Benefits from Utilizing Forest Biomass for Energy

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"The social and environmental benefits of biomass (utilization) are not compensated in the commercial marketplace. As an inevitable result, they are under-produced in comparison to their value to society". (Western Governors' Association 2006)

Report Summary

This report was prepared by the Sierra Nevada Conservancy to assist with the implementation of the 2012 California Bioenergy Action Plan and to support the work of the Biomass Working Group.

Land managers and others are increasingly considering the use of waste from thinning forests ("biomass") to produce energy and other products. The practice is attractive because the sale of biomass material leads to less open burning of forest waste that remains after fuel reduction work. Using waste material for energy also typically improves the economics of managing healthy forests. Converting forest waste can also provide needed jobs in underserved rural forest communities and offer a host of other public benefits.

This report examines the array of public benefits that accrue directly from utilization of forest biomass in the production of energy. The goal is to describe the broad public values that can result from increased support and investment in the forest biomass-to-energy industry.

The primary public benefits derived from using forest biomass for energy come from the ancillary values of restoring forest health. Additional benefits occur from the social and economic contributions to rural forest communities and the production of renewable energy that offsets the uses of fossil fuels. Some examples of important public benefits are:

- Many forests in California are at risk to damage from wildfire, insect outbreaks, disease agents, drought and changing climate because of their over-stocked conditions. Removing forest biomass for energy can be done in ways that promote healthier forests while protecting soil and water resources. Healthy forests provide an array of other benefits.
- Healthy forests reduce the extent of severe fires and dramatically reduce the costs and damages from wildfire. Examples are reduced costs of fire suppression, improved firefighter safety, and reduced damage to property and the environment.

- Healthy forests in the Sierra Nevada help protect the water supply for 25 million Californians. Sediment deposited by runoff after severe fires can require costly clean-up operations for managers of public drinking water facilities as well as managers of hydroelectric and water storage facilities. Carefully managed forests can ameliorate large sediment movements by reducing fire severity and protecting soils.

- Forest bioenergy facilities have been consistently shown to provide dramatic improvements over the air emissions produced by pile burning and wildfires.

- Many of the benefits to public health come from added fire protection and reduced pollution to air and water. An assessment of a proposed bioenergy facility in Placer County found that the project posed no significant risks to public health and would offer considerable improvements over the traditional method of burning forest waste in piles.

- Healthy forests continuously increase carbon storage in the large trees while making stands more resistant to severe fire.

- Bioenergy production provides two kinds of greenhouse-gas benefits. Like all renewable energy, bioenergy avoids the use of fossil fuels which add anthropogenic carbon to the atmosphere. In addition, biomass energy produces less greenhouse-gas emissions than the various alternative disposal fates for forest waste such as pile burning.

- Biomass harvest that is done to reduce the likelihood of severe fire will generally be regarded as beneficial for wildlife as long as abundant key structural components (snags, down logs, hardwoods, etc.) are retained.

- Healthy forests can help avoid serious disruptions to forest recreation.

- Biomass power facilities mean jobs with comparatively good wages that are needed in some disadvantaged rural forest communities.

- Forest bioenergy facilities provide a reliable source of renewable energy that helps diversify California's renewable energy portfolio while offering firm reliable power when other sources such as wind and solar may be off line.

Introduction

The Sierra Nevada Conservancy (SNC) is one of the state agencies that have been tasked to implement the California Bioenergy Action Plan (Bioenergy Interagency Working Group 2012). Action 2.1 in the Bioenergy Action Plan is to "Quantify the Costs and Benefits of Bioenergy".

The SNC is also a leader of an ad hoc "Biomass Working Group" that has been convened to stimulate development of a distributed forest bioenergy sector in California. The group has been meeting since 2010. The Biomass Working Group consists of local, state, and federal agency leaders, industry representatives, environmental interests, and others. The group is bound by their mutual interest in revitalizing a forest biomass-to-energy industry so it can help restore forests and improve rural forest-community vitality. The Biomass Working Group has been working with state and federal agencies to improve regulations and policies that will facilitate expansion of the forest biomass industry. One primary focus has been on increasing the price of power sold by bioenergy facilities to help improve investments in the industry. Rate consistency and proportional ratepayer benefits are two of the issues that make the pricing of electricity produced from these facilities challenging. Unlike wind, solar and geothermal resources, forest bioenergy requires feedstock that is costly to collect, process and transport. Increases in the price of power sold from forest bioenergy facilities are needed to sustain a viable industry with high feedstock costs.

