rate of the trees



10 years after the fire

Note the large input of fuels due to tree mortality

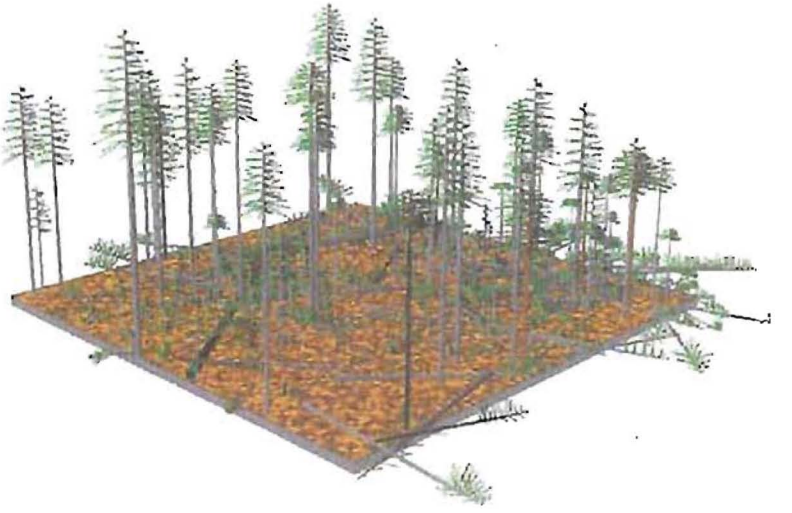


Scenario #2 – Treated Stand

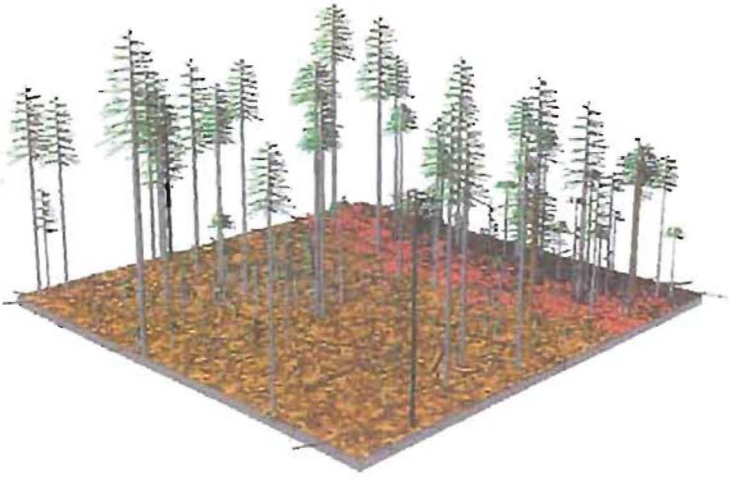
- Same Stand, under the same conditions, except treated to reduce stocking, ladder fuels, and surface fuels
- Canopy tree stocking reduced approximately 50%
- Ladder fuels reduced (50% of trees less than 3" diameter removed)
- Lower post harvest surface fuels (7 tons/acre).

White Fir stand showing the modeled cutting

Note that the downed trees are removed prior to the fire

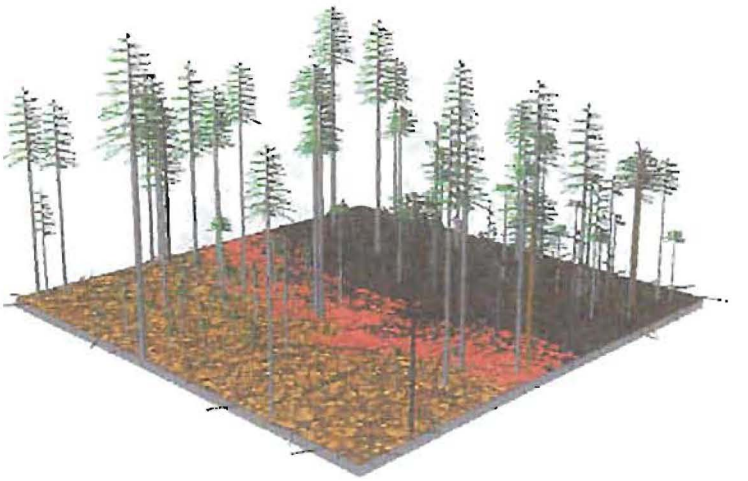


Beginning of fire



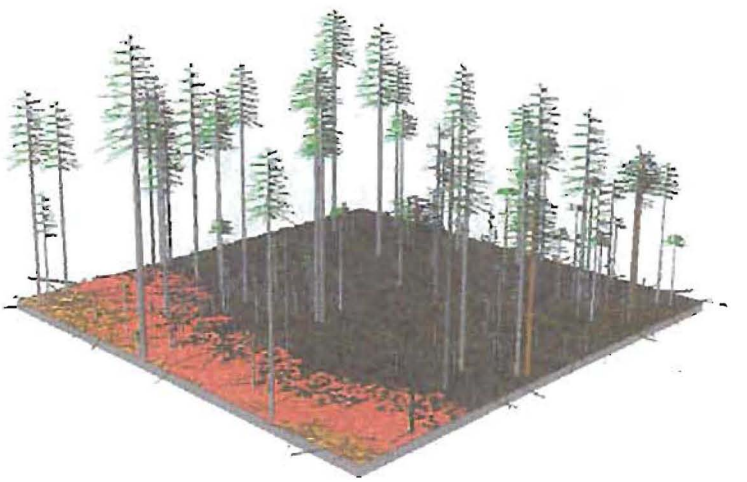
During the fire

Note the low flame lengths and lack of crowning fire behavior



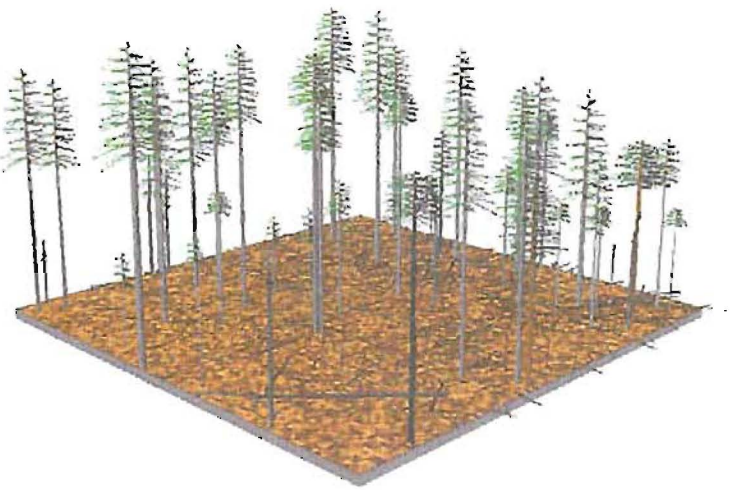
During the fire

Note the lack of tree mortality due to the reduction in fire intensity



10 years after the fire

Note that the reduction in tree mortality has resulted in reduced fuel inputs in the post-fire stand



Biomass Use and Feedstock Issues

The supply of biomass as feedstock for energy production depends not just on supply and demand but also on the physical amounts from different sources; delivered costs; and national, regional, state, and local laws, regulations, and policies. Regional variations influence the United States' potential biomass supply and ultimately the placement of bioenergy facilities. Whether biomass is removed and used for energy affects ecological systems and influences long-term climate change mitigation measures.

Availability of Biomass

Biomass feedstocks for bioenergy and biofuel include forest and agricultural resources, residuals from forest product mill operations, and municipal solid and urban waste wood (Perlack et al. 2005). Although each source is important, this article focuses on forest resources—residues from timber harvest, hazardous fuel reduction, forest health restoration projects, and energy wood plantations—based on forest growth, removals, and mortality (Figure 4-1).

The "Billion Ton Report" projected the potential amount of biomass to be as much as 1.2 billion tons of biomass availability annually in the United States (Perlack et al. 2005). It is now recognized, however, that the actual amount, given social, political, and market constraints, will be less (Sample et al. 2010, US DOE 2011).

