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# Impacts of the Biomass Producer or Collector Tax Credit on Oregon's wood fuels market and economy

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# Executive summary

Oregon's Biomass Producer or Collector (BPC) Tax Credit encourages the production, collection, and transportation of biomass for biofuel production. It helps offset the transportation costs for biomass producers and collectors for a variety of bioenergy feed stocks by paying a set rate per unit of material delivered to a qualified bioenergy facility. This report is intended to help evaluate the effects of the tax credit on the Oregon's wood fuel market and Oregon's economy more broadly. Approximately 85 percent of the BPC tax credit is awarded to collectors of forest biomass from logging slash or stewardship projects, offering $10 per green ton of forest biomass delivered to bioenergy facilities. Forest biomass certified by the BPC Tax Credit Program in 2010 traveled an average of more than 100 miles from forest to bioenergy facility. Our analysis of the BPC tax credit indicates the program has had the following effects:

- Helped prices in the wood fuels market remain competitive
- Supported between thirty-two and seventy-three Oregon jobs in 2010
- Created more economic activity than the program costs in foregone tax revenue

## Approach

We developed statistical models for the predicted price of wood fuels and the volume of forest biomass and compared them to actual volume and prices. We then developed economic impact models of forest biomass production based on a financial survey of biomass producers who applied for the credit and on biomass production cost data from the Oregon Department of Forestry.

## BPC Tax Credit Program effects on the wood fuel market

The start of the BPC Tax Credit Program in 2007 coincided with a severe recession and crash in the housing and forest products markets. This reduced the availability of mill residuals for feedstocks, and increased demand for forest biomass instead. Our research suggests that the BPC tax credit likely affected the wood fuels market by preventing higher feedstock prices and lower market volumes than would have otherwise occurred. Forest biomass volume increased between 100,000 and 190,000 bone dry tons (BDT) more than the forecast models predicted, and prices were about $7 per BDT less than predicted after the BPC tax credit became available. The Biomass Crop Assistance Program and American Recovery and Reinvestment Act funding are other likely contributors to these trends in the wood fuels market. The BPC tax credit and these other government interventions appear to have provided incentives for bioenergy production from forest biomass by improving the margin on forest biomass collection.

## Economic impacts of the BPC Tax Credit Program on Oregon's economy

At a time of high unemployment, government budget deficits, and market weakness, the BPC tax credit likely acted as an economic lever that provides incentives for more economic activity than it costs. Our research indicates that collection and delivery of biomass under the BPC Tax Credit Program created an average of about five jobs, nearly $250,000 in wages and benefits, and more than $850,000 in total economic activity per 10,000 BDT of forest biomass. Based on the Oregon Department of Energy's accounting of certified tax credits for 2010, and our economic impact and wood fuels market models, we estimate that the forest biomass portion of the tax credit program likely supported between thirty-two and seventy-three jobs in Oregon in 2010, or approximately 11 percent to 24 percent of the total forest biomass portion of the wood fuels market. The results also indicate that the BPC Tax Credit Program likely generated at least as much value for Oregon's economy as the program cost in foregone tax revenues, and may have produced up to 2.4 times more value for Oregon's economy than it cost.

# Introduction

In recent years, federal and state governments across the United States have sought to foster the development of renewable energy using a variety of policies. There are at least 370 state policies that specifically support biomass energy, using a wide variety of strategies including tax credits, grants and loans, and other incentives.[1] One such program is Oregon's BPC tax credit. The BPC tax credit encourages the production, collection, and transportation of biomass for energy production. The credit is issued to an agricultural producer or biomass collector for biomass used as biofuel or to produce biofuel. Wood to energy facilities such as institutional heat, pellet manufacturers, and others also may accept forest biomass eligible for the BPC tax credit. Relatively little is known about how government programs such as the BPC tax credit affect biomass utilization, making it difficult to know which policies are the most effective at fostering biomass energy development.

## Purpose of this project

The purpose of this report is to evaluate the economic effects of Oregon's BPC tax credit on Oregon's wood fuels market and economy. Specifically, we focus on the forest biomass component of the program and describe the characteristics such as the volume, source, and delivery locations of forest biomass certified by the program in 2010. We analyzed the effects of the program on the wood fuels market and Oregon's economy more broadly and offer a theory of the effect of the tax credit on the wood fuels market and the impacts of that effect on Oregon's economy. Although we have presented one interpretation of the data, we are open to other theories that may explain the tax credit's impacts. We hope this report helps to foster policy dialogue and further understanding of the wood fuels market and the BPC tax credit.