Securing higher prices for forest bioenergy has been challenging because California's process for establishing electricity rates apply to all renewable energy sectors, even when those sectors are based on very different technologies and have different economic considerations. Forest bioenergy sometimes has more differences than similarities when dealing with other renewable energy sectors like solar, wind and hydroelectricity. In addition, prevailing policy by state energy regulators directs that electricity ratepayers should only be responsible for the proportionate share of the costs associated with bioenergy production that is commensurate with their benefits. Those costs should be based on the proportion of overall public benefits that are derived from forest restoration and bioenergy production.

Accounting for the full array of public benefits from using forest biomass for energy will be critical for gaining the financial, regulatory, and other assistance necessary to foster a robust forest biomass industry. Understanding these benefits will also be essential for balancing the costs of restoring forests and bioenergy production between the ratepayers and the general public. This paper examines these benefits for the Sierra Nevada Conservancy in support of the California Bioenergy Action Plan and the Biomass Working Group.

Background

Many of California's forests are unhealthy, largely as a result of a century of successful fire suppression. Reducing the frequency and severity of fires causes forests to become unnaturally over-crowded with vegetation. The excess vegetation contributes to the flammable material that is available when fires occur and often helps fires reach atypical severity that can destroy

the entire forest stand. While California forests have always experienced severe wildfire events, the increasing trend in severely burned forests today exceeds the historic patterns. Increasing temperatures and drier conditions caused by changing climate conditions are also contributing to this trend.

The forest health challenge is most notable on the public forests in California. For example, the US Forest Service recently reported that 6-9 million acres of national forest in California need restoration (US Forest Service 2011). This translates into a desired treatment rate of 200,000 – 500,000 acres per year for the next 20 years. The primary focus of forest restoration will be thinning to remove much of the excess vegetation. The traditional method for disposing of the biomass produced from thinning is burning in piles. Burning contributes to air pollution, is costly, and can only be done for a portion of the year.

Land managers are increasingly considering the use of forest waste or "biomass" to produce energy and other products. The practice is attractive because the sale of biomass material can help reduce the cost of thinning, thereby allowing treatment of larger areas with fixed or declining budgets for forest restoration. The cost of hauling biomass feedstock is high and it represented the largest component (47%) of the total cost in a recent study of project economics in Arizona (Pan et al. 2008(b)). Paying more than $40/bone dry ton for biomass fuel can make bioenergy projects infeasible. Practices have been identified to help reduce hauling costs, but feedstock cost remains a very challenging issue and it is the most significant issue for most forest bioenergy projects. Other benefits derived from improved forest health, such as reducing fire risks, mitigating air emissions, and creating renewable energy sources, should increase the attractiveness of public investments in harvesting forest biomass for energy (Pan et al. ibid).

Thinning forests produces an average of 13 bone dry tons (BDT)/acre. Distributing 50 megawatt (MW) of small (1-3MW) forest biomass-to-energy facilities across forested regions of the state (as recently mandated by the California Legislature with Senate Bill 1122) could provide sources for 400,000 BDT/yr and dispose of forest waste from roughly 31,000 acres of forest restoration annually.

Providing more biomass to existing or recently retired larger biomass facilities would allow additional forest restoration work in the Sierra Nevada and elsewhere. For example, the US Forest Service (2013) estimated that reoperation of closed biomass facilities would help the agency avoid costly adjustments where the facilities were planned to use biomass from existing forest restoration projects for energy. If these facilities could return to operation, the Forest Service could avoid: delays in fuels reduction work on 53,000 acres of forests; increased costs of $34 million to complete existing forest restoration contracts; and the direct loss of 136 jobs associated with forest thinning and bioenergy production.

The most economical form of biomass energy is cogeneration to produce heat and electricity. Biomass applications for direct heat production have been very limited in California. Competition from other renewable energy sources such as solar and wind has been a factor

that is impeding the development of a forest-based bioenergy industry. Yet, biomass conversion offers a unique set of benefits: a way to convert forest waste into renewable energy while simultaneously decreasing potential fuel for wildfires, reducing air pollution from pile burning, producing jobs in rural communities, and providing an array of other cost-effective public benefits.

Current Understanding of Benefits from Biomass-to-Energy Programs

The primary benefits from using forest biomass for energy come from the ancillary values of restoring healthy forests. Additional benefits occur from the social and economic contributions to rural forest communities and the production of renewable energy that offsets the uses of fossil fuels. The economic values for some benefits have been documented while information on others is sparse. Below is a summary of the current understanding of the benefits and values of thinning forests and using a portion of the residual material for energy production.