Five types of biomass have been defined (White 2010):

- *Potentially available biomass* is all the woody biomass reported to be available.
- *Technically available biomass* is the amount of woody biomass that can actually be used, determined as a percentage of potentially available biomass and representing the amount expected to be recoverable using current or expected technology (e.g., Perlack et al. 2005). Updated estimates of these volumes are also provided as available supplies based on accessibility and operability for each US region (Greene et al. 2010).
- *Market price biomass* is the amount of woody biomass that could be available at a given market price (e.g., Biomass Research and Development Initiative [BRDI] 2008, Walsh et al. 2003).
- *Supply curve biomass* is the amount of woody biomass available over a range of biomass prices (White 2010).
- *Performance-based biomass* is the amount of woody biomass available via a field verification of a coordinated resource offering protocol (CROP). Developed for the US Forest Service, CROP is a tool for assessing biomass supply from land management agencies, based on "ability to perform" removal (versus potential to remove based primarily on inventory) (Mater and Gee 2011).

The use of energy fuels has changed slowly over time. Wood served as the main form of energy for about half of the United States' history. Coal surpassed wood in the late 19th century and was in turn overtaken by petroleum products in the mid-1900s. Natural gas consumption experienced rapid growth in the second half of the 20th century, and coal use also began to expand as the primary source of electric power generation (Energy Information Administration 2010). The majority of bioenergy produced from woody biomass is consumed currently by the industrial sector—mostly at pulp and paper mills that use heat and electricity produced on site from mill residues (White 2010). But that is changing. As of January 2011, there were 445 (nonpulp and paper mill) operating and announced wood-using bioenergy projects in the United States, ranging from wood pellet mills and wood-to-electricity plants to pilot projects for cellulosic ethanol (Forisk Consulting 2010).

Factors that Affect Feedstock Supply

Changes in feedstock supply are controversial and a point of contention for competing industries (paper and pulp versus bioenergy), environmental groups, private landowners, and public land managers. The controversy is amplified by uncertainties surrounding the effects of climate change on forests and the best mix of mitigation and adaptation strategies to use across forest types and landowner categories. Research

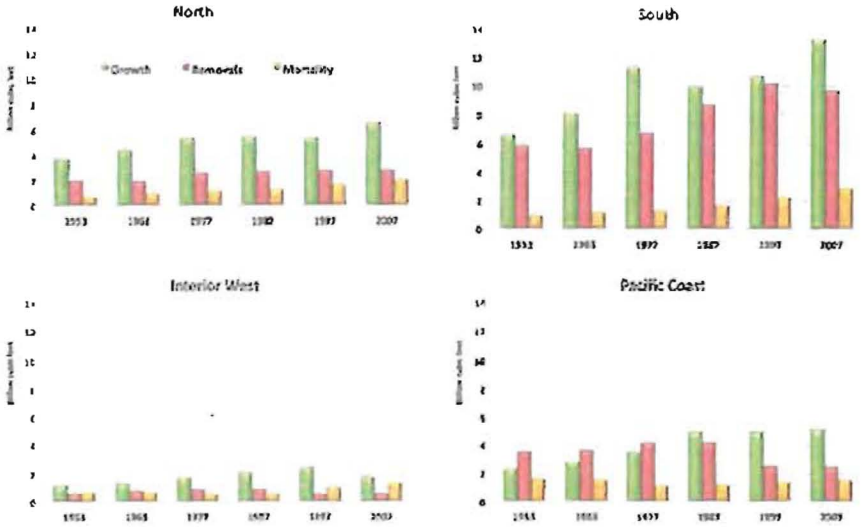


Figure 4-1. US forest growth, removals, and mortality, 1952–2006. (Source: Based on Smith et al. 2009.)

has begun to analyze the perceived competition conflicts between traditional consuming forest products mills and new wood energy plants. For example, Ince et al. (2011, 142) modeled US forest sector market and trade impacts of expansion in domestic wood energy consumption under hypothetical future US wood biomass energy policy scenarios. Bowyer (2011) also examined policy implications for bioenergy development, as well as the likely impact of global energy trends on biomass demand.

Environmental Consequences and Constraints

The ecological effects on soils, wildlife, fire regimes, and water quality of using biomass for bioenergy depends on the existing condition of the forest stand and the amount of biomass to be removed over a specific period. The results depend on such factors as the timing of removal and the nature of the biomass (e.g., logging residues or short-rotation woody crops; Pan et al. 2008, 2010, Hurteau et al. 2008).

There are concerns that if too many bioenergy and biofuel plants are established over time they will not be sustainable. However, sustainable forest management practices are well known and widely practiced and can protect forests' environmental and ecological values. States such as Minnesota, Wisconsin, and Pennsylvania, are developing woody biomass removal guidelines to ensure small-scale and sustainable bioenergy plants can meet long-term environmental, ecological, and economic needs. Use of forestry best management practices and certification systems such as the American Tree Farm System, Sustainable Forestry Initiative, and Forest Stewardship Council is also widespread.

There can be environmental tradeoffs involved in removing harvesting residuals where the residuals have value in maintaining site productivity and biodiversity. Site responses to residue removal and retention depend on site conditions and limiting factors. Scientific evidence from sites across North America suggests that the productivity of most sites is largely resilient to removing harvesting residuals (Powers et al. 2005). For instance, Westbrook et al. (2007) found that even with removal of all harvesting residues and all nonmerchantable woody biomass between 1- and 4-in. dbh, nutrient losses from a Georgia pine plantation were expected to be replaced by precipitation in 5 years. Overall, documentation of negative effects on site productivity due to biomass removal is rare.

Two recent meta-analyses of the scientific literature suggest that effects of biomass harvest on biodiversity can vary by forest harvesting practice and other factors. Studies of forest thinning have generally reported positive or neutral effects on diversity and abundance of terrestrial vertebrates and invertebrates across all taxa, although thinning intensity and the type of thinning may influence the magnitude of response (Verschuyl et al. 2011). Studies that document biodiversity response to harvest of coarse woody debris and/or standing snags report substantially and consistently lower diversity and abundance of cavity- and open-nesting birds and reduced invertebrate biomass in treatments with lower amounts of downed coarse woody debris and/or standing snags (Riffell et al. 2011). Effects of harvesting coarse and particularly fine woody debris on other taxa do not appear to be great, although there have been few studies of these practices (Riffell et al. 2011). With scientific support lacking for significant project level impacts, harvesting guideline provisions should allow managers the flexibility to tailor prescriptions to site conditions and limiting factors and promote analysis of the impacts across a scale that includes numerous ownerships and projects.

Genetic Improvement and Woody Crops

Genetic tree improvement programs have focused on improving phenotypic characteristics, predominantly to increase volume for timber production. Today, mostly private companies are investing in poplar and willow to increase feedstocks through advanced genetics in tree selection. Mass control pollinated and varietal pine seedlings that exhibit genetic gains are now available (Dougherty 2007).

Poplar breeders in the United States have focused on increasing adaptability, growth rates, and pest and stress resistance. Significant increases have been achieved through traditional selection and breeding along with intensified cultural practices. Efficiencies have also been gained in harvesting and handling. Opportunities for manipulating feedstock quality have long been recognized but have gone largely unrealized because of uncertainties over which traits to modify for what process and because of some social resistance to genetic modification of trees. Quality changes can affect process efficiency in numerous ways, but reliable information concerning the effects is sparse (Dinus 2000, BRDI 2008, Sample et al. 2010, White 2010).

Short-rotation woody crops, such as shrub willow, hybrid poplar, southern pine, and eucalyptus, have the potential to increase biomass feedstocks, but large-scale production of these crops has yet to occur (Volk et al. in press). Hybrid poplars grown in the Midwest, South, and Pacific Northwest under intensive silviculture can provide biomass for energy as well as sawlogs, veneer logs, and fiber for the pulp and paper industry (Volk et al. in press). Coppice systems are still under development, but yields from commercial plantations range from 9 to 10 oven-dry tonnes (odt)/ha per year in the Midwest to 18 odt/ha per year in the Pacific Northwest (Netzer et al. 2002). With additional research, including breeding and genetic advances, sustainable yields of 16, 24, and 36 odt/ha per year are possible in the Midwest, South, and Pacific Northwest, respectively (Volk et al. in press).