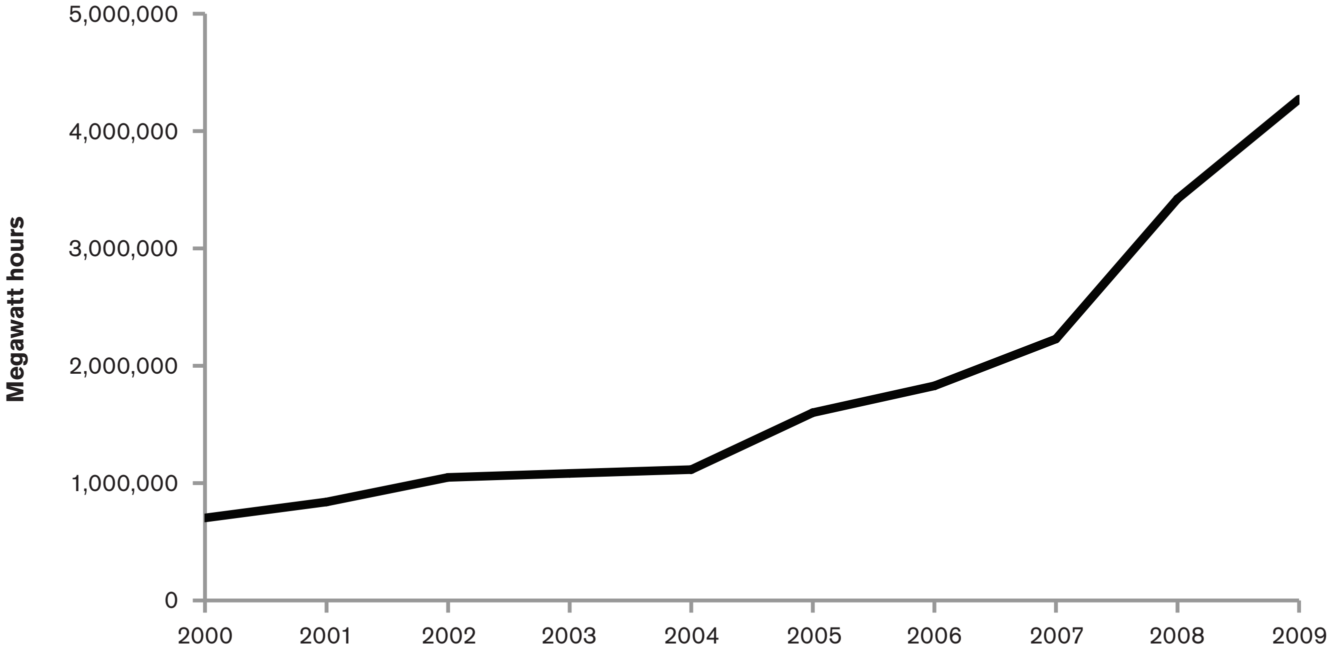
# The wood fuels market

Renewable energy production (e.g., solar, wind, biomass, geothermal) is a means for the United States to bolster its energy independence and reduce dependence on fossil fuel energy sources. Growth has occurred in the nation's renewable energy sector, and Oregon is no exception (see Figure 1 on page 5). Renewable energy generation (e.g., solar, wind, biomass, geothermal) has grown sixfold in Oregon since 2000, constituting 7.5 percent of the state's total electricity production in 2009.[2]

Wood fuels are a significant component of Oregon's renewable energy sector. As of 2008, electricity generation from wood fuels comprised about 21 percent of the total renewable energy portfolio in Oregon (excluding hydroelectricity). Independent power producers and combined heat and power facilities produced the vast majority of this energy.[3] Electricity production from wood fuels grew by 75 percent, or 410,000 to 717,000 megawatt hours, between 2004 and 2008.[4] Three Oregon Department of Energy (ODOE) surveys of bioenergy wood fuel over the last decade use suggest that wood fuel demand also appears to have increased from 2000 to 2010, even as the number of facilities responding to the survey has declined (see Figure 2 on page 5).

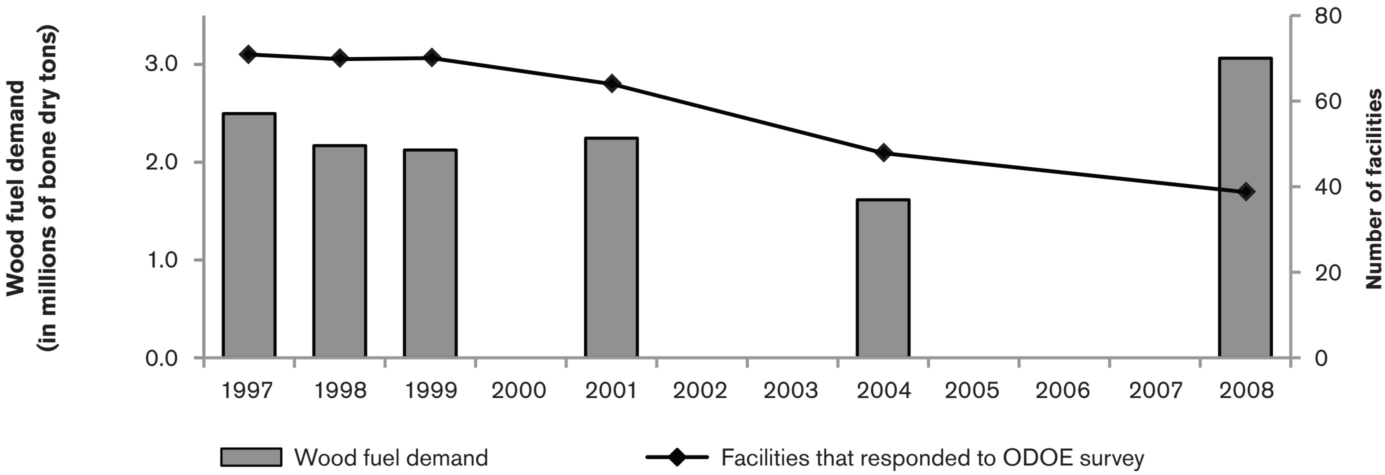
We defined wood fuels to include fuels used to fire wood boilers to generate steam or electricity, and excluded those higher quality pulp wood chips and other materials that typically become pulp and paper products or other composite products. Wood fuels are derived from three primary sources: mill residues, urban wood-waste, and forest biomass. Most mill residues do not feed the wood fuels market and instead feed strong competitive markets for pulp, paper, paneling, and other composite markets. Remaining mill residues, known as hog fuel, can be high-graded into landscaping products, but are typically the only mill residue used as feedstock for energy production. However, weaknesses in pulp, paneling, and landscaping markets may increase the amount of hog fuel dedicated to energy production. Urban wood-waste