Using Biomass for Energy Can Help Restore and Maintain Healthy Forests

Many of California's forests are at risk to wildfire, insect outbreaks, disease agents, and drought due to their over-stocked conditions. As a result, high levels of tree mortality and disease are commonly observed. Removal of biomass material can lead to healthy forests that are more resilient and resistant to fire, diseases, insects, and drought. Biomass power production can offset some of the costs of forest treatments by paying for the removal of waste material while promoting better and more extensive forestry management (Morris 2008). Relationships between biomass removal and forest health have been summarized as follows (Stewart et al. 2011):

- As a general rule, reducing the density of trees in coniferous forest stands of the West improves the vigor of residual trees, thereby promoting resistance to diseases, insects, and fire in the remaining stand.
- Reducing fuel continuity across the crown of the forest and reducing "ladder fuels" in the understory trees lowers the potential for severe fire that can destroy the stand.
- Treatment of residual biomass after timber harvest is usually needed to reduce wildfire hazards for the residual stand (Weatherspoon and Skinner, 1995). Forest treatments that leave high levels of woody debris behind can increase potential wildfire intensity and severity because of the increased ground fuel accumulation. Biomass harvest usually focuses on removing excess logging and thinning debris and helps protect the treated stand from severe fire.
- Mechanical treatments that reduce wildfire hazards by collecting excess forest fuels can be done in ways that protect soil and water resources. Biomass and associated nutrients are retained onsite with careful management, helping buffer soils from the compaction, runoff, and productivity impacts of harvesting.

- Insect pests such as the *Ips* beetle can increase following thinning treatments if the wood waste is not removed. Biomass harvesting removes much of the potential beetle habitat and can be expected to deter beetle infestations and promote healthy forests.
- Forest thinning and biomass removal can reduce mortality from root diseases by promoting vigor and pathogen resistance of the residual trees. When not carefully done, thinning and biomass harvest can also induce root disease by wounding trees and damaging root systems, or disturbing forest soils.

Removing forest biomass can promote healthier forests while protecting soil and water resources. Studies have been underway for about two decades to assess the long-term effects of biomass removal on soil chemical and physical properties and fundamental forest productivity. The potential impacts of additional biomass harvesting on soil productivity, soil erosion, and stream water quality are similar to the impacts of more intensive forest harvesting regimes used for pre-commercial and commercial thinning for saw-timber production (Stewart el al. 2011). A ten-year studying of four mixed-conifer sites in the Sierra Nevada produced little change in potential soil nitrogen availability following whole-tree removal, but significant declines in nitrogen availability following the removal of the forest floor. Removing the forest floor of soil and embedded biomass is not a standard biomass harvest practice and it has only been done to research the consequences on soil nutrients. Protecting soil resources will be a key to maintaining productivity during removal of forest biomass for energy.

Decades of research on forest management practices across North America have led to the development and use of many best management practices (BMPs) to protect soil productivity and water quality. The continued use of BMPs is required for biomass harvesting operations on public and private forests in California.

Healthy Forests Provide a Variety of Benefits

Healthy forests provide a number of ancillary benefits to the public and others. Some important examples are provided below.

1. Healthy Forests Reduce the Costs of Fire Protection

Thinning forests dramatically reduces the extent and severity of wildfire (Agee and Skinner 2005) and thinned forests provide direct benefits for fire protection. For example, strategic placement of forest thinning treatments was estimated to reduce burned acres by 22% per year for a large study area in the Sierra Nevada (USDA Forest Service 2009). The Forest Service estimated that the treatments saved $246 million in avoided damages from wildfire and $18 million in avoided fire suppression costs over a 40-year assessment period in a 2.7 million acre study area in the Sierra Nevada. Public and firefighter safety is also improved by thinning because the severity and size of fires are reduced.

Reducing the extent and severity of wildfires will also help control the increasing costs of managing fires. Fire suppression costs for the three large wildland fire-fighting agencies

(CalFire, USDA Forest Service, and USDI Bureau of Land Management) averaged about $1.2 billion per year in California during 2006-2010 and the costs are increasing (source: discussions with agency staff). Further, the US Forest Service has received over $100 million in settlement costs for damage and suppression costs for fires caused by others on California national forests since 1994. Healthy forests can help reduce these costs.

Reducing fire risk helps the public by reducing the costs of managing wildfires. Reducing fire risk also helps the 70% of Californians who buy their power from the three largest investor owned utilities (IOUs). Since 2004, the three IOUs have requested roughly $75 million in rate increases based on wildfire costs and $110 million in costs to remove bark beetle infested forest lands to prevent wildfire (Public Utilities Commission Catastrophic Event Memorandum Account cases 2005 Cal. PUC Lexis 262; 2006 Cal. PUC Lexis 411; 2006 Cal. PUC Lexis 408; 2008 Cal. PUC Lexis 65; 2010 Cal. PUC Lexis 413; 2010 Cal. PUC Lexis 182; and 2011 Cal. PUC Lexis 406.). Moreover, the IOUs sought an additional $400 million from ratepayers to address insurance and other costs associated with wildfire in 2012. The increases in insurance rates were directly related to the increased risk of wild fire (source: records for Public Utilities Commission proceeding 09-08-020 - see Opening Joint Amended Application, p.3).