Pine and eucalyptus grown in the South also have the potential to supply biomass as well as sawlogs and fiber. Loblolly pine's widespread cultivation and high growth rates make it a likely candidate for short-rotation culture (Dickmann 2006), but extensive development is required. Eucalyptus has been called an ideal species for biofuels and bioenergy (Volk et al. in press), and in the South, it can be produced and delivered at a cost competitive with grasses and other hardwoods. Under the right growing conditions, it can produce more than 29 odt/ha per year for either biomass feedstock or ethanol (Gonzalez et al. 2009, 2010, 2011a, 2011b).

Economics

Traditional forest products such as sawtimber and pulpwood are more or less complementary uses, because pulpwood can be managed to become sawtimber. Forest biomass, at least for energy generation, can come from pulpwood-size trees, which are easily substituted: established markets, silvicultural systems, and harvesting and logistics supply chains already exist. Although traditional pulpwood harvesting can accommodate small woody biomass and forest residue collection, there is a point at which production efficiency suffers (Westbrook et al. 2007). Price to the landowner will invariably be a determining factor of end use. The traditional forest products industry, particularly the pulp

and paper sector, has already seen price competition for pulpwood to be turned into pellets (Greene et al. 2010).

Government Policy

The Biomass Research and Development Act of 2000 authorized an interagency board (representing USDA, Department of Energy, Department of the Interior, and the Environmental Protection Agency) to promote development of biofuels in the United States. The Board recently issued an eight-point strategic plan focused on this goal. Agency coordination was recognized as important given often conflicting agency initiatives and guidance from Congress. For instance, the Energy Policy Act of 2005 disallowed the use of federal woody biomass for the renewable energy credit. In contrast, Section 203 of the Healthy Forests Restoration Act of 2003 (PL 108-148, codified at 16 US Code Section 6531) provided authority for the Biomass Commercial Utilization Grants Program, which emphasizes the use of woody biomass especially from wildfire-affected areas in the wildland–urban interface. The Food, Conservation, and Energy Act of 2008 (PL 110-234; Farm Bill 2008), under Title IX, Section 9011-9013, promotes the use of woody biomass for research and development of biofuels, wood-to-energy programs for states and local communities, and includes the Biomass Crop Assistance Program (BCAP).

Differing and often conflicting definitions of *renewable biomass* in current federal energy policies hinders policy implementation and the development of biomass markets. A universal definition of renewable biomass that includes renewable, sustainable forest biomass—and does not confound this definition by attempting to address other policy goals—would promote the development of sustainable energy and environmental policies on appropriate lands.

A further problem is that policies designed to promote the use of forest biomass energy have focused on development of transportation fuels despite public concerns about this direction. As Caputo (2009) describes the situation:

> ... federal incentives have largely focused on the production of renewable transportation fuels and co-products. Input from stakeholders indicates that future policies should focus on improving forest sustainability, increasing research capabilities, and improving the economics of biomass utilization. Additionally, many feel that the production of heat and power should be given similar attention to the production of liquid transportation fuels as an important use for woody biomass.

Landowner Preferences

The availability of biomass feedstocks will also depend on landowner preferences, which vary based on the type of ownership. Numerous studies have documented that for nonindustrial private forest landowners, harvesting is often a secondary objective (e.g., Butler 2008). Even industrial and those nonindustrial private forest landowners interested in harvesting forest biomass are often reluctant to engage in the long-term contracts necessary to participate in forest carbon offset projects.

Nonindustrial forest landowners who seek maximum revenue, may plant short-rotation woody crops, such as hybrid poplar or willow, in response to the incentives created by BCAP. For example, Gan et al. (in press) found that without financial incentives and technical assistance, fewer than 6% of landowners would be willing to thin forest stands for energy production even if it reduced fire hazard, but with government cost sharing and technical assistance for growing biomass, two-thirds of timberland landowners would consider producing biomass for bioenergy purposes. The most reasonable expectation about biomass production by private landowners is that they will be guided by economic reality and sustainability. High transaction costs can prevent interested nonindustrial landowners with small acreage from participating in biomass projects.

Wood–Fossil Fuel Substitution Effects

When trees are harvested, carbon is removed from the forest. It is tempting to conclude that forest harvesting should be avoided to reduce carbon emissions and maximize carbon storage. However, careful consideration of carbon flows reveals that conversion of wood to useful products can significantly reduce overall societal carbon emissions. Major considerations are the low carbon emissions associated with wood products manufacture, carbon storage in long-lasting wood products, avoided emissions that result when wood is used in place of energy-intensive materials and products, and the efficient use of wood residues for energy.

To arrive at a cogent picture of the forest sector's overall effects on atmospheric carbon, we need to understand the material and energy flows as inputs and outputs within well-defined system boundaries. Analysis using attributional life-cycle assessment (LCA) methods that measure inputs and outputs within a system boundary explains the interactions at that scale. We then need to integrate these effects across system boundaries to see how substitution of harvested wood products for fossil fuels and fossil fuel–intensive products can offset the flow of carbon dioxide from fossil fuel reserves to the atmosphere.

Product Flows of Harvested Wood

Carbon makes up a considerable proportion of wood volume, amounting to about 50% of the moisture-free weight. Within forests, significant quantities of carbon are stored (or sequestered) in the twigs, branches, boles, and roots of trees. Additional carbon is stored in forest litter and forest soils. In 2005–2009, some 24–25 billion tonnes of carbon was stored in standing trees, forest litter, and other woody debris in US forests, and another 20–21 billion tonnes was in forest soils and roots (US Environmental Protection Agency [EPA] 2010). Carbon is also found within harvested wood products. The carbon in wood products in use and in landfills during 2005–2007 was estimated at 2.3–2.4 billion tonnes—equivalent to 5.2–5.7% of forest carbon pools.

Carbon was sequestered in US forests during 2005–2007 at a rate of 192 million tonnes/year. The annual rate of carbon accumulation within wood products in use and in landfills was estimated at about 28–29 million tonnes—14.8% of the rate of sequestration within forests and 22–23% of the annual additions to nonsoil forest carbon stocks (US EPA 2010). Rates of accumulation in harvested wood products were notably lower in 2008–2010 because of the sharp decrease in overall economic activity and home construction.

Much of the carbon in wood products resides in the nation's housing, as well as in commercial, industrial, public, and other structures. Wood-framed buildings make up about 90% of homes in the United States, and in all homes, whether wood framed or not, wood furniture, cabinets, flooring, and trim are dominant.

Emissions from Wood Products Manufacture

The carbon dioxide that is removed from the air as a tree grows is combined with water and converted to simple sugars within the leaves, conveyed downward through the branches and bole in the form of sap, and then converted into complex polymers that combine to form an intricately structured polymeric material that has a higher strength-to-weight ratio than structural steel. That this natural process uses freely available solar energy largely explains why the energy embodied in wood products is lower than for any other construction material (Glover et al. 2002, Perez-Garcia et al. 2005, Gustavsson and Sathre 2006, Lippke et al. 2010). "Embodied energy" refers to the quantity of energy required by all the activities associated with a production process, including gathering, transporting, and primary processing of raw materials. Lumber, in particular, requires little energy to produce, because only minimal processing is needed to convert the naturally produced wood to desired shapes (Milota et al. 2005, Puettmann et al. 2010). Wood products, such as furniture, require more steps in processing and therefore more energy (e.g., Puettmann and Wilson 2005, Wilson 2010) but still significantly less energy than nonwood materials (Lippke et al. 2010).

Not only does production of lumber and wood products require relatively little additional energy beyond the solar energy used in tree growth and wood production, but very little of that additional energy comes from fossil fuels. In the United States in 2008, renewable energy produced from tree bark, sawdust, manufacturing and harvest residuals, and byproducts of pulping in papermaking processes provided 65% of the energy used in manufacturing paper products and more than 73% of the energy used in manufacturing wood products (American Forest and Paper Association 2010). In the same year, the wood and paper industries of the United States accounted for 94% of the manufacturing sector's derived renewable fuel use, and they generated 37% of the total energy produced by cogeneration-capable systems within all manufacturing sectors.