**Figure 1 Growth in Oregon's renewable energy sector**




Note: includes solar, wind, biomass, biogas, and geothermal.
Source: U.S. Energy Information Administration.

**Figure 2 Total wood fuel use reported and number of facilities that responded to Oregon Department of Energy bioenergy surveys by survey year**




Note: gaps indicate years in which ODOE did not conduct the bioenergy survey.
Source: Oregon Department of Energy.

includes woody materials typically collected at a landfill or other central location from construction contractors, pallet recycling, landscaping debris, and other wood fiber from urban or industrial processes. Urban wood waste constitutes between 10 and 20 percent of the wood fuel supply in Oregon.[5]

Forest biomass is the final segment of the wood fuels market, and the main subject of this report. Forest biomass in Oregon comes from two main sources: forest logging slash and small diameter materials generated from thinning and other forest health projects. Biomass collectors process this material in the woods by grinding it into hog fuel or chipping it. The hog fuel and chip material are then transported to a bioenergy facility (often located at a lumber or paper mill), where it is combusted in an industrial boiler to produce heat and electric energy. The energy typically provides process steam and powers kilns to dry lumber products as well as electricity for the grid. Although forest biomass is abundant, the high costs of field collection, processing, and transportation relative to hog fuel and urban wood wastes have traditionally made it a less economically competitive feedstock in the wood fuels market. Forest biomass has grown as a segment of the wood fuels market over the past decade, constituting between 3 percent and 34 percent of the wood fuels market between 2000 and 2010.[6]

The wood fuels market is a dynamic intersection of forest products and energy markets, both of which have experienced dramatic fluctuation over the past decade. The economic collapse of the national housing market in 2007–8 decreased demand for softwood lumber, which caused declines in the availability of relatively cheap hog fuel from mills. Historically sawmills consumed hog fuels to meet their electric and heat demands, or sold them to pulp and paper mills. However, recent increases in demands for renewable energy may change the balance between the supply of mill residues and demands for wood fuels. Coupled with growth in demand for wood-based energy production, the decline in less expensive mill residues and competition with other markets has caused wood fuel consumers to seek other fuel sources, such as forest biomass.

In addition to the links to other wood products markets, wood fuels sit on the margins of broader energy markets and can also affect the wood fuels market. Prices for electricity, petroleum, natural gas, and other energy sources may all influence the demand for wood fuels for energy production in Oregon. Higher prices in these other energy markets may also make wood fuels a more attractive energy source. However, higher energy prices may negatively impact the costs of forest biomass due to the transportation costs of hauling wood fuels from forest to market.

# Oregon's BPC Tax Credit Program

Oregon's BPC tax credit is issued to agricultural producers or biomass collectors for eligible biomass delivered to a biofuel producer for use as biofuel or to produce biofuel. Eligible biomass types include forest biomass, manure, oil seed crops, used cooking oil or waste grease, agricultural crops and residues, and others. The credit value is calculated by multiplying the delivered weight of the biomass by the appropriate tax credit rate. Beginning in 2010, to receive the credit, an application must be filed with the Oregon Department of Energy (ODOE) for certification. The certification process reviews the application to ensure that the biomass is eligible, verifies the production or collection location, reviews the weight of the biomass, and confirms the biomass was used as biofuel or to produce biofuel in Oregon. Biomass materials delivered to stand alone electricity generating facilities did not qualify for the tax credit because the ODOE sets efficiency criteria for bioenergy production that these facilities typically do not meet. Once a tax credit has been certified, the producer or collector can transfer the tax credit in exchange for a payment. In 2010, the maximum value that the tax credits could be transferred for is 90 percent of the total value.

Other biomass sources are commonly utilized in the BPC Tax Credit Program as well. Manure, which is commonly managed through land application or storage lagoons, is increasingly used in anaerobic digestion on dairy farms. Anaerobic digesters capture methane that is produced from decomposition and may produce beneficial byproducts such as animal bedding and liquid fertilizer. Oilseed crops such as canola, camelina, soybeans, safflower, and sunflower produce high-quality oil that can be converted to biofuels. Seventy to 75 percent of the weight of oil seed crops is converted to meal, which is marketed as a high-value animal feed. More than 3.5 million pounds of oilseed crop was certified by the 2010 BPC Tax Credit Program and was delivered to one Oregon biofuel producer. Used vegetable oil and waste grease, commonly known as FOG (fat, oil, and grease), is used to manufacture tallow, animal feed supplements, and biofuel. FOG is collected by pump trucks from restaurants or at municipal water treatment plants and is converted to biofuel through anaerobic digestion or through a separation process. More than half a million gallons of FOG was certified by the 2010 BPC Tax Credit Program. Agricultural crops and residues span a variety of materials, from energy crops such as perennial grasses and woody plants to crop residues and food processing operations wastes. Anaerobic digestion is currently the only bioenergy production process in Oregon that utilizes agricultural crops and residues. Other feedstocks such as wastewater biosolids, grain crops, and virgin oil or alcohol were minimally utilized or unutilized in the BPC Tax Credit Program.

