

# Ensuring Forest Sustainability in the Development of Wood Bioenergy

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Wood bioenergy development holds important opportunities —and challenges—for sustainable forest management. In the US, two major priorities in national policy—mitigating climate change, and achieving greater energy security through increased domestic renewable energy production—have converged to create new and rapidly expanding demands on US forests for wood-based bioenergy. Forest land owners may benefit from expanding wood markets, especially new markets for previously unmerchantable materials. However, rapid expansion of wood bioenergy facilities leading to local overcapacity could result in excessive harvesting, with significant negative consequences for biological diversity, water quality, and other important forest conservation values.

Recent federal and state laws have expanded investment incentives and tax credits for wood bioenergy. This is expected to accelerate the development of the wood bioenergy industry, more than doubling the amount of woody biomass harvested from US forestlands (Perlack et al. 2005). This paper addresses three important components to ensuring that wood bioenergy and biofuels production does not lead to overharvesting and unsustainable forest use: (1) methodologies for realistic assessments of available woody biomass supply as a basis for planning new capital investment in bioenergy facilities, (2) economic, social and ecological considerations for determining suitable type, scale, and distribution of new wood bioenergy facilities, and (3) the adequacy of the existing policy framework to safeguard forest conservation values, and provide incentives for bioenergy industry development that is financially viable and sustainable over the long term.

## Background

On December 29, 2006, the Manchester (UK) Guardian reported that “an ice island the size of a small city is adrift in the Arctic after breaking free from one of Canada’s largest ice shelves.” The ice island is 3 miles wide and 9 miles long. It broke clear of Ellesmere Island, about 500 miles south of the North Pole, triggering tremors so powerful they were picked up by earthquake sensors 155 miles away. Unlike the free-floating Arctic ice pack, the melting of this island will add new volume to the North Atlantic and contribute to a rise in sea level. It triggered anew the scientific debates over whether the effects of climate change will be gradual, or will happen more suddenly and quickly than even the most pessimistic climate models have predicted. It also meant that, for population centers on the Atlantic coast in North America and Europe, climate change is getting closer to home.

On November 8, 2006, another powerful tremor was felt in Washington, DC, 3,000 miles to the south of Ellesmere Island, as the results of the 2006 elections became clear. Voters were sending a series of powerful signals to their national leaders. One of these signals that Congressional leaders in both parties heard loud and clear is that the American public is

deeply concerned about the impacts of global climate change, and they want to see meaningful action by our national leaders to (1) better understand the many-layered effects of climate change (economic and social as well as ecological), (2) mitigate further climate change to the extent possible, and (3) begin preparing for the inevitable impacts of climate change where needed.

## Incentives for bioenergy and biofuels development

Political leaders at all levels of government in the US have acknowledged the seriousness of the climate change issue, and pledged their support for efforts to reduce US energy consumption and increase renewable energy production. Although the US has not renewed its national commitment to the Kyoto Protocol, several state governments have taken the initiative and committed to greenhouse gas reduction goals, to be achieved through a cap-and-trade mechanism similar to that created by the Kyoto Protocol. At least 30 state governments have enacted Renewable Portfolio Standards (RPS) that require electric utilities to produce a certain percentage of their power from renewable sources by some specific future date. The requirements range widely, resulting in a patchwork of laws that can create compliance difficulties for regional utilities that operate in several states. To establish a more consistent approach, Congress has considered a national-level RPS requiring 20 percent renewable energy by 2020, but this has yet to be enacted into law.

When Congress enacted the Energy Independence and Security Act (EISA) at the end of the 2007 session, it set ambitious goals for renewable energy production especially liquid biofuels for transportation—9 billion gallons in 2008, increasing annually to a goal of 36 billion gallons by 2022 (P.L. 110-140, §202). The intent behind these mandated goals is to guarantee a market for biofuels, and thus stimulate research, development, and growth in the biofuels industry (Yacobucci 2008). From 2000 to 2007, ethanol production in the US increased by more than 256 percent, to 6.5 billion gallons per year (Renewable Fuels Association 2008).