Because wood is produced using solar energy, the manufacture of lumber and other wood products requires little additional energy. Moreover, only one-quarter to one-third of the energy consumed is fossil energy. The result is that total emissions from wood products manufacture, including emissions of carbon dioxide, are typically lower than for potential wood substitutes on a weight or mass basis (Table 5-1). For example, carbon emissions for the manufacture of a tonne of lumber are markedly less than for a tonne of steel, plastic, or aluminum.

Product Substitution

For every use of wood there are substitutes: wood studs can be replaced by steel studs, wood joists by steel I-joists, wood walls by concrete walls, wood floors by con-

Table 5-1. Net carbon emissions in manufacture per tonnes.

Material	Net emissions (tCe)
Framing lumber	0.033
Concrete	0.034
Concrete block	0.038
Medium-density fiberboard (virgin fiber)	0.088
Brick	0.088
Glass	0.154
Recycled steel (100% from scrap)	0.220
Cement (Portland, masonry)	0.265
Recycled aluminum (100% recycled content)	0.309
Steel (virgin)	0.694
Molded plastic	2.502
Aluminum (virgin)	4.529

Notes: Values are based on life-cycle assessment and include gathering and processing of raw materials, primary and secondary processing, and transportation; a 10% increase in energy consumption is assumed for the production of concrete block. tC, tonnes of carbon equivalent.
Source: Based on US EPA (2006, Exhibit 2-3); data for concrete is from Flower and Sanjayan (2007).

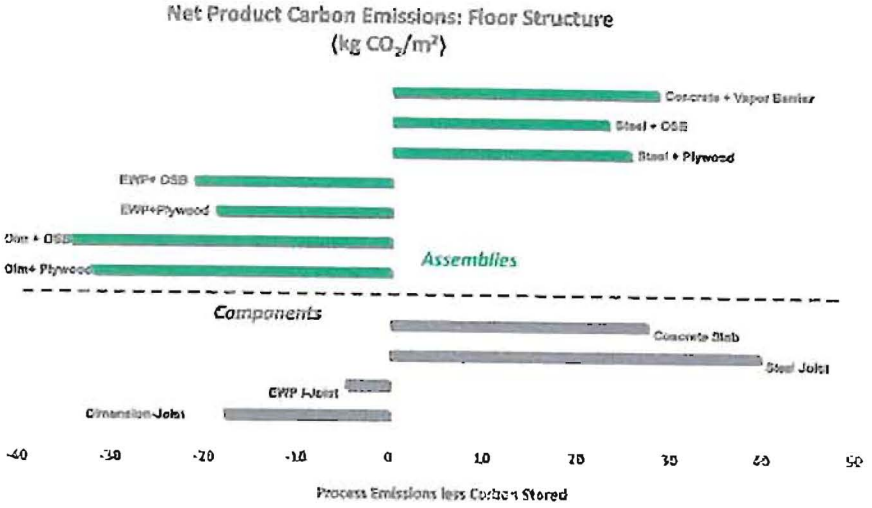


Figure 5-1. Process emissions less carbon stored in floor structure components and assemblies. Notes: EWP = engineered wood product, OSB = oriented-strand board, Dim = dimension lumber. (Source: Adapted from Lippke and Edmonds (2009).)

crete slab floors, and biofuel by fossil fuel. Every product use has its own life-cycle carbon footprint (Perez-Garcia et al. 2005, Lippke and Edmonds 2009). Using life-cycle inventory (LCIs), which include the carbon stored in wood as well as the processing emissions to harvest, transport, and make the product, one can compare the net carbon consequences of substituting one product for another.

Life-cycle analyses have shown marked differences in energy requirements and carbon emissions associated with different building materials and the structures made from them (Glover et al. 2002, Gustavsson and Sathre 2006, 2011, Perez-Garcia et al. 2005, Buchanan 2007, Gerilla et al. 2007, Salazar and Meil 2009, Lippke et al. 2010). Comparisons of structures having comparable heating and cooling requirements show that wood products and structures require the least energy to produce and consequently have the lowest greenhouse gas (GHG) emissions profile. Thus, substituting wood for more energy-intensive, nonrenewable materials produces a substantial net reduction in carbon emissions, called the substitution effect. In addition, wood stores carbon for the useful life of the product, enhancing the benefits of wood relative to other building materials.

The comparisons in Table 5-1 are per tonne of product. More appropriate comparisons, which reflect the functions that products perform, have been made between wood and nonwood assemblies for walls, floors, and sheathing. Wood fares well in such comparisons because of its high strength relative to weight, its low embodied energy, and carbon stored in the product itself. Lippke and Edmonds (2009) show the relative process emissions and stored carbon per functional unit for wood and nonwood products (Figure 5-1). In Figure 5-1 the vertical zero line is where process emissions equal carbon stored. A component (black bars) or assembly (green bars) to the right of the zero line produces more emissions than it stores, and one to the left of the line stores more carbon than it takes to produce (i.e., is a carbon sink) as long as the product remains in use. Longer useful life, recycling, and reuse extend the period of this offset. Similar charts for wall assemblies (not shown) show the same patterns, with wood products storing more carbon than is emitted during their harvest and manufacturing.

Another study compared wood and steel houses built to Minneapolis code standards and wood and concrete houses built to Atlanta code standards (Meil et al. 2010). The two designs shared many of the same structural assemblies (i.e., foundation footings and basement block wall, support beams and jack posts, and roof), and therefore the differences in the environmental effects can be traced to their respective wall and floor assemblies. For the Minneapolis house, the steel design was found to embody 66% more energy (measured in megajoules per square foot of assembly) and generated 49% more global warming potential than the wood design. Focusing on only the assembly groups affected by changes in material use (i.e., walls, floors, and roofs) revealed more pronounced differences. For instance, compared with the wood design, the steel design's floors and roof were found to embody 245% more energy and produce a corresponding increase in global warming potential. In the Atlanta comparison, increases in embodied energy and global warming potential were determined to be 41% and 65% higher for concrete construction than for wood houses, respectively. Comparisons of building components made to specified codes using wood, steel, and concrete options show that wood designs produce not only the lowest global warming potential, but also provide the lowest emissions to air and water. (See, for example, Table 3-1, Malmsheimer et al. 2008). Only in the solid waste category does wood fare worse than steel, a result that arises because steel is precut and wood is cut on site during construction (Lippke and Edmonds 2006). Further examination of fossil fuel consumption and associated carbon emissions, linked to construction of entire structures, reveals that differences in global warming potential for the various designs are in nearly direct proportion to the differences in fossil fuel consumption (Tables 5-2 and 5-3).

An analysis of carbon storage and avoided emissions for wood versus steel construction in a large wood structure also illustrates the carbon-related advantages of wood (Table 5-4). The completed structure, in Anaheim, California, comprises five sto-

Table 5-2. Consumption of fossil fuels associated with exterior wall designs in warm climate home.

	Fossil fuel energy (MJ/ft²)	
	Lumber-framed wall	Concrete wall
Structural components[a]	6.27	75.89
Insulation[b]	8.51	8.51
Cladding[c]	22.31	8.09
Total[d]	37.09	92.49

[a] Includes studs and plywood sheathing for the lumber-framed wall design and concrete blocks and studs (used in a furred-out wood stud wall) for the concrete wall design.
[b] Includes fiberglass and six-mil polyethylene vapor barrier for both designs.
[c] Includes interior and exterior wall coverings. Exterior wall coverings are vinyl (lumber-framed wall design) and stucco (concrete wall design). Interior wall coverings gypsum for both designs.
[d] Includes subtotals from structural, insulation, and cladding categories.
Source: Edmonds and Lippke (2004).

Table 5-3. Consumption of fossil fuels associated with floor designs (excluding insulation).

	Fossil fuel energy (MJ/ft²)
Dimension wood joist floor	9.93
Concrete slab floor	24.75
Steel joist floor	48.32

Source: Edmonds and Lippke (2004).