2. Healthy Forests Provide Benefits to Water Resources

The Sierra Nevada region receives 60% of the state's precipitation, provides water for 25 million people and the state's agricultural industry, and contributes nearly 50% of the hydropower generated in California (Water Education Foundation, 2011). The runoff and sediment output from forests after severe wildfires can be several orders of magnitude greater than pre-fire conditions. The increased outputs have been linked to loss of soil cover, loss of canopy protection, loss of surface roughness to slow runoff, water repellency by the soil, and soil sealing from ash and sediment particles (Larsen et al. 2009). Burned areas can take two years for soil hydrophobicity to dissipate and sediment output can take five years to return to its pre-fire levels (Larsen et al., 2009).

Sediment load deposited by runoff after severe fires can require costly clean-up operations for managers of public drinking water facilities as well as managers of hydroelectric and water storage facilities. Carefully managed forests can ameliorate large sediment movements by reducing fire severity and protecting soils. Careful forest management can also maintain stream temperatures and desired fish habitats by retaining the forest canopy near streams and rivers.

Several projects are now underway to link the beneficiaries of clean and abundant water to the management of upstream forests. Each project is being arranged so that the beneficiaries help pay for the costs of managing the upstream forests in ways that protect their water quality and water supply. These projects offer some insights on the value of well-managed forests for protecting water quality and supply.

Denver Water Project
The watershed that provides the water supply for the City of Denver was affected by the Buffalo Creek fire which burned 11,900 acres in 1996. The rains that followed released the equivalent of ten years of sediment into the South Platte River and deposited 15 surface acres of debris that blocked the City's water treatment facilities. Treatment costs for the drinking water of Denver's 1.3 million customers increased by $250,000 in the year following the fire (Kennedy 2011).

In 2002, the Hayman Fire burned 138,000 acres within the same watershed (Kennedy 2011). The rains that followed carried 1 million cubic yards of sediment into the city's primary water storage reservoir. The Denver water utility spent over $31 million to remediate the damages. In 2010, Denver Water Agency continued dredging the reservoir in an attempt to remove more 625,000 tons of sediment at an additional cost of $30 million. More work remains.

Santa Fe, New Mexico
The Cerro Grande fire burned 48,000 acres and caused $17 million in damage to the City of Los Alamos' water supply infrastructure in 2005. In the first year following the fire, the Los Alamos reservoir accumulated 21,800 m^3 of sediment, or 140 times the pre-fire rate of sedimentation (Lavine, Kuyumjian, & Reneau, 2006). The nearby City of Santa Fe subsequently analyzed their potential for damage from a similar wildfire in their watershed. Santa Fe estimated their cost at $4.3 million to manage upstream forests to protect their water supply. In contrast, the potential cost that would result from a 7,000 acre fire in the watershed was estimated at $22 million (Santa Fe Watershed Association 2009).

Santa Ana River
The Santa Ana River watershed supplies most of the drinking water for over 5 million people. During 2003, The Grand Prix, Old, and Padua Fires burned over 120,000 acres within the watershed, primarily within the San Bernardino National Forest. These fires have had significant impacts on the Santa Ana River for many years and they have impacted 430 square miles of the watershed. Costs of mitigating the effects of the fires within the watershed are estimated to be near $450 million, mostly for sediment and toxin removal, as well as repairs to infrastructure (Santa Ana Watershed Protection Authority 2004). Local water managers are now working with the Forest Service and others to manage upper watersheds to prevent similar wildfire damages in the future.

3. Healthy Forests Reduce Impacts to Air Quality
Although forest bioenergy facilities release emissions that impact air quality, the facilities are dramatic improvements over the emissions produced by pile burning and wildfires. Further, wildfires tend to occur in late summer, when air quality is already degraded. Bioenergy produces much lower rates of emissions over the course of an entire year. Some examples of studies that evaluate the air quality improvements associated with bioenergy production are provided below.

- Compared with the traditional method of burning forest waste after harvest in the Central Sierra Nevada, utilization of biomass for electricity reduced particulate matter emissions by 98%, nitrogen oxides by 54%, non-methane volatile organics by 99%, carbon monoxide by 97%, and carbon dioxide equivalents by 17%. The emissions produced from biomass processing and transport operations were negligible (Springsteen et al. 2011).