Table 1. Biofuels production goals under the 2007 Renewable Fuels Standard			
Year	Renewable biofuels/1	Advanced biofuels/2	Total
		(billions of gallons)	
2008	9.0		9.0
2009	10.5	0.6	11.1
2010	12.0	0.9	12.9
2011	12.6	1.4	14.0
2012	13.2	2.0	15.2
2013	13.8	2.8	16.6
2014	14.4	2.8	17.2
2015	15.0	5.5	20.5
2016	15.0	7.2	22.2
2017	15.0	9.0	24.0
2018	15.0	11.0	26.0
2019	15.0	13.0	28.0
2020	15.0	15.0	30.0
2021	15.0	18.0	33.0
2022	15.0	21.0	36.0
1. Generally, ethanol from corn grain, sugar cane, and other direct fermentation sources.			
2. Includes ethanol and biodiesel from converted agricultural waste and woody biomass.			
Source: Energy Independence and Security Act of 2007 (P.L. 110-140)			

To further spur the development of the domestic biofuels industry in the US, Congress also limited imports through a 2.5 percent ad valorem tariff and a most-favored-nation duty of \$.54 per gallon of ethanol (with the exception of Caribbean Basin Initiative countries, from which ethanol can be imported duty-free) (P.L. 110-234, §15333). From 2006 to 2007, imports of ethanol from the Caribbean nation of Trinidad and Tobago increased more than 72 percent (Renewable Fuels Association 2008). At the same time, imports of ethanol from Brazil dropped by more than 56 percent.

But Congress also modified the means by which they expect biofuels production goals to be achieved. In particular, they acknowledged the increasing concerns about the impact of expanded corn ethanol production on food supplies around the world—and on land conversion and water quality in the US. EISA reduced the federal tax credit for corn ethanol production from \$.51 per gallon to \$.45 per gallon, and established a tax credit of \$1.01 per gallon for cellulosic ethanol and \$1.00 per gallon for biodiesel (P.L. 110-234, §15331). The expanded Renewable Fuel Standard in EISA specifically mandates the use of “advanced biofuels” produced from feedstocks other than corn that have 50 percent lower lifecycle greenhouse gas emissions than petroleum-based fuels. Of the 36 billion gallons of biofuels to be produced by 2022, 21 billion must be from advanced biofuels.

### **Increasing bioenergy capacity**

There is broad popular support in the US for expanding renewable energy production to reduce greenhouse gas emissions, increase the share of energy coming from domestic sources, and stimulate the development of new industry in the US focused on renewable energy technology. Although not established as a matter of official national policy, there is general support for setting a goal of 25 percent of the nation’s energy coming from renewable sources by 2025. This “25x’25” goal encompasses all energy use, including transportation fuels, and is not limited to just electric power. A 2006 study by the RAND Corporation found that achieving the 25x’25 goal is technically feasible and can be accomplished at little or no significant increase in the nation’s energy expenditures (Bernstein et al. 2006). The conclusion was based on the assumption of a 20 percent decline in renewable energy costs between now and 2025, which is consistent with recent trends, and long-term oil prices that do not fall below the range projected by the federal Energy Information Administration.

In 2008, however, this study was superseded by a second RAND Corporation study which found that meeting the 25x’25 goal would be far more challenging than outlined in the earlier version of the report (Toman et al. 2008). Like the earlier report, the 2008 study concluded that biomass energy, especially for the production of liquid transportation biofuels such as ethanol or biodiesel, would be the largest single component of the increase, far greater than wind, solar, geothermal or other sources. The study found that a “large, inexpensive and easily converted biomass supply” is essential to meeting this goal without significant increases in government or consumer expenditures on energy, and that “developing such a supply would require harvesting energy crops at a scale that greatly exceeds current production.” According to economist and lead author Michael Toman, “Without increased biomass availability, expanded renewable energy use could impose economic burdens and result in environmental setbacks due to land conversion.” The study

concluded that setting more moderate renewable energy targets—such as 15 or 20 percent by 2025—would reduce the economic impacts, though the greenhouse gas reduction would also be less significant.

The current availability and long-term *sustainable* supply of woody biomass is one of the central questions in determining what role America's forests will play in addressing these national priorities for mitigating climate change and expanding renewable energy production, through both bioenergy and biofuels. Will wood bioenergy be a significant part of that “large, inexpensive and easily converted biomass supply” essential to meeting national goals for renewable energy production? To what extent will the nation's forests be able to support harvesting “at a scale that greatly exceeds current production”? How will the nation's forests contribute to increased biomass availability without also retreating from recent achievements in biodiversity conservation and other important aspects of sustainable forest management?