Table 5-4. Carbon storage and avoided emissions from wood versus steel commercial/residential complex.

Carbon sequestered and stored (CO_2e)	3,970 tonnes
Avoided greenhouse gases (CO_2e)	8,440 tonnes
Total potential carbon benefit (CO_2e)	12,410 tonnes

Source: This case study is based on use of the Forintek Wood Carbon Calculator for Buildings based on research by Sathre and O'Connor (2010) and is described by WoodWorks (2011).

ries of wood frame construction over a concrete parking garage and first level and includes 251 luxury apartment units and 13,000 ft² (1,208 m²) of retail space. The structure incorporates 5,201 m³ of wood, with resulting long-term storage of 3,970 tonnes of equivalent carbon (CO_2e), with twice that level of avoided GHG emissions resulting from selection of wood rather than traditional steel construction.

The effect of substitution on a per hectare basis is illustrated in Figure 5-2, which compares substitution of wood for concrete in construction and its carbon implications over a timeline of two rotations of a forest initially planted on bare land. Carbon stored in products (designated as "products carbon") is significant relative to the carbon stored in the live- and dead-tree biomass (designated as "forest carbon"). Furthermore, well before the end of two rotations, overall sequestration of carbon (forest carbon plus products carbon plus substitution carbon) far exceeds carbon sequestration in an unmanaged forest (i.e., a forest managed without timber extraction, shown as the dotted line designated as "no-harvest carbon"). The figure includes the carbon emissions associated with generation of bioenergy from short-lived product pools, taking into account that the efficiency of the conversion of wood to energy is lower than for gas- or coal-fired boilers. A net benefit in this case appears about 30 years after stand establishment, with benefits increasing over time. The managed and no-harvest forest scenarios both use growth trends in Douglas-fir, a species that is known to maintain growth well into advanced years (Curtis and Marshall 1993). Other species with growth rates that peak sooner show even larger differences in the relative carbon sequestration between managed and unmanaged forests. These trajectories show the relative carbon consequences assuming a change in management intent at the point when the first thinning was implemented. In practice, a no-harvest forest scenario would more often than not have a lower forest growth trajectory because the investment in regenerating the forest from bare land would not have occurred without the expectation of a return on the investment in later years. .

As the examples illustrate, substitution values vary with the wood product or assembly in question and its alternative. Sathre and O'Connor (2010) conducted a meta-analysis to estimate average substitution rates for common building products. They arrived at a value of 2.1 tonnes of carbon displaced per tonne of wood carbon used. This is a more general characterization of substitution across all wood uses than the specific examples shown in Figures 5-1 and 5-2 and Tables 5-3 and 5-4.

End-of-Life Considerations

Based on census data, the half-life of the US housing stock is approximately 80 years (Table 5-5; Winistorfer et al. 2005). First-order decay functions have often been used to estimate losses of wood in use over time (e.g., Intergovernment Panel on Climate Change [IPCC] 2007b), but they greatly overestimate early losses because they assume the highest decay (loss) rate when there is the most stock, with a declining rate thereafter. Because houses are rarely demolished in their first 10 years, first-order decay func-

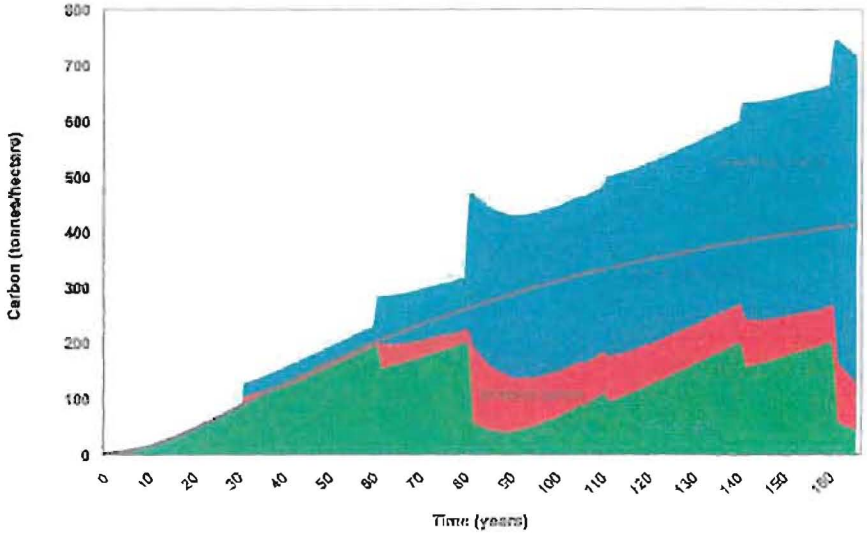


Figure 5-2. Carbon (tonnes per hectare) stored in forests (designated as "forest carbon") in products (designated as "products carbon"), and retained in the lithosphere because of substitution for concrete and fossil fuel energy (designated as "substitution carbon"), compared with carbon stored in an unmanaged forest (dotted line designated as "no-harvest carbon"), per hectare of forest. Notes: Douglas-fir forest, 80-year rotation, with intermediate thinnings at years 30 and 60; portion of wood harvested at rotation age used for long-lived construction products; dotted line indicates unmanaged forest. (Sources: Perez-Garcia et al. (2005), Wilson (2006).)

Table 5-5. Projected half-lives for end uses of wood.

Use	Half-life (yr)
Single-family home (1920 and before)	78.0
Single-family home (1921–1939)	78.8
Single-family home (1939–)	85.0[a]
Multifamily home (as fraction of half-life for single-family home)	52.3[b]
Housing alteration and repair (as fraction of half-life for single-family home)	25.7[c]
All other uses for solidwood products	38.0
Paper	2.5

[a] Based on half-life increase per 20 yr for post-1939 period.
[b] Based on half-life of multifamily home that is 0.61 of single-family home.
[c] Based on half-life of repair and remodel that is 0.30 of single-family home.
Source: Based on Skog (2008).

tions fail to capture the carbon storage potential of long-lived materials. An alternative approach has been proposed by Marland et al. (2010), who applied gamma functions to distributed product pools so that short-lived products, such as paper, decay quickly but long-lived products, such as oriented strandboard and lumber, decay more slowly. Refinement of the parameters used by Marland et al. (2010) to reflect actual decay rates on a regional, national, or wood basket basis is needed, but the functional form improves on previous estimates of decay rates.

The collection efficiencies of landfilling have carbon storage implications (Skog 2008). Of the wood products that enter solid waste disposal sites, more than three-quarters of the carbon in solid wood and almost one-half of the carbon in paper is never released to the atmosphere (Table 5-6). The carbon that is released during decay takes many years to reach the atmosphere. For example, the 23% of the solid wood that does decay has a half-life of 29 years. Skog (2008) found that when paper is landfilled, the nonlignin component (56%) decays, leaving the lignin component (44%) as a long-term store in the landfill (Table 5-6). This nondegradable fraction varies by grade, from approximately 10% for bleached chemical pulp fibers to 85% for mechanical pulp fibers (US EPA 2006).

Methane emissions from wood degradation in a landfill can offset any benefits of carbon stored there. Heath et al. (2010) found that with current landfill design and operating practices, US landfills appear to be a net long-term sink for carbon in wood products but a long-term source of GHG emissions from paper products, particularly

Table 5-6. Fate of material in solid waste disposal sites.

	Fraction permanently sequestered	Fraction that decays	Half-life of decaying portion
Solid wood	77%	23%	29.0 yr
Paper	44%	56%	14.5 yr

Source: Based on Skog (2008).

paper that contains a large fraction of carbon that is degradable under anaerobic conditions. This suggests that incentives should be high to reuse paper and wood, recycle it, or burn it to recover its heating value, and that landfills should be managed to recapture the energy value of methane emissions. Collection systems are evolving rapidly. For example, US EPA (2007b) reported that the recovery or oxidization of methane increased from 20 to 50% between 1990 and 2006. Methane capture from landfills is one of the most cost-effective investments for atmospheric GHG reduction because of the dual benefit stream of reducing methane release (methane has 25 times the global warming potential of CO_2; Forster et al. 2007) and converting the methane into usable energy that offsets fossil fuel emissions.