- The Stockholm Environmental Institute compared the GHG and air pollutant emissions for 15 different fates for forest biomass across six categories: solid waste disposal, soil amendment, residential energy (e.g. stoves), industrial energy, industrial feedstock, and liquid fuel (Lee et al. 2010) and their findings included:

    - Emissions from pre-processing of residues, including the gathering, chipping and transporting residues make up less than 4% of overall emissions from all operations.
    - Air pollutant emissions from burning biomass at industrial facilities (with emissions controls) result in CO and PM2.5 emissions that are much lower than emissions from uncontrolled burning on-site.

- Carbon dioxide, methane, and particulate emissions from biomass-combustion boilers were 60%, 3%, and 41% less, respectively, than the rate from pile burning in a recent study in Montana (Jones et al. 2010).

In addition to the adverse impacts of pile burning on air quality, the smoke from wildfires often mixes with atmospheric conditions downwind to create surface ozone (Pfister et al. 2008). During and after fires throughout California in 2007, the ozone produced exceeded public health standards over 100 days (Pfister et al. 2008). Particulate matter also exceeded the background level by four times downwind of fires in California (Wu et al. 2006). Removing forest biomass to promote forest health can help reduce the emissions from wildfires.

4. Healthy Forests Provide Benefits to Public Health

Many of the benefits to public health from biomass utilization come from added fire protection and reduced pollution to air and water as reported in previous sections. Few projects have evaluated bioenergy facilities across the spectrum of public health considerations. One study by the Sequoia Foundation examined public health impacts from a proposed 2MW facility in Eastern Placer County (Sequoia Foundation 2012). The assessment determined that the project posed no significant risks to public health and it would offer considerable improvements in each of the six health categories evaluated when compared to the traditional biomass disposal method of pile burning.

5. Healthy Forests Help Mitigate the Effects of Changing Climates

Like all renewable energy generation that displaces fossil fuels, bioenergy production avoids the production of an equivalent amount of energy from fossil fuels. In addition, bioenergy production avoids the biogenic greenhouse-gas emissions produced by other methods for disposing of forest waste such as pile burning and instead replaces them with much lower emissions from energy production using controlled combustion technologies (Morris 2008, Lee et al. 2010).

Forests are the largest source for global carbon storage after the oceans. California forests currently sequester about 30 million metric tons of CO2 annually (CalFire 2010). Wildfire, not forestry, is the dominant influence on forest carbon flux and sequestration today (Stewart et al 2010). In fire-prone forests of the West, large releases of carbon occur when trees are killed or partially killed by wildfire (Hurtt et al. 2002, Hurteau et al. 2008). Large releases also occur when thinned forest material is piled and burned (Springsteen et al 2011).

Several projects have suggested that the best way to safely store carbon in forests of the Sierra Nevada and elsewhere is to accumulate it in a relatively small number of large trees that are resistant to severe fires (e.g. Hurteau and North 2009). Forest management practices have been developed to accomplish this arrangement through thinning and prescribed fire (North et al. 2009). Forest thinning is often the preferred treatment today because many forests stands have accumulated large fuel loads that prevent the safe use of prescribed fire.

Determining the long-term consequences of forest management on carbon stocks is difficult and often controversial. Some studies report that fuels treatments result in increased carbon emissions (Mitchell et al. 2009; McKechnie et al. 2011) and others report reduced carbon emissions (Stephens et al. 2009; Jones et al. 2010). The variation in results may be related to the modeling techniques for estimating the complex changes in the carbon pools in forests over time. Carbon stocks are reduced by removing biomass during forest thinning, pile burning, wildfire, and decomposition of residual dead wood. Carbon storage also increases over time as forest grow and additional carbon may be held in the wood products that are produced from thinned forest materials. The fossil fuels consumed during thinning and transport produce carbon emissions and bioenergy facilities also release carbon compounds and other emissions. Still, biomass energy systems are generally recognized to be carbon neutral, because the carbon in the fuel is already part of the global carbon stock that circulates between the atmosphere and the biosphere (Morris 2008). In addition, Forest biomass energy has an encouraging net energy benefit compared with other biomass sources (Pan et al. 2008(a)).

The complex calculations to estimate overall long-term gains or losses in carbon are heavily influenced by the quality of information, modeling assumptions, and techniques employed. Estimates of initial carbon stocks as well as the rates of emissions, growth, and decomposition are often based on incomplete information and these attributes can vary considerably among sites. The long-term consequences on atmospheric carbon are also influenced by the timing and intensity of forest disturbances (Hudiburg et al.2011,), and the return interval of disturbances may have the largest overall effect (Winford and Gathier 2012).