### **Assessing the sustainable supply of woody biomass**

A recent analysis by the leading federal agencies in agriculture, energy, and environmental protection estimates that the amount of woody biomass that can be produced sustainably is approximately 368 million tons annually—more than 2.5 times current consumption (Perlack et al. 2005). This projection is based on current production of wood-based bioenergy, estimates of currently unutilized sources of woody biomass that could be economically exploited, and estimates of additional woody biomass that could become available through forest growth and projected increases in wood products manufacturing.

Biomass from wood currently constitutes nearly three-quarters of the total annual consumption of biomass for energy in the US, with the remaining quarter coming from agriculture. Of the estimated 142 million tons of woody biomass consumed annually for energy production, fuelwood for power plants and commercial/residential use accounts for 35 million tons/year. More than two-thirds of this woody biomass (96 million tons) comes from—and is utilized by—the forest products industry. The two major components of this are (a) secondary wood residues from wood products manufacturing such as bark and sawdust, (44 million tons/year) and (b) pulping liquors left over from the manufacture of pulp for paper and paperboard (52 million tons/year). Most secondary wood residues currently are captured on-site and used as fuel for generating heat and electricity. In the pulp and paper industry, the pulping liquors are also fully utilized on-site. Although the pulp and paper industry on average is more energy self-sufficient than any other major industry (60 percent), it still consumes large amounts of oil, natural gas, and electricity. With efficiency gains from improved technology, the pulp and paper industry is striving to increase the proportion of its energy generated internally from pulping liquors.

The capture and utilization of thermal energy as well as electricity is key to maximizing the efficiency of woody biomass use for energy. A typical wood-fired electric power plant captures less than 25 percent of the energy input (see Table 2). In contrast, a typical cogeneration (combined-heat-and-power, or CHP) facility is three times more efficient, capturing up to 80 percent of the energy input. Scale is an important consideration in the design and operation of CHP facilities. At too large a capacity, not all of the thermal energy can be utilized and is wasted. But to obtain maximum efficiency, a CHP facility must use high-pressure steam turbines to run the generators. This requires continuous monitoring by

trained personnel, and thus is not practical or economical for small-scale applications. Wood products manufacturing facilities can be ideal for CHP applications because they require relatively large amounts of process heat (e.g., for paper drying at a pulp and paper plant, or to operate drying kilns for curing lumber at solid wood products plants) as well as electricity, and they already have a significant volume of woody biomass feedstock on-site.

Table 2. Relative efficiency of electricity, thermal, and combined-heat-and-power (cogeneration) facilities.

	Size (MW)	Wood use (Green tons/yr)	Capital cost (US\$millions)	Operations cost (US\$millions)	Efficiency (Percent)
<b>Electricity only</b>					
Utility plant	10-75	100,000-800,000	20-150	2-25	18-24
Industrial plant	2-25	10,000-150,000	4-50	4-50	20-25
School campus	N/A	N/A	N/A	N/A	N/A
Commercial/industrial	N/A	N/A	N/A	N/A	N/A
<b>Thermal only</b>					
Utility plant	14.6-29.3	20,000-40,000	10-20	2-4	50-70
Industrial plant	1.5-22.0	5,000-60,000	1.5-10	1-3	50-70
School campus	1.5-17.6	2,000-20,000	1.5-8	0.15-3	55-75
Commercial/industrial	0.3-5.9	200-20,000	0.25-4	0.02-2	55-75
<b>Combined heat and power/1</b>					
Utility plant	25(73)	275,000	50	5-10	60-80
Industrial plant	0.2-7(2.9-4.4)	10,000-100,000	5-25	0.5-3	60-80
School campus	0.5-1(2.9-4.4)	5,000-10,000	5-7.5	0.5-2	65-75
Commercial/industrial	0.5-2(2.9-7.3)	5,000	5	0.5-2	65-75

1. Sizes for combined-heat-and-power (CHP) facilities are a combination of electrical and thermal capacity; the first figure is electrical and the figure in parentheses is thermal. 1 MW = 3,413 Btu/hour.