Wood Energy

The US Department of Energy (DOE) estimates that in 2009, about 8% (7.75 quadrillion Btu) of the energy consumed in the United States came from renewable sources (excluding ethanol; US DOE 2010). For 2004–2008, about 30% (2.1 quadrillion Btu) of this renewable energy was supplied from woody biomass, equivalent to about 2% of annual energy consumption from all sources and the largest source of renewable energy after hydropower (US DOE 2009). Renewable energy consumption (excluding ethanol) is projected to increase to 8.4 quadrillion Btu by 2015 and to 9.7 quadrillion Btu by 2030. Assuming the current share of renewable energy coming from woody biomass remains static, woody biomass would be the source of about 2.5 quadrillion Btu of energy in 2015 and 2.9 quadrillion Btu of energy in 2030. At present, wood energy consumption requires about 111 million oven-dry tonnes (odt) of woody material annually (assuming 17.2 million Btu/odt of wood). Under DOE's reference projection, approximately 132 million odt of wood will be used for energy in 2015 and 152 million odt will be used in 2030 (White 2010).

Using biomass instead of fossil fuels for meeting energy needs has several advantages. Specific benefits depend on the source of the wood (and its alternative fate if not used for energy) and the intended use. Benefits can include reduction of GHG emissions (particularly CO_2) and other air pollutants, energy cost savings, local economic development, reduction in waste sent to landfills, and the security of a domestic fuel supply. In comparison with other renewable energy sources, such as wind and solar power, biomass is more flexible (e.g., can generate both power and heat) and reliable, because it is a nonintermittent energy source whereas the alternatives rely on the weather.

In the United States, the potential role of forest bioenergy is readily accepted by private parties in regions where relatively low value pulp is the major output (Galik et al. 2009a). It is more controversial in the context of public forests. As in Europe, the pursuit of aggressive bioenergy targets in the United States could affect traditional users of industrial roundwood, especially pulp producers in the southeast region of the country (Abt et al. 2010), but in other areas of the country it could create opportunities for synergy. Increasing the use of managed forests for biomass could enhance forest resiliency and productivity without using scarce high-quality agricultural land or irrigation water.

Heat and Power (Combustion and Gasification)

Of the 9,709 megawatts (MW) of biomass electric capacity in the United States in 2004, about 5,891 MW (61%) was generated from wood and wood wastes. Another 3,319 MW of generating capacity was from municipal solid waste and landfill gas, and 499 MW of capacity was attributable to other biomass, such as agricultural residues, sludge, and anaerobic digester gas (US EPA 2007a).

Much of the biomass used for energy, especially the biomass burned in pulp mills, is burned in combined heat and power (CHP) systems. CHP is not a single technology but an integrated energy system that can be modified depending on the needs of the energy end user. The hallmark of all well-designed CHP systems is an increase in the efficiency of fuel use. By using waste heat recovery technology to capture a significant proportion of heat created as a byproduct in electricity generation, CHP typically achieves total system efficiencies of 60–80%

for producing electricity and thermal energy. These efficiency gains improve the economics of using biomass fuels, as well as produce other environmental benefits. More than 60% of all biomass-powered electricity generation in the United States is in the form of CHP (US EPA 2007a).

Energy Balance and Benefits of Biomass Energy

A small amount of fossil fuel is used to produce bioenergy—approximately 1 U of fossil fuel for every 25–50 U of bioenergy (Börjesson 1996, Boman and Turnbull 1997, McLaughlin and Walsh 1998, Matthews and Mortimer 2000, Malkki and Virtanen 2003, Matthews and Robertson 2005). Biofuels (transportation fuels) typically require more input energy, so the energy balance for producing biofuels is less favorable, as well as more variable—approximately 1 U of fossil energy for every 4–5 U of bioenergy (Gustavsson et al. 1995). Net carbon emissions from generation of a unit of electricity from bioenergy can be 10–30+ times lower than emissions from fossil-based electricity generation, depending on the systems and fuel types being compared (Boman and Turnbull 1997, Matthews and Mortimer 2000, Spath and Mann 2000, Mann and Spath 2001, Matthews and Robertson 2005, Cherubini et al. 2009).

Although energy self-sufficiency is one reason for pursuing the development of woody biomass-to-energy initiatives (Energy Independence and Security Act 2007), there are other reasons to use woody biomass as an energy source. In the West, wildfire risk is high and increasing, and removing excess biomass to reduce risks is desirable in many cases. Reducing fire risk while maintaining other forest values often entails removing low-value material while retaining higher-value trees for other purposes. Without a viable economic return for woody biomass that is removed, the costs are prohibitive and the likelihood of action is low.

Wildfire emissions are equal to 5% of total GHG emissions in the continental United States (Wiedinmyer et al. 2006). Avoiding wildfire emissions by thinning susceptible forests and using the harvested material as a woody biomass feedstock is a potentially valuable side benefit that is often ignored in the assessment of the carbon consequences of bioenergy. Oneil and Lippke (2010) calculated the GHG forcing per tonne of biomass burned during wildfires using default emission and consumption values from Wiedinmyer et al. (2006) to compare the implications of thinning to reduce fire risk versus stand-replacing wildfires. Because open burning generates methane and nitrous oxides, two potent GHGs, burning a tonne of biomass in a wildfire generates more emissions in CO_2e than the carbon content of the wood burned. Burning the same wood under controlled conditions in a boiler reduces non-CO_2 emissions by up to 98% while generating energy. The substitution of woody biomass for fossil fuel energy provides a GHG offset because the fossil fuel remains underground and the flow of fossil carbon to the atmosphere is reduced.

Thus, harvesting woody biomass to reduce wildfire risk, damage, and, ultimately, emissions delivers an additional atmospheric benefit beyond the substitution of fossil fuel (Mason et al. 2006, Hurteau et al. 2008, Stephens et al. 2009, Reinhardt and Holsinger 2010). That additional benefit is constrained, however, by the number of treatments and their spatial extent: limited treatments may not be sufficient at the landscape scale (Reinhardt and Holsinger 2010). The effectiveness of the benefit is also constrained by the ecology of the forests in question. For example, in a detailed analysis of fire risk reduction treatments for Pacific Northwest coastal western hemlock–Douglas-fir and western hemlock–sitka spruce forests with 500-year fire return intervals, Mitchell et al. (2009) found that the treatments would be ineffective at reducing carbon dioxide emissions and that leaving the forests untreated would be a better option. This result is not unexpected in a region where fire is rare and fire risk reduction treatments are highly unlikely.

Energy Substitution

The substitution effect noted in conjunction with production and use of wood products rather than metals, plastics, or concrete also applies to use of wood in production of energy. Using wood to produce electricity, heat, liquid fuels, or other forms of energy avoids the flow of fossil carbon to the atmosphere, provided that energy offsets the use of fossil fuels. Although a CO_2 molecule is a CO_2 molecule, regardless of source, crediting biofuel use as a fossil fuel offset recognizes the reduction of the flow of fossil carbon. Consistent carbon accounting counts the emissions *and* takes credit for the offset value (i.e., the amount of fossil fuel carbon that was not emitted, net of the fossil fuel used to produce the biomass energy). Current protocols and policies generally do not allow this credit (see Section 6).

Potential biofuel feedstock that burns or decays in the woods is a net decrease in the carbon stock—the equivalent of an emission. The loss of carbon from the forest is already accounted for in the forest carbon stock change, but care must be taken when extrapolating the results from a single stand to a wider context (Figure 5-3). For a single stand under sustainable management, the forest carbon cycles around some average value that is contingent on inherent site productivity, rotation age, and species mix, and there is a time interval between uptake and release of carbon (Figure 5-3a). However, no processing facility relies on a single stand to provide feedstock, so extrapolating the time-dependent dimension of a single stand analysis to the emissions profile of a facility is inappropriate and leads to incorrect conclusions (O'Laughlin 2010).