The complexity of these relationships and the variability among sites and regions may make it essential to complete area-specific assessments to estimate total carbon outcomes (Winford and Gathier 2012). Thinning forests and using the material for energy is generally regarded as desirable in the Sierra Nevada where many forests are at risk to severe fires that would release large amounts of carbon. Well-managed forests can increase carbon stored in the large trees while improving the resistance of residual stands to severe fire (North et al 2009). Thinning of well-managed stands of larger trees over time will balance the added carbon storage through tree growth with carbon losses from tree removal (Lipkke and Oneil 2010).

Converting forest biomass to energy has been shown to provide benefits to overall greenhouse gas (GHG) emissions when compared to open pile burning and wildfire emissions. The US Forest Service (1999) estimated a 65% reduction in GHG emissions by converting wood waste to energy for 40 years in a 2.7 million acre forested region of the Sierra Nevada. Further, Morris (1999) compared the impacts of biomass energy to three alternative fates for the material: open burning, disposal in landfills, and accumulation in the forests. Morris compared the four possible fates on criteria air pollutants, greenhouse gas emissions, and other factors. He estimated that the cumulative total public benefits of biomass removal on emissions to be valued roughly at 9.85 cents/kWh. The Western Governors' Association (WGA) produced a similar assessment to that of Morris, which yielded very similar results. The WGA estimated the public benefits value of biomass power was 11 cents/kWh. The total value for ancillary benefits was an additional 11 cents/kWh. Most of the value was in avoidance of GHG and other criteria pollutant emissions (9.4 cents.kWh). In a later study, Morris (2008) determined that leaving residual materials on site following forest restoration produces higher levels of biogenic greenhouse-gas levels than using the material for electricity production.

Wood-based bioenergy will be most effective for GHG mitigation when the biomass is a byproduct of the production of lumber and other primary wood products that result from forest restoration. When used for energy, biomass that substitutes for fossil fuels used to produce heat and electricity generation will typically provide larger climate benefits than substituting biofuels for gasoline or diesel in transport (Bauen et al 2009).

"Bio-char" is a high-carbon residue which can be produced as a byproduct of forest bioenergy and can be used as a soil amendment. Bio-char can sequester significant amounts of carbon in the soil for hundreds to thousands of years (Institute for Governance & Sustainable Development 2008).

Apart from positive effects in both reducing air emissions and increasing the sequestration of greenhouse gases, the production of bio-char and its application to soil will deliver immediate benefits through improved soil fertility and increased crop production. Conversion of biomass carbon to bio-char carbon leads to sequestration of about 50% of the initial carbon stocks compared to the low amounts retained after burning (3%) and biological decomposition (<10–20% after 5–10 years), therefore yielding more stable soil carbon than burning or direct land application of biomass (Johannes et al. ibid). Bio-char soil management systems can deliver tradable carbon emissions reduction, and sequestered carbon is easily accountable and

verifiable. The application of bio-char to soil has been proposed as an approach for establishing a significant, long-term, sink for atmospheric carbon dioxide in terrestrial ecosystems (Johannes et al. 2006).

6. Healthy Forests Provide Desirable Habitat Conditions for Plants and Animals

California forests provide habitats for a large array of plants and animals. These species are dependent on the diversity and spatial arrangements of habitat characteristics that develop across forests as a function of disturbance patterns, topography, rainfall, and other factors. Historical fire records indicate that fires in the Sierra Nevada burned with varying degrees of intensity, providing the diverse stand structure that created a broad array of habitats and niches. Trends in population size are largely influenced by the availability of preferred habitats for most species. Except for a small number of game and protected species, information on the economic value of individual species, habitats, and biodiversity are lacking for the Sierra Nevada and California.

Precise information about habitat requirements is also lacking for the vast majority of species in the Sierra Nevada and elsewhere. In the absence of this information, many scientists believe that mimicking the historic patterns of disturbances is a reasonable way to provide the diversity and arrangement of habitats that will maintain biodiversity in California forests. These scientists also believe that the current trend in severe fires is moving forests away from desired conditions. Many believe that restoring forests as prescribed by North et al. (2009 and 2012) can correct the trends. These reports encourage thinning and prescribed fire as desired treatments and they support the use of biomass for energy.

Biomass harvesting reduces the understory vegetation and smaller diameter/canopy trees. There is typically also additional removal of some of the existing dead and downed woody debris. These are important wildlife habitat components that are rarely deficient at a regional level, but can be limiting at scales important to some wildlife populations if they are not addressed with stand treatment prescriptions. Many of these important habitat elements are protected by management guidelines for forest management (Stewart et al. 2011).