Source: USDA Forest Service. 2004. Techline: Wood Biomass for Energy WOE-1. Forest Products Laboratory, Madison, Wisconsin.

Another alternative to constructing new large-scale wood-fired power plants is in the co-firing of conventional coal-fired power plants, which means using woody biomass as a supplemental energy source in high-efficiency boilers. Existing coal-fired power plants can be retrofitted to co-fire with up to 10 percent woody biomass at relatively low cost (Oak Ridge National Laboratory 2004). This has the added advantage of significantly decreasing the power plant's emissions of sulfur dioxide (SO<sub>2</sub>) and nitrogen oxide (NO<sub>x</sub>).

#### *Underutilized resources*

According to the USDA/DOE analysis (see Table 3), the largest single opportunity for increasing the use of currently underutilized sources of woody biomass for energy is through utilizing residues from hazardous fuels treatments and forest thinning (60 million tons/year). Large areas of both public and private forest land in the US are overstocked, and many of these areas are prone to insect and disease infestations and wildfire. The USDA Forest Service reports that more than 49 million acres of forest have been lost to wildfires during the past decade, with firefighting costs alone exceeding \$8.2 billion (Graham et al. 2004). Silvicultural thinning and removals to reduce the level of hazardous fuels nationwide would technically yield an estimated 8.4 *billion* tons of woody biomass. Several factors would

reduce the amount of woody biomass that is practically available to no more than 60 million tons/year:

- Operational accessibility is limited by remoteness, steep slopes, sensitive soils, and potential adverse effects to soil and water resources.
- Economic feasibility is limited by transportation costs and the relatively low value of woody biomass, and the fraction of woody biomass that is economically recoverable on site.
- Social and political acceptability limits the extent to which thinnings and fuels treatments can be accomplished, particularly on federal lands.

	Existing	Currently unutilized	Potential growth	Total
	(million tons/year)			
Fuelwood (heating and electric utilities)	35		16	51
Secondary wood residues (forest industry)	46	8	16	70
Pulping liquors (forest industry)	52		22	74
Urban wood waste	8	28	11	47
Primary wood residues (logging and other)	1	41	23	65
Hazardous fuels treatments		60		60
Total	142	137	89	368

Source: Perlack et al. 2005. Biomass as Feedstock for a Bioenergy and Bioproducts Industry.

The second greatest opportunity is in increasing the recovery of primary wood residues from logging and other removals. Current logging practices result in much of the material in tops, limbs and small branches being left on site. The USDA/DOE report estimates that if fully utilized, this could provide as much as 67 million tons/year in additional woody biomass for energy. However, it is estimated that an average of 60-65 percent of this material could be practically and economically recovered using current technology (Stokes 1992). The remaining amount is left on site to maintain soil productivity and water quality. As a result, the USDA/DOE study indicates that only an additional 41 million tons/year could be available from improved utilization of primary forest residues.

#### *Growth potential*

The standing inventory in US forests is expected to continue to increase, because forest growth is projected to continue to significantly exceed the rate of removals (Haynes 2003). Also, increased production in the forest industry in the US is expected to increase the amount of primary logging residues, as well as secondary residues and byproducts that can be utilized for bioenergy. This additional potential, estimated at 89 million tons/year, is detailed in Table 2.



## Bioenergy industry response to goals and incentives

The ambitious goals for bioenergy and biofuels production, and the powerful assortment of incentives, subsidies, tax credits and import tariffs designed to achieve them, are certainly having the desired effect of stimulating investment and capacity in this new industry.

Government estimates of plentiful, cheap and sustainable supplies of woody biomass in some regions of the country have further encouraged major new capital investments in new industrial capacity for bioenergy and biofuels.

Meanwhile, oil prices on the global market have steadily increased, creating new urgency in the transportation and electric power industries, and keen interest on the part of individual households and communities turning to alternative energy as a cheaper and more stable source of heat and power. Community energy initiatives have brought centralized “district heating” to towns and college campuses, but also to large cities such as Minneapolis. This has in turn engendered feverish growth in the market for wood pellets and chips, which is also struggling to meet domestic demand from thousands of modern, new commercial and residential wood-fired furnaces.