A more correct characterization of the effects of harvesting biofuel uses a landscape-level analysis to determine whether the harvest needed to sustain processing facilities within an economic haul distance increases or decreases average carbon stores on the land. If harvesting results in a stable average of carbon across the total forest through time (Figure 5-3b), the forest itself is carbon-cycle neutral. If forest carbon stocks are unaffected by the choice between forest biomass and fossil fuels, the products removed from the forest provide a carbon benefit to the atmosphere equal to the avoided emissions from fossil fuels less any fossil energy it took to produce energy from the biomass feedstock. To meet this condition, it is necessary to ensure that harvests and mortality do not exceed net growth across the forest and that soil conditions and carbon sequestration potential are maintained.

An analysis using publicly available data from the US LCI database (National Renewable Energy Lab 2011) and the EPA TRACI Impact method found that the global warming potential for a cradle-to-grave analysis was greater for coal than for woody biomass (Figure 5-4; Lippke et al. 2011). The comparison in Figure 5-4 is for the cleanest coal type (bituminous); other coal types produce more emissions and therefore produce an even larger differential between the fuel types. Results show that if the uptake of CO_2 in the forest is ignored, disregarding the fundamental difference between renewable and nonrenewable fuels, emissions from using biomass as a feedstock

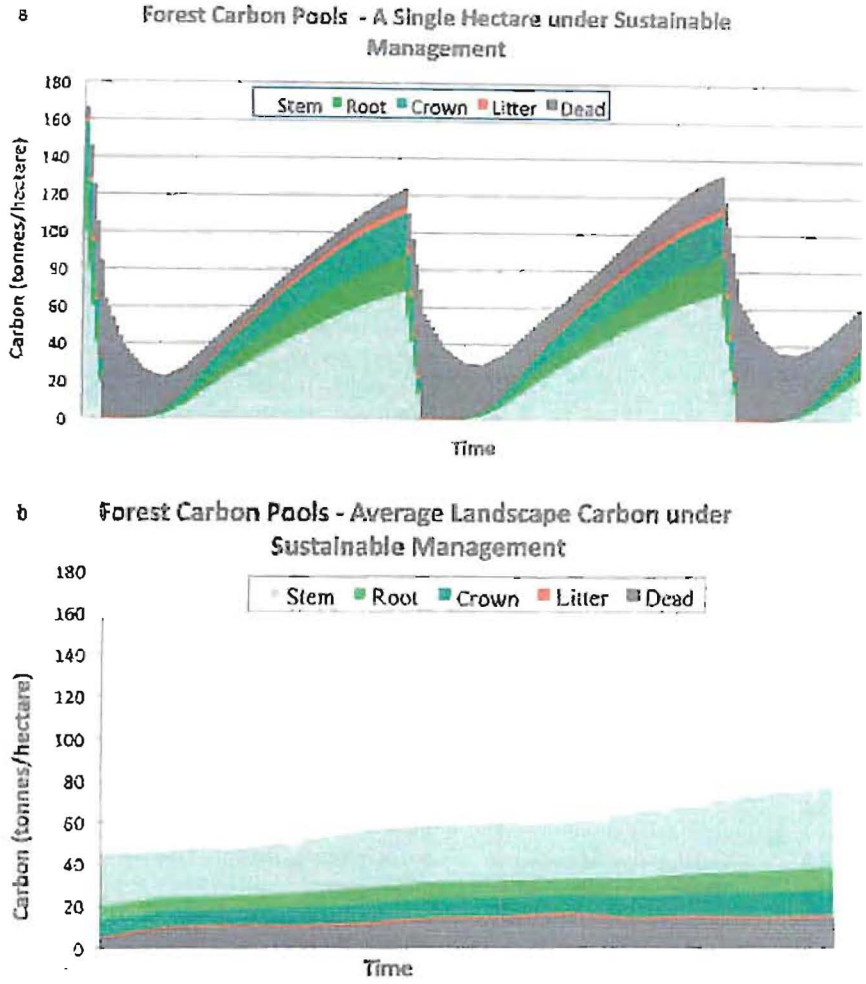


Figure 5-3. Forest carbon under sustainable management, by (a) single hectare and (b) landscape. (Source: Oneil et al. 2011.)

are 82% of coal-fired emissions per megajoule of electricity produced. If biomass is considered a renewable resource such that emissions represent prior uptake, burning biomass to generate electricity produces 4% of the emissions of a coal-fired power plant.

The net biomass bar in Figure 5-4 assumes that the biomass was produced in an area where forest carbon stocks remain stable over the long term. Some assume that harvesting causes a reduction in forest carbon stocks, and particularly soil carbon, relative to a scenario where the biomass is not used for energy, creating a carbon debt that must be overcome before the forest biomass–based system yields net benefits (e.g., Schlamadinger et al. 1995, Searchinger et al. 2009). Such thinking is based on initiation of measurement and comparison at the point of harvest.

Whether and how biomass is included in emissions accounting affects policies aimed at reducing overall GHG emissions. Accounting should (1) accurately characterize atmospheric consequences of reducing the flow of fossil fuel emissions by using biofuels and (2) measure the effects on the forestland base in terms of growing stock and soil carbon. The assumptions and boundaries for analyzing the GHG emissions of bioenergy are critical to the resulting conclusions and must be clearly understood when studies are used to justify policies or regulations.

Determination of Carbon Neutrality

Analyses of the benefits of forest-based products and systems should incorporate spatial and temporal boundaries appropriate for forestry and forest products. Forest management practices may be applied at the individual stand or project level, but wood supply systems involve large areas managed for long periods of time. Using a single stand or project to model a wood supply system can severely distort systemwide outcomes (Lucier 2010).

At the scale of a wood supply area, sustained-yield forestry and sustainable management systems keep growth and removals in balance, and the loss of carbon from harvests in any given year is equal to gains in carbon elsewhere in the area. The net change in carbon stocks in all years is then zero; i.e., net removals of carbon from the atmosphere equal the amount of carbon in wood removed from the forest, and the system is carbon neutral. The variation in definitions of carbon neutral (Table 5-7), however, suggests the need for elaboration when using the term.

Even if forestland is maintained as forestland, deviations from carbon-cycle neutrality can occur in both directions. Climate change, more frequent insect and disease outbreaks, exotic and/or invasive disturbance agents, failure to regenerate, and severe wildfires that reduce soil productivity can affect long-term carbon storage potential. Ensuring continued carbon benefits from the forest sector requires maintaining long-term site productivity. Given adequate nitrogen supplies to maintain carbon stores in dynamic equilibrium, average forest carbon stores can increase concurrent with ecological protections, such as riparian buffers and habitat requirements. Incorporating most ecological sustainability criteria into this forest management framework does not affect a forest's carbon-cycle neutrality, but overall carbon benefits will be underestimated if harvested wood products and their substitution effects are not taken into account. LCI and LCA occur within defined system boundaries. Substitution occurs when one product is replaced by another product and the comparison is between the LCIs within each boundary. An example would be the comparison between steel joists and engineered I-joists that are functionally equivalent. There are also displacement factors when biofuel is used instead of fossil fuel for manufacturing that occurs inside the system boundary. The displacement occurs inside the system boundary of a particular product and forms part of its LCI.

Figure 5-5 integrates harvested wood products and substitution benefits for the forest management regime in Figure 5-3b to provide the landscape context. It is based on current patterns of wood use from harvested

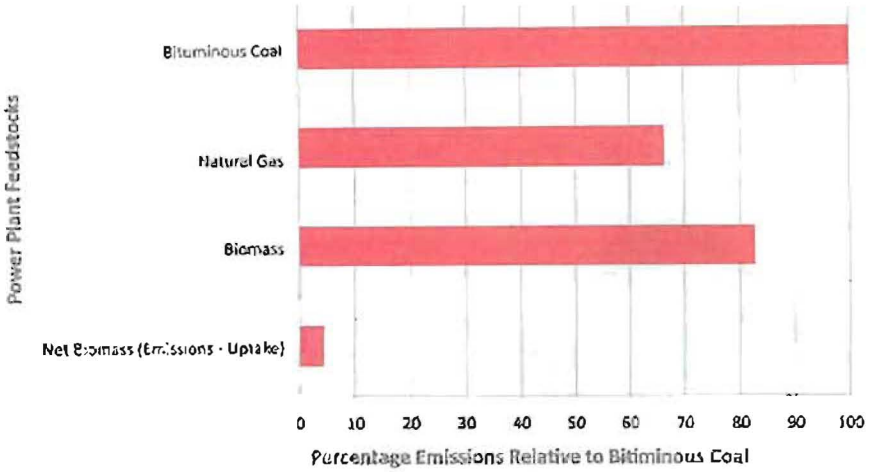


Figure 5-4. Comparison of GHG emissions from electric power plants. (Source: Adapted from Lippke et al. 2011.)