Compared to “no harvest” alternatives, biomass harvests are similar to 1) the thinning and removal of less commercially valuable trees or 2) the removal of harvest residues that historically were burned or left in the forest to decay. A recent meta -analysis of 33 studies of thinning impacts on biodiversity across North America found “generally positive or neutral effects on diversity and abundance across all taxa” (Verschuyl et al. 2011). The maintenance of dead and down wood is widely considered to be the area with the greatest importance during biomass harvesting. The maintenance and recruitment of structural elements such as large green trees and snags, logs, and coarse woody debris, which would otherwise not be replaced under an intensive biomass harvesting scenario, are issues of critical concern for the maintenance of biodiversity. Biomass harvest that is conducted to reduce the likelihood of severe fire in California forests will generally be regarded as beneficial for wildlife as long as abundant key structural components (snags, down logs, hardwoods, etc.) are retained.

7. Healthy Forests Provide Important Recreation and Aesthetics

Outdoor recreation activities help generate $85.4 billion in annual spending in California, more than any other state in the country. Spending on outdoor recreation in the state also helps support 732,000 jobs and generates $6.7 billion in state and local taxes, according to the study by the Outdoor Industry Association (Los Angeles Times 2013).

California forests are a major destination for public recreation. Most the recreation occurs on public forests, but considerable outdoor recreation is offered by private forestland owners as well. Severe fires can seriously disrupt recreation, alter recreational experiences for forest visitors, and damage recreational facilities. Maintaining healthy forests can help protect them from severe fires.

Region-wide, tourism is heavily dependent on the natural beauty and landscape of the Sierra Nevada and it now accounts for 15 percent of the region's total payroll (Sierra Business Council 2006). In a number of counties, it is the single most important economic activity. Popular activities include camping and hiking, backpacking, skiing, fishing, hunting, boating, off-road vehicle use, mountaineering, wildlife watching and much more. Recreational fishing and whitewater rafting are the two most significant recreational uses of Sierra Nevada water. Fishing accounts for nearly $200 million a year. Whitewater rafting is estimated to generate $50 million a year (Water Education Foundation 2011).

The national forests comprise 20 million acres or 20% of the land base in California and about 41% of the Sierra Nevada. The USDA Forest Service operates 2,141 recreational facilities in the state. During 2005-2009 the national forests accommodated an annual average of about 28 million visits. Visitors spent an average of $1.9 billion per year in local businesses. The majority of visitors participated in activities that can be seriously disrupted by severe fires: viewing nature and wildlife, hiking, skiing, fishing, picnicking, and camping (USDA Forest Service 2012).

The USDI Bureau of Land Management (BLM) owns about 15 million acres in California. The BLM owns about 11% of the land in the Sierra Nevada. In Fiscal Year 2011, recreational and other activities on BLM-managed land infused more than $2.5 billion into the California economy and supported more than 9,600 California jobs (USDI Bureau of Land Management 2012).

Many of the California State Park System's 278 units are located in forests. During 2010-2011 a total of 63,453,272 visitors used the state park system. These visitors paid a total of $85,097,979 in user fees. The number of day-user visitors in 2010-2011 was 57,193,002 and over-night camping was provided for 6,260,270 visitors (California State Parks 2011). A recent survey by the California Department of Parks and Recreation determined that the following activities ranked highest among visitors to California state parks: relaxing (40%), walking short distances (29%), hiking on trails (28%), camping (22%), and photography (20%). Day-use fees for these visitors ranges from $2-10 depending on the amenities provided. Camping fees range from $5/night for primitive locations to $45/night for sites with full accommodations (California Department of Parks and Recreation 2009).

Using Biomass for Energy Offers Benefits to Rural Forest Communities

In addition to the benefits associated with healthy forests, forest bioenergy production provides important social and economic benefits to rural areas. These include high-quality family-wage jobs and the generation of local and regional tax revenues (Morris 2009).

While some regions of the Sierra Nevada are seeing expanded prosperity, the benefits have not reached everyone or everywhere. In some counties, the growing number of children in poverty, declining personal incomes, low educational attainment levels, and outdated communications infrastructure show that some people and communities are being left behind. These trends reinforce the need to invest in disadvantaged communities to help them restore their well-being (Sierra Business Council 2006).

Because forest-based bioenergy facilities use biomass produced from forest management, most are located in rural areas that have been dominated by resource-based economies. These communities are often characterized by slow economic growth rates and high unemployment (Morris 1999). Eighty four lumber mills have closed in California since 1989 (California Forestry Association 2008) and the closures have had an impact on some rural communities. Many of the mills also operated bioenergy facilities that produced heat and electricity from mill residues and waste from nearby forest improvement projects. In addition, five forest biomass power generation facilities have closed since 2005, with a total generation capacity of over 65 MW.