In many regions of the US, the wood products companies recognize the need to maximize their utilization of woody biomass, and minimize their exposure to rising prices for fossil fuel energy. But they are also exploring the potential for becoming net producers of energy themselves, taking advantage of renewable energy incentives in the short term, and contributing to increased use of carbon-neutral fuels for the long term. For the forest products industry, which is notoriously cyclical, this has the added advantage of providing a secondary revenue stream that is more stable and predictable, and thus reduces overall financial risk.

Modern, highly-efficient technologies for better capturing both thermal energy and power from the combustion of secondary wood residues are revolutionizing the solid wood products industry. Energy investors are approaching existing solid wood products plants with offers to construct new, small-scale combined-heat-and-power (CHP) facilities that are fully integrated with the existing plant, providing both co-generated electricity and process-steam for heating and drying purposes. By allowing the plant to shut down its older, less efficient boilers, this can greatly increase the efficiency with which secondary wood residues are utilized. For the community, it can also result in improved air quality and lower water consumption. The energy company makes back its investment in the sale of heat and power to the wood products plant, but also through the sale of surplus “green energy” into the regional power grid. This also helps prepare the energy company for steadily increasing requirements for the percentage of its power that must be produced from renewable sources in states that have enacted a Renewable Portfolio Standard.

Existing pulp and paper plants are also actively exploring ways that they can jointly produce wood bioenergy along with their traditional paper products. Wood is a combination of cellulose, hemi-cellulose, and the lignin that holds wood cells together, and only the cellulose is needed for paper. The hemi-cellulose and dissolved lignin are what make up the organic portion of the pulping liquor, which is burned at most pulp mills to provide heat and electricity. One alternative currently being explored is turning the pulping liquor into a liquid biofuels such as ethanol or biodiesel. This is done either through a process of gasification

and catalytic conversion to biofuels, or through the more energy-efficient but technologically more challenging process of using enzymes to convert the hemi-cellulose and lignin into simple sugars that can then be fermented to produce ethanol.

Which of these alternatives is best depends on several factors, including the type of pulping process at the mill to begin with, the mix of hardwood and softwood fiber needed to produce the paper products the mill was designed to manufacture, and the age of the mill and its existing chemical recovery boiler. By jointly producing a liquid biofuel, the pulp and paper plant may be able to take advantage of the various government incentives and subsidies for biofuels production. How long these incentives are expected to last, and how they are expected to be modified over time, can make the difference in whether or not this is the best alternative for a given plant.

In some instances, the best alternative may be to make some modest additional capital investments in the pulp mill's existing capacity to produce heat and power from its pulping liquors. The rules governing the use of renewable energy credits may not recognize the value of electrical co-generation when the electricity is used within the plant itself (a "closed-loop"). In some states, however, this co-generated electricity can be sold to a third-party (an "open loop"), such as the regional power company. The power company can re-sell this electricity, thereby providing "green energy" that helps satisfy its RPS requirements, and qualifying for renewable energy credits. The pulp mill can purchase its electricity on the open market, sometimes at a lower rate than what they were paid by the power company for their co-generated electricity.

### **Meeting bioenergy production goals**

The kind of widely distributed, small- to medium-scale wood-bioenergy and biofuels operations such as those described above are valuable opportunities, and may be very positive from the standpoint of economic and environmental sustainability. However, achieving the federal mandates for advanced biofuels production, or state mandates for electricity production from renewable sources, would seem to necessitate the construction of large-scale, high-capacity biofuels plants and wood-fired power plants.

The kind of CHP plants described above, operating in conjunction with an existing solid wood products plant, typically has a capacity of 5-15 megawatts (MW). The ambitious RPS goals in many states seem to necessitate wood-fired power plants in the range of 50-100 MW, especially in northern regions where opportunities for developing other types of renewable energy such as wind and solar are very limited. Joint production biofuels plants at a typical 1500 ton/day pulp mill may produce no more than 20 million gallons/year of ethanol or other biofuels. It will take a great many of these to add up to the 21 billion gallons/year of advanced biofuels that are called for by 2022.

But there may be important tradeoffs to consider, in terms of environmental sustainability, and perhaps even in terms of the long-term financial viability of a large-scale wood bioenergy facility. Transportation costs will always be an important consideration in supplying woody biomass feedstocks, and even large-scale plants are not designed to draw from more than a roughly 75-mile radius. The demands on the local forest resource can be



significant, even if there are no other major wood products or wood bioenergy facilities in the vicinity.