Table 5-7. Definitions of carbon neutrality.

Type	Definition	Example
Inherent carbon neutrality	Biomass carbon was only recently removed from the atmosphere; returning it to the atmosphere merely closes the cycle	All biomass is "inherently carbon neutral"
Carbon-cycle neutrality	If uptake of carbon (in CO_2) by plants over a given area and time is equal to emissions of biogenic carbon attributable to that area, biomass removed from that area is carbon-cycle neutral	Biomass harvested from regions where forest carbon stocks are stable is "carbon-cycle neutral"
Life-cycle neutrality	If emissions of all greenhouse gases from the life cycle of a product system are equal to transfers of CO_2 from the atmosphere into that product system, the product system is life-cycle neutral	Wood products that store atmospheric carbon in long-term and permanent storage equal to (or greater than) life-cycle emissions associated with products are (at least) "life-cycle neutral"
Offset neutrality	If emissions of greenhouse gases are compensated for by using offsets representing removals that occur outside of a product system, that product or product system is offset neutral	Airline travel by passengers who purchase offset credits equal to emissions associated with their travels is "offset neutral"
Substitution neutrality	If emissions associated with the life cycle of a product are equal to (or less than) those associated with likely substitute products, that product or product system is (at least) substitution neutral	Forest-based biomass energy systems with life-cycle emissions equal to (or less than) those associated with likely substitute systems are (at least) "substitution neutral"
Accounting neutrality	If emissions of biogenic CO_2 are assigned an emissions factor of zero because net emissions of biogenic carbon are determined by calculating changes in stocks of stored carbon, that biogenic CO_2 is accounting neutral	The US government calculates transfers of biogenic carbon to the atmosphere by calculating annual changes in stocks of carbon stored in forests and forest products; emissions of CO_2 from biomass combustion are not counted as emissions from the energy sector nor are emissions from decay of dead trees in the forest counted as emissions in the forest sector

Source: NCASI (2011).

sites across a landscape that support a viable forest industry. It does not include increased recovery of forest residuals for bioenergy use, which would offset more fossil fuel and increase the slope of the graph. In Figure 5-5 the displacement is the amount of carbon benefit that accrues from using biofuel in place of natural gas for drying of the long-lived products produced in the Inland Northwest. Displacement can be larger in other regions where fossil fuels comprise a greater share of the energy used to generate electricity or where more wood waste is used for energy. In this case from the Inland Northwest, the analysis incorporates LCI data on mill drying and the high percentage of nonfossil electricity generation in the region caused by extensive hydroelectric resources. Note that the total emissions (including biofuel emissions) resulting from production of these products shows up as a negative benefit in Figure 5-5, depicting the emissions associated with generating the total positive carbon benefits shown in this figure. The displacement factor above the line is the amount of equivalent fossil fuel emissions that were avoided by using biomass in place of natural gas for drying. The displacement factor takes into account the differential in burning efficiency between natural gas and biomass.

As this example shows, where forest operations do not exceed the forest's ability to regenerate, the gains from forest management are seen in carbon pools and offsets outside the forest, without a decline in forest carbon storage. The forest is carbon-cycle neutral in its own right; all products removed from it are additional carbon sinks as long as they are in use, and the substitution benefits of using wood in place of comparable building products or energy sources also accrue. If a change in forest operations (e.g., shorter rotations, high natural mortality without salvage, and reduced stocking because of climate shifts) causes a decline in forest carbon storage, the slope of the graph changes and the forest itself is no longer carbon-cycle neutral. Maintaining or enhancing forest productivity so that a continuous flow of products can come from the forest provides the greatest carbon mitigation benefit.

The forest is only the first tier. Making products that displace fossil fuel–intensive products provides a cumulative offset by reducing fossil fuel emissions and delivers the largest carbon benefit (Eriksson et al. 2007, Lippke et al. 2010). Discussions about base-

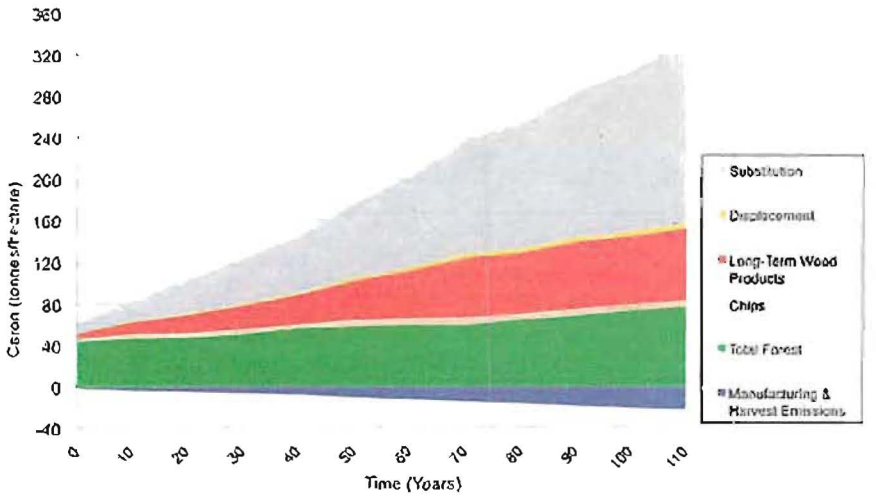


Figure 5-5. Carbon trajectories under sustainable management of a forested landscape (as shown in Figure 5-3b). (Source: Oneil and Lippke 2010.)

lines and additionality are about who gets the credit. Likewise, discussions about leakage are about where it occurs in the global economy. These concepts are relevant in the marketplace but irrelevant for climate change mitigation because if, for example, a construction company does not use wood, it will likely use a competing product with a higher carbon footprint. These market factors are explored in Section 6.

Even where growth and removals are in long-term balance, carbon stocks can fluctuate across the wood supply area. Although the timing of year-to-year carbon fluxes can affect the radiative forcing of the atmospheric system, focusing on these transient conditions instead of the long-term balance between growth and removals can lead to different conclusions about the costs and benefits of harvested biomass and wood products.

The temporal scale of an analysis can be important in several other ways, especially as it affects biomass carbon accounting. The time period for accounting may be expanded to include flows of CO_2 into trees; CO_2 emissions from decomposing biomass in the forest; and emissions associated with establishing, growing, or regenerating the forest (including land-use change and other activities that alter long-term average carbon stocks). The end point for the accounting may extend through the end of life of the product (World Resources Institute/World Business Council for Sustainable Development 2011).

Life-cycle studies often combine all flows of GHGs to and from the atmosphere into a single number reflecting the total effects over a product's life cycle. It may be important, however, to understand the timing of removals and emissions, particularly if comparing forest-based and substitute products or comparing alternative uses for land. Such comparisons may show short-term benefits attributable to delayed harvesting, but over time, these benefits diminish and eventually cease as forests age and natural emissions approach uptake. The benefits associated with using products from forest-based systems, however, often continue to accumulate (Schlmadinger and Marland 1996, Lippke et al. 2010, 2011). Extending the period of analysis through multiple rotations can be critical to understanding the short-term and long-term implications of using forest-based products.

Temporal considerations can also be important when discounting is used to reflect the time value of emissions and reductions (Levasseur et al. 2010). Such studies are the norm in the physical models used in climate modeling but are relatively uncommon in life-cycle studies and policy-related work.