## BPC legislative history and authority

House Bill 2210 authorized the BPC Tax Credit Program in 2007. In addition to the tax credit, House Bill 2210 established Oregon's Renewable Fuel Standards, provided property tax exemptions for facilities producing ethanol and other biofuels, and created an income tax credit for consumer use of biofuel fuel blends or solid biofuel. Oregon Revised Statutes Chapter 315.141 describes and authorizes the tax credit, and applicable tax credit rates are found in Oregon Revised Statutes Chapter 469.790. No explicit intent, purpose, goals, or targets for the program are included in the statutes, and there is no cap on the amount of tax credits that can be issued or earned.

In 2009, the Oregon Legislature amended the program with House Bill 2078 and established a certification program to be developed and administered by ODOE. House Bill 2078 also authorized ODOE to set a minimum discount value for BPC tax credits that are transferred to other taxable entities. The legislature charged ODOE with evaluating the BPC Tax Credit Program. Prior to 2010, certification of BPC tax credits was not required, and information on the program for tax years 2007, 2008, and 2009 are not easily accessible by ODOE or the Oregon Department of Revenue, which oversaw the program prior to 2010.

The 2011 legislature further amended the program through House Bill 3672. The legislature extended the BPC tax credit through tax years beginning before 2018 and adjusted the way certain tax credits are calculated. Tax credits for forest and agricultural biomass will be calculated on a dry weight basis beginning in 2012. Prior to 2012 these tax credits are calculated on a green or wet ton basis. Yard debris and municipally generated food waste will no longer be eligible for tax credits beginning in 2012.

## Use of BPC tax credit for biomass in 2010

Tax year 2010 is the first year ODOE administered the BPC Tax Credit Program, and certified information is only available for tax year 2010. As of March 2011, approximately $6,600,000 in tax credits had been requested by fifty-two taxpayers for tax year 2010 (see Table 1 below). Of this total amount, about $5,500,000 (83 percent) was for forest biomass. Relatively few tax credits have been issued for the production of liquid biofuels.

Based on a review of the 2010 BPC tax credit applications, we estimated the distance traveled from origin to destination and delivered price per bone dry ton (BDT).[7] Approximate forest biomass transportation distances were calculated for nearly 260,000 certified green tons. Haul distances varied widely, ranging from less than fifty miles to more than 200 miles, with an average of 103 miles and half of the material transported more than ninety-five miles (see Figure 3 on page 9). Only applications for about 95,000 BDT of certified material included usable price data. This information indicated that during 2010 the price paid by facilities for woody biomass ranged from $10 to $45 per BDT, and averaged approximately $30 per BDT. The highest prices we observed were typically offered by facilities in Washington state and northern Oregon.

The price of and travel distances for forest biomass are determined by a variety of factors including material quality, demand and competition, negotiated agreements, and others. The data contained in the tax credit applications provides useful insight

**Table 1 Biomass Producer or Collector Tax Credit rates and 2010 utilization**

**A. 2010 BPC tax credit application characteristics**

| | |
|---|---|
| Total number of applications | 96 |
| Number of individual taxpayers | 52 |
| Number of taxpayers applying for forest biomass | 35 |
| Average amount requested by taxpayer | $126,931 |
| Number of biofuel producers | 31 |
| Oregon | 24 |
| Washington | 6 |
| California | 1 |

**B. 2010 tax credit rates and utilization**

| Type of biomass | Tax credit rate | Units | Volume | Tax credit amount |
|---|---|---|---|---|
| Forest biomass | $10.00 | green ton | 557,770 | $5,507,700 |
| Manure | 5.00 | wet ton | 92,048 | 460,240 |
| Oil seed crops | 0.05 | pound | 3,592,827 | 179,641 |
| Used cooking oil or waste grease | 0.10 | gallon | 1,614,462 | 161,446 |
| Yard debris | 5.00 | wet ton | 29,888 | 149,441 |
| Agricultural residues | 10.00 | green ton | 12,606 | 126,057 |
| Wastewater biosolids | 10.00 | wet ton | 1,590 | 15,897 |
| Grain crops | 0.90 | bushel | 0 | 0 |
| Virgin oil or alcohol | 0.10 | gallon | 0 | 0 |

into the program. However, to understand the effect of the program on the wood fuels market or on Oregon's economy, an approach that analyzes the broader market factors and the cost structure of biomass production is needed.