- A 100 MW wood-fired power plant will require 10,000-14,000 tons of wood per KW capacity, or roughly 1,000,000-1,400,000 tons of wood annually
- A 50 million gallon/year ethanol plant is estimated to require 1 ton of wood per 43 gallons of ethanol, or roughly 1,200,000 tons of wood annually
- A 500,000 ton/year wood pellet plant will require roughly 1,000,000 tons of wood annually

Several of these large-scale wood bioenergy or biofuels plants are already operating or will be operating soon:

- In Soperton, Georgia, Range Fuels, Inc. is constructing a cellulosic ethanol plant designed to use southern pine. With a target start-up date in early 2009, the plant is being developed in phases, and will eventually produce up to 100 million gallons of ethanol annually. Projected capacity in the first phase is 20 million gallons/year.
- The title of “largest wood pellet plant in North America” has changed hands three times in the past year, with the current record holder being Green Circle Bioenergy’s wood pellet plant in Cottdale, Florida, with a capacity of 560,000 tons/year.
- Nacogdoches Power recently got approval to go ahead with construction of a new 100 MW wood-fired power plant in Austin, Texas. Georgia-based Oglethorpe Power followed recently with announcement of its plan to construct three new 100 MW wood-fired power plants in Appling, Echols and Warren counties.

Minnesota Power last year announced plans to construct a 50 MW wood-fired power plant in Minnesota, but has since shelved those plans. Minnesota Power, which provides power to the pulp and paper industry, iron mines, and 141,000 customers in northeastern Minnesota and northern Wisconsin, decided it would be best to encourage the existing pulp mills in the area to make investments to maximize the efficiency of their electrical co-generation, and then purchase the power from the pulp mills. This allows Minnesota Power to make progress toward its RPS requirements. It also avoids placing the power company in direct competition with some of its largest customers—the pulp mills—for essential feedstocks.

The construction of new large-scale wood bioenergy facilities is a concern to existing wood products industries in every region of the country, but especially in the South. Even with the optimistic USDA/DOE estimates of unutilized logging residues and overstocked forests, in most instances residues and thinnings will not be enough to supply the woody biomass requirements of these facilities. To the extent they must purchase pulpwood and logs, stand-alone wood-bioenergy facilities will compete directly with the existing wood products industry in the region for basic feedstocks. Where wood supplies are already tight, this will be at best a zero-sum game, with gains in one industry coming at the expense of the other. At worst, there is simply too much industrial capacity to be sustainably supported by the

local forest resource. Feedstock volumes are lower and prices higher than expected. Long-term financial viability of both industries is negatively affected, engendering uncertainty and economic instability in local communities. And there is a significant risk, at least for the near term, that the local forest resources will be overharvested, and important environmental values compromised.

In the South, the interpretation of the regional forest resource supply and demand situation by the wood bioenergy industry seems to have been particularly flawed. A simple reading of the Forest Inventory and Analysis (FIA) information provided by the USDA Forest Service and the state forestry agencies depicts a region with a large forest inventory and some of the fastest growth rates in the country. The region's forest land is predominantly in private ownership, and state environmental regulation is relatively light. But the South also has the greatest concentration of wood products manufacturers in the world, and the forest resource is among the most efficiently and completely utilized. Most regions of the US show forest growth rates well above the rate of removals; in the South, removals regularly exceed growth rates, particularly during upswings in the business cycle.

### **Implications for greenhouse gas emissions reduction**

Part of the rationale for increasing renewable energy production from biomass is to reduce emissions of carbon dioxide and other greenhouse gases by substituting for fossil fuels. Wood and other forms of biomass used for energy are widely referred to as “carbon neutral” because the carbon dioxide emitted can be sequestered by subsequent rotations of regenerated forest. Because fossil fuels are used in the harvesting and transportation of woody biomass it is not truly carbon-neutral, but greenhouse gas emissions can be significantly less than they would be with an equivalent amount of fossil fuel.

But this is not necessarily the case. Recent studies suggest that clearing existing forest in order to grow dedicated fuel crops, including short-rotation forest plantations, can create a “carbon debt” that will significantly increase greenhouse gas emissions in the short run (Searchinger et al. 2008). Working off this carbon debt to the point where there is a net reduction in greenhouse gas emissions can take decades.