As an example of the current economic challenges in many rural forest communities, the following description was offered for the town of North Fork in the foothills of the Sierra Nevada: "As a result of the closing of the mill in 1994, North Fork experienced severe economic dislocation. Over 10% of the community's jobs were lost, and this was after a 150% decline in jobs over the previous 10 years. The Native American Mono community, which had many people employed by the mill or in associated logging businesses, was particularly hard hit by the mill closure and has been very slow to recover. Approximately one-sixth of businesses have closed down since the mill closing, including one of the town's two markets, a restaurant, the town's only gift store, the army surplus store and a gas station. In addition, other businesses or contractors that supported the mill operation, such as logging contractors, equipment operators and truck drivers, were put out of business. The County also experienced a loss of tax income from these business failures, as well as from the loss of timber harvest revenues. According to the Madera County Crop Report, the timber harvest value dropped from $6,363,000 in 1993 to $1,225,000 in 1997, an 80% change." (North Fork Community Development Council 2003).

Biomass power facilities provide jobs with comparatively good wages. Power plant employees and workers in supporting role (such as fuel handling) receive attractive pay and benefits packages. Support jobs are generated at a ratio of almost 2:1 compared to plant employment, with total employment equal to 4.9 fulltime jobs per each megawatt of net plant generating capacity. The long-term nature of this employment provides durable improvement and added stability to the local and regional economies surrounding the plants (Morris 1999).

Biomass power production contributes to local, state, and federal taxes. Assuming a hypothetical average annual income of $35,500 (not including benefits or employer-paid taxes), and 4.9 workers per MW of installed capacity, Morris (1999) estimated that biomass power plant employees and support workers generate $26,200 in federal income tax, and $8,700 in state income tax, for each megawatt of operating biomass electric generating capacity. Local and personal sales taxes are not included. Property tax, based on a rate of 1% of assessed valuation, equates to $8,900/MW power plants plus $1,400/MW for fuel supply infrastructure and related equipment. In addition, based on average taxable purchases of supplies, parts, and equipment of $28,000/MW, sales tax at 7% yields an additional $2,000/MW annually. The total tax revenue generated from biomass energy production is approximately $47,200/MW power produced per year. This translates into a total tax contribution of $88 million in the United States annually that is attributable to the independent biomass energy industry (Morris 1999).

Using Biomass for Energy Provides a Firm Source of Renewable Clean Energy

California's Renewable Portfolio Standard (RPS) was established by the California Legislature in 2002 with the goal of diversifying the electricity system and reducing growing dependence on natural gas. The current RPS target calls for increasing the amount of renewable electricity in the state's power mix to 33 percent by 2020. To support the RPS target, Governor Brown's Clean Energy Jobs Plan called for adding 20,000 MW of new renewable capacity by 2020, including 8,000 MW of large-scale wind, solar, and geothermal resources and 12,000 MW of localized renewable generation close to consumer loads and transmission and distribution lines.

To comply with the Governor's plan, the California Energy Commission (CEC) developed a Renewable Energy Action Plan to "expedite permitting of the highest priority [renewable] generation and transmission projects"(California Energy Commission 2013). The intent was to support investments in renewable energy that will create new jobs and businesses, increase energy independence, and protect public health. The CEC's plan notes that:

> "Developing a variety of (renewables) technologies can create a more attribute-based, diversified portfolio to minimize risks and realize co-benefits. For example, woody biomass projects strategically located to reduce fire load can reduce the risk of wildfires that damage transmission and distribution lines and strengthen electric system reliability and public safety."

Biomass provides a renewable source of energy, potentially improving energy security through the substitution of oil and natural gas. The use of domestic bioenergy resources will contribute to the diversification of the energy mix (Bauen et al. 2009).

Maintaining reliable operation of California's electricity system, with increasing levels of intermittent renewable energy resources (such as solar and wind), is bringing new challenges to the managers of the state's electricity system (California Energy Commission 2013). New challenges include real-time increases and reductions in generation output, voltage, or frequency; ramping generation that follows swings in wind or solar generation; creating

reserves that are standing by and ready to connect to the grid when needed; replacement power for outages; and strategies to deal with generation over capacity. Forest biomass-to-energy provides an advantage over other renewable energy sources such as wind and solar because production can occur continuously or "on demand". To acknowledge the advantages of forest-based bioenergy, Senate Bill 1122 was passed in 2012 to direct the California Public Utilities Commission to mandate procurement of 50 Megawatts of community-scale forest bioenergy by the major investor-owned utilities.

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