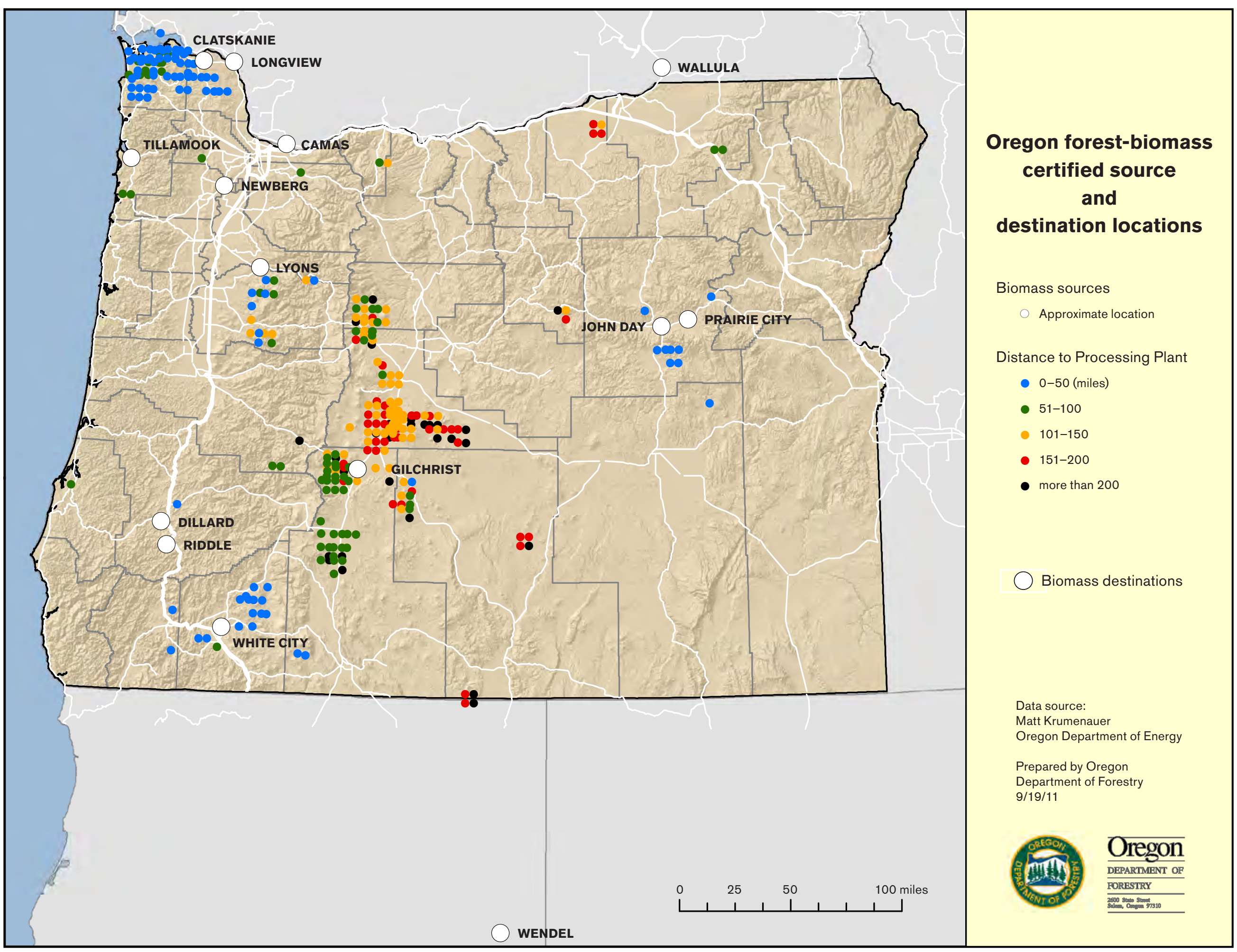
# Approach

We asked three questions aimed at illuminating the effect of the BPC tax credit on the wood fuels market and Oregon's economy:

- Has the tax credit influenced the volume of forest biomass collected and the prices paid for woody fuels?
- How many jobs are created and how much economic activity is generated in Oregon from forest biomass collection activities and delivery to energy facilities?
- What has been the impact of the BPC tax credit on Oregon's economy?

To address these questions, we took three steps (see Figure 4 on page 10). First, we developed regression models to predict wood fuel prices and the volume of forest biomass that enters the wood fuel market based on market conditions (see Appendix 1 for technical details of the forecast modeling). Specifically, we created statistical models based on the

**Figure 3 Forest-biomass certified source and destination locations**



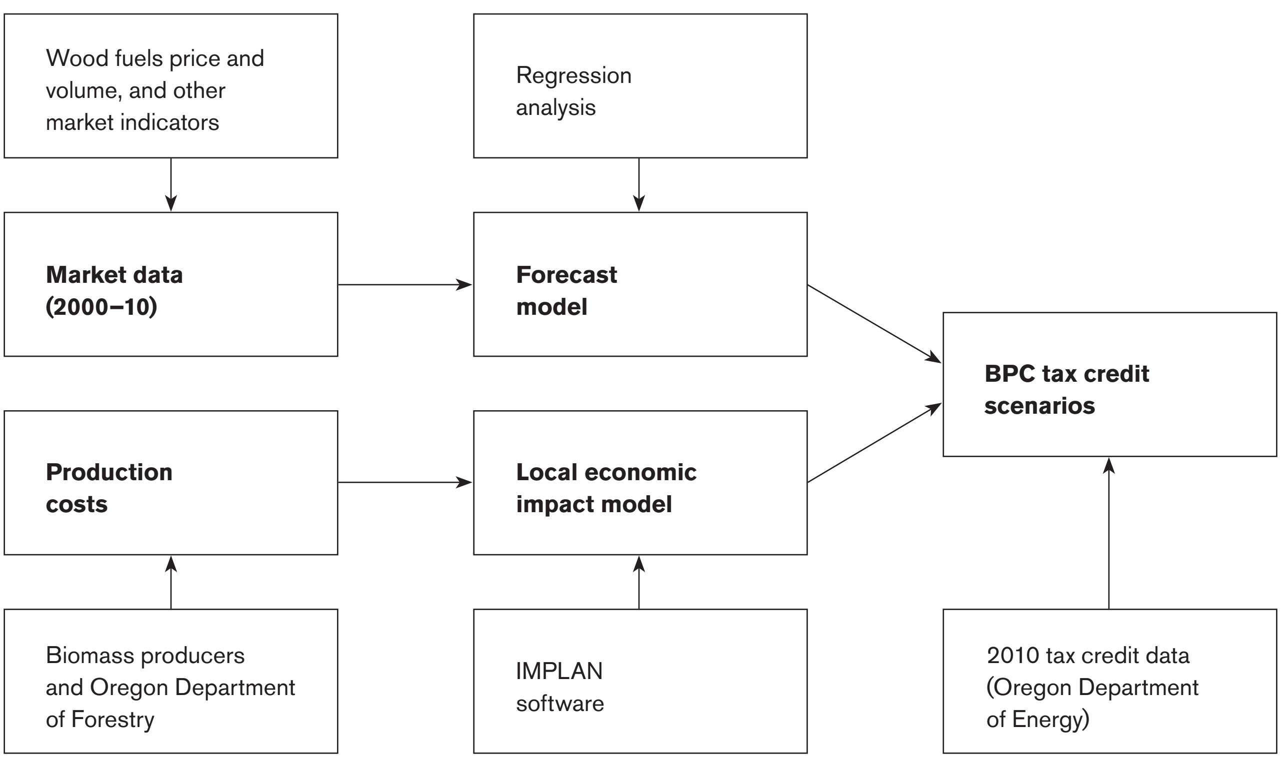
pretax credit period (2000–6) and then forecasted 2007–10 wood fuel prices and forest biomass volumes. The forecast values indicated the expected market price and volume when the prediction was based only on market dynamics and not government interventions. We then compared the forecasted values to the actual prices and volumes observed from the market to evaluate the likelihood that the tax credit had an effect on the market.

In developing these models, we had two working assumptions. First, we assumed that if the actual observed volumes were different (higher) than the forecast volumes, the tax credit could be an explanation. Second, we assumed that if the actual observed prices were different (lower) than the forecast prices, the tax credit could be an explanation. In both cases, we recognized that our working assumptions were not causal hypotheses, and that other explanations also contribute to the differences between observations and forecasts in the wood fuels market.

Our second step was to understand the economic impacts of biomass production on jobs and economic activity in Oregon. To do so, we developed an economic impact model using a profile of the expenditures associated with biomass production. This profile contained cost data collected from biomass producers who applied for the tax credit and from the Oregon Department of Forestry (ODF). We used the expenditure profile with IMPLAN 3.0 software to estimate the employment, economic, and tax impacts of the production of 10,000 BDT of forest biomass delivered to bioenergy facilities (see Appendix 2 for technical details on the economic impact modeling).

In our third step, we integrated the regression modeling with the impact modeling results to produce three possible scenarios of the impact of the BPC Tax Credit Program on Oregon's economy in 2010. We used ODOE's reported 2010 program cost and volume to ground the scenarios. Each scenario at-

**Figure 4 Research approach to evaluating the economic effects of the BPC tax credit**



tributed a percentage of the certified 2010 tax credit applications for forest biomass production to the tax credit. Each scenario is measured in BDT, and is described by the percent of the unexplained forest biomass volume from the forecast model that the scenario represents. Scenario results include estimates of the following:

- Number of jobs and amount of wages and benefits that the credit supported
- Total economic activity that the credit generated
- Tax credit's multiplier effect

The jobs, wages, and benefits include those direct, indirect, and induced jobs, wages, and benefits supported by the biomass production attributed to the tax credit. We measured total economic activity as the value of direct, indirect, and induced goods and services produced as a result of the tax credit. The tax credit multiplier measures the amount of economic activity that the tax credit generated relative to the net cost of the tax credit. Values greater than one indicate that the tax credit produced more economic activity than it cost.

# Results

## Trends in the wood fuels market

From 2000 to 2005, wood fuels prices averaged approximately $25 per bone dry ton (BDT). During this period, however, the total volume of wood fuels in the market steadily increased from around 1.5 million BDT to more than 2 million BDT as a result of growth in demand for bioenergy production (see Figure 5 on page 12). During this period, mill residuals constituted nearly 90 percent or more of the total market volume in wood fuels. Beginning in 2006, the volume of mill residuals flowing into the wood fuels market began to fall. By 2009, that decline had cut in half the volume of the mill residual available to the wood fuels market. This decrease of available mill residuals corresponds to a steep increase in wood fuels prices from 2005 to 2007, topping out at more than $40 per BDT. While mill residuals available to the wood fuels market were declining, the volume of forest biomass flowing into the wood fuels market nearly tripled between 2005 and 2008, a twelvefold increase since 2000.

The increase in volume of forest biomass in the wood fuels market corresponds to the timing of the BPC Tax Credit Program, which began in 2007. However, other factors could also explain this increase. The volume of forest biomass in the wood fuels market is highly correlated with (1) the volume of mill residuals in the wood fuels market, (2) total amount of wood fuels demand, and (3) wood fuels prices. Given these internal market conditions, we asked if the observed volume increase would have been lower without the BPC Tax Credit Program.

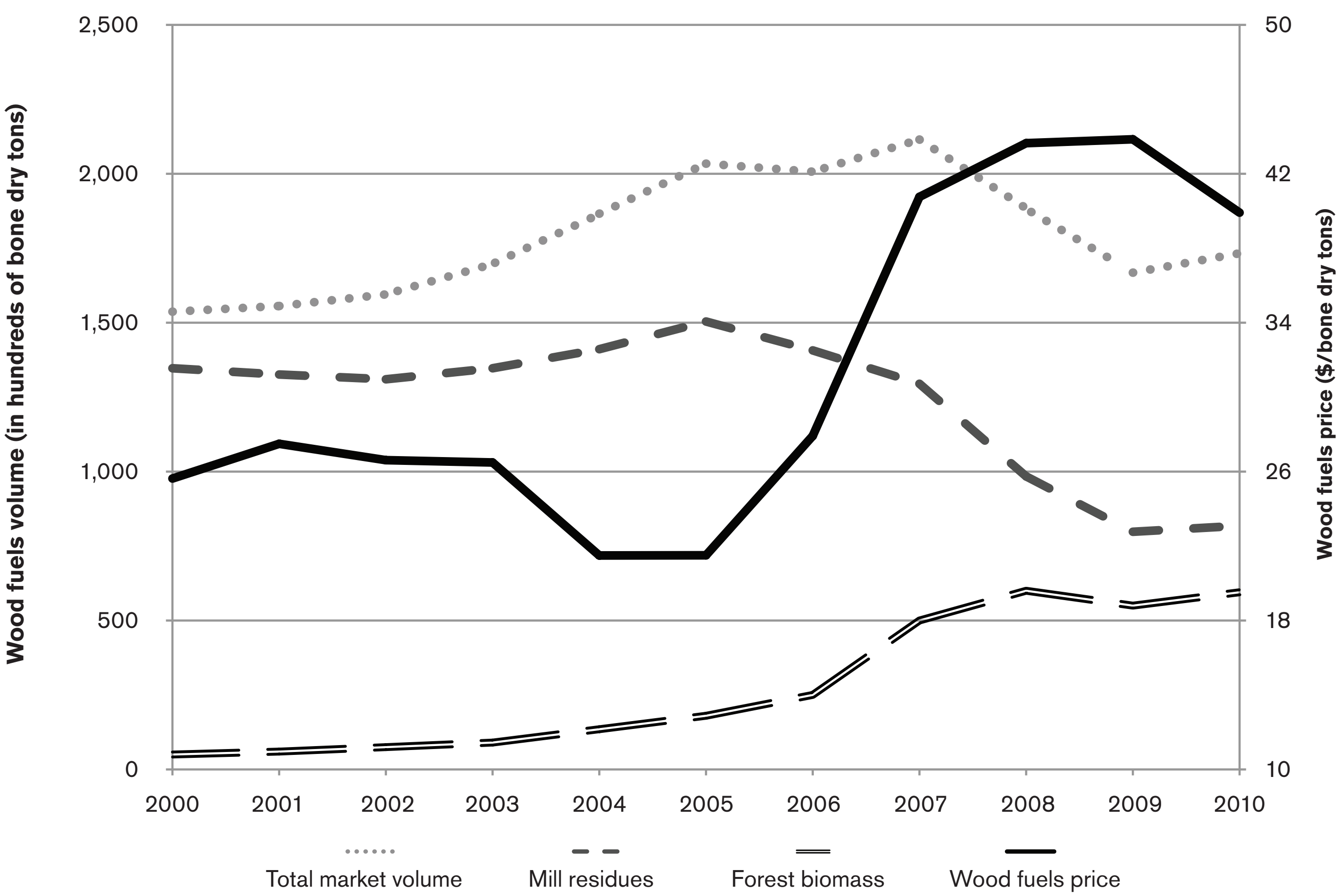
The increase in wood fuel prices also corresponds to the timing of the tax credit program. Counter to expectations of the impact of a tax credit, the market price rose at the same time the tax credit was implemented. A number of internal and external market factors can explain this price increase. First, the limited availability of mill residuals likely drove the market to more expensive alternative sources such as forest biomass. In addition, other forest products and energy markets play a role in prices. Wood fuel prices are negatively correlated with lumber market prices, suggesting that weak lumber markets reduce the volume of mill residuals available and increase wood fuels prices. Wood fuels prices are positively correlated with pulpwood prices, suggesting that higher pulpwood prices draw materials away from the wood fuels markets and increase prices. In the energy sectors, all indices we examined were positively correlated to wood fuels prices, suggesting that bioenergy production may be marginally more attractive to energy producers when measured against alternative fossil fuel sources. Given these and internal market dynamics, we asked if the observed price increase would have been higher without the BPC Tax Credit Program in place.

## Wood fuels market forecast models

We developed two regression models to help explain the variability in price and volume of forest biomass in the wood fuels market. Both regression models were estimated based on 2000–6 data only to build the model based on the market dynamics prior to the tax credit. We established a good fit for each model that explained 81 percent and 98 percent of the variability in wood fuel prices and forest biomass volume, respectively. Forecast volumes varied between –7,000 and 10,000 BDT of the observed forest biomass volume over the seven-year-model development period, indicating that forecast volumes in this period never deviated more than 11 percent of the observed values at any period. Forecast quarterly prices varied between –$2.31 and $2.59 of the observed price per BDT over the twenty-eight quarters of the model development period. The forecasted prices in the model development period never deviated more than 11 percent from the actual price at any given period, and nearly 60 percent of the forecast prices are within 5 percent of the actual observed price.

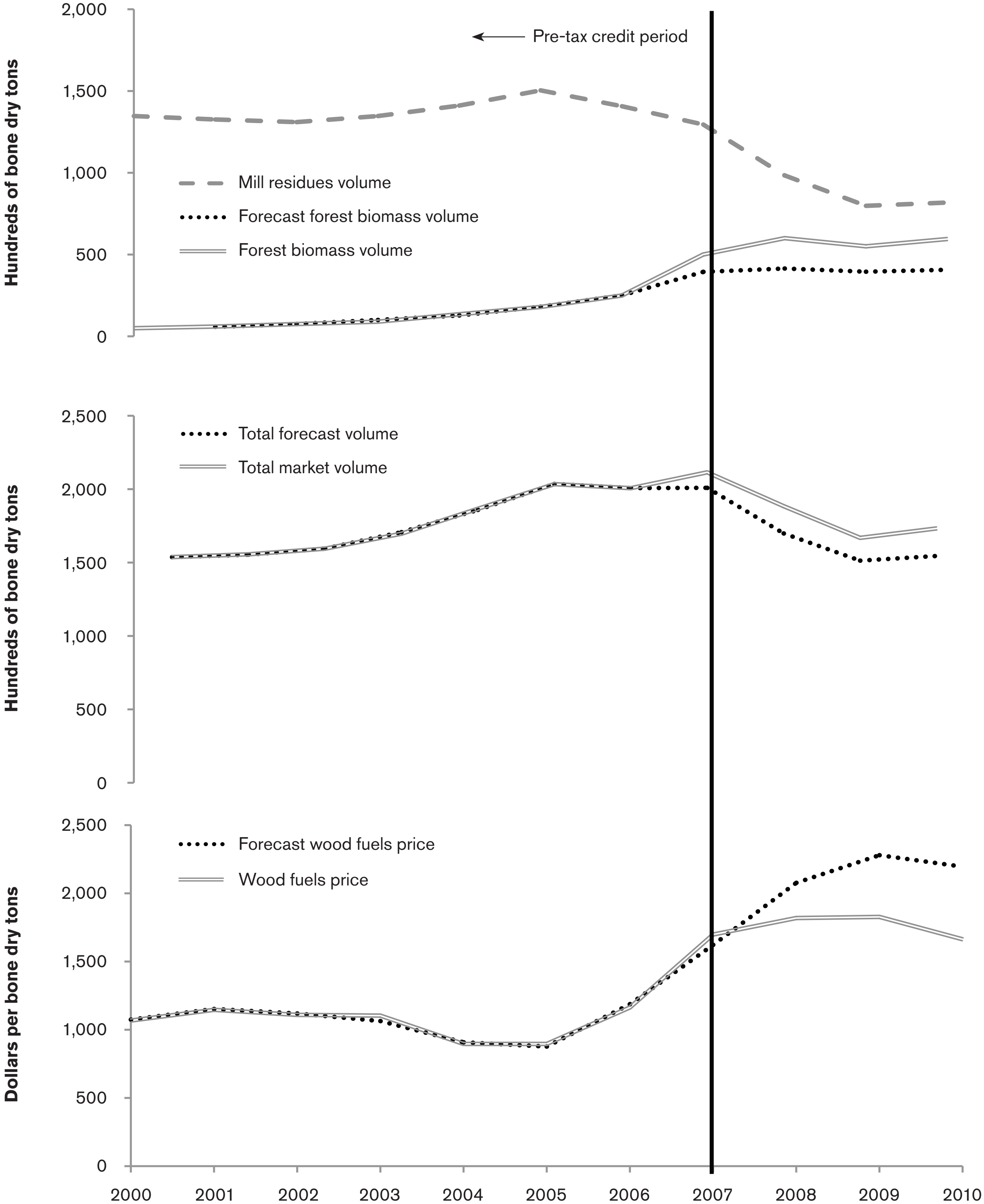
In the 2007–10 period, the forecast models deviate substantially from the actual observed prices and volumes; however, the trends match very closely to the observed trends (see Figure 6 on page 13). The quarterly wood fuel price model predicts prices $6.87 per BDT greater on average than the observed prices in the 2007–10 tax credit period, and as much as $17.47 per BDT greater than the observed price in the second quarter of 2010. The annual forest biomass volume model predicts volumes 159,000 BDT less on average that the observed volumes in the 2007–10 tax credit period, ranging from 105,000 BDT less volume forecasted in 2007 to 188,000 BDT less volume forecasted in 2010 (see Figure 7 on page 14).

**Figure 5 Oregon wood fuels by source**




Note: urban wood waste not shown.

**Figure 6 Wood fuel market annual observed and forecast volume and price trends**