On the other hand, improvements in the management of existing forests can have a payback that is almost immediate. Silvicultural thinning and hazardous fuel reduction can increase the growth rate in residual stands, and thus accelerate the rate of carbon sequestration. These improvements in forest management can also decrease the probability of future losses to insects, disease, or wildfire, thereby avoiding potentially significant greenhouse gas emissions. A single wildfire in southern Oregon in 2002 burned more than 200,000 hectares and is estimated to have released 3.5 -4.4 million metric tons of carbon into the atmosphere (Campbell et al. 2007).

Bioenergy and biofuels facilities that create local markets for residuals, wood waste, thinning materials, and woody biomass from hazardous fuels treatments can create new economic opportunities for improvements in forest management that can result in net reductions in greenhouse gas emissions. Larger-scale bioenergy and biofuels facilities, to the extent they necessitate the conversion of productive forests to dedicated biomass energy crops, may result in significant near-term increases in greenhouse gas emissions.

## **Toward a viable and sustainable wood bioenergy industry**

What steps can be taken to promote the development of a wood bioenergy industry that is economically, socially, and environmentally sustainable, and financially viable in its own right? How can we as a society maximize the production of carbon-neutral renewable energy from woody biomass while avoiding unintended and unacceptable negative economic and environmental consequences?

There are important lessons to be learned from the example of how the corn ethanol industry developed in the US. Extremely rapid development, facilitated by a powerful set of government incentives and subsidies, led to industry overcapacity, a doubling of corn prices over a very short period of time, and biofuels companies struggling financially to stay alive. Before it became evident that corn ethanol would not reduce net greenhouse gas emissions by nearly as much as projected, and that there were significant unintended environmental and economic consequences, the corn ethanol industry was already committed to a capacity that is probably unsustainable without a continued high level of subsidization and trade protection.

There may be places in the country in which the introduction of large-scale wood bioenergy facilities is practical and viable. In others, a more sustainable approach may be the establishment of a greater number of wood bioenergy facilities of small- or medium-scale, more widely distributed across the region. Many of these could be developed in conjunction with existing facilities, in a relatively short time, with capital investments that are modest in comparison with the cost of building an entirely new facility. Many existing coal-fired power plants could co-fire with up to 10 percent woody biomass with only minor modifications. Highly efficient cogeneration (CHP) facilities could be expanded or added at existing wood products manufacturing plants, taking advantage of their existing transportation infrastructure, wood handling capabilities, and established relationships with both wood suppliers and the local community. In both these instances, there is the added advantage that existing coal-fired power plants and wood products plants are already widely distributed, and the wood needs to support the additional wood bioenergy production could be more easily—and more sustainably—accommodated.

Government-funded incentives, subsidies, tax credits and trade tariffs create a policy framework that will encourage individual decision makers to make choices that will advance certain public policy goals and objectives. The existing policy framework for wood bioenergy is intended to build up the domestic biofuels industry to reduced GHG emissions to mitigate future climate change, and to increase US energy independence through greater reliance on domestic renewable energy. Freely operating economic markets will “right size” the wood bioenergy industry in the long run. In the short run, however, the existing policy framework for renewable energy may cause market distortions that undermine or suppress other components of the forest products and wood bioenergy sector. This could result in economic disruptions that will continue to ripple long after the subsidy programs have ended.

Rather than repeat the mistakes of corn ethanol development, let us now take the time to envision a future in which wood bioenergy plays a significant if not major role in renewable energy production in the United States, but one that we can be sure is sustainable. Through technological change, increased efficiencies, and improvements in the various processes for converting wood to energy, this role could well increase over time—and still be sustainable at this higher level.

The existing framework of federal and state policies—including the current production goals for bioenergy and biofuels—is a major driver determining the pathway of wood bioenergy development on which we find ourselves today. It is becoming increasingly clear that by following the present trajectory we will miss the mark. The path we are presently on may not be taking us toward that longer-term vision of a sustainable wood bioenergy industry that is fully integrated with forest resource capabilities and the economies of forest-based communities. If this is so, then what further adjustments are needed in the federal and state policy framework? How does the structure of incentives need to be modified so that it nudges development closer to the pathway leading to long-term sustainability?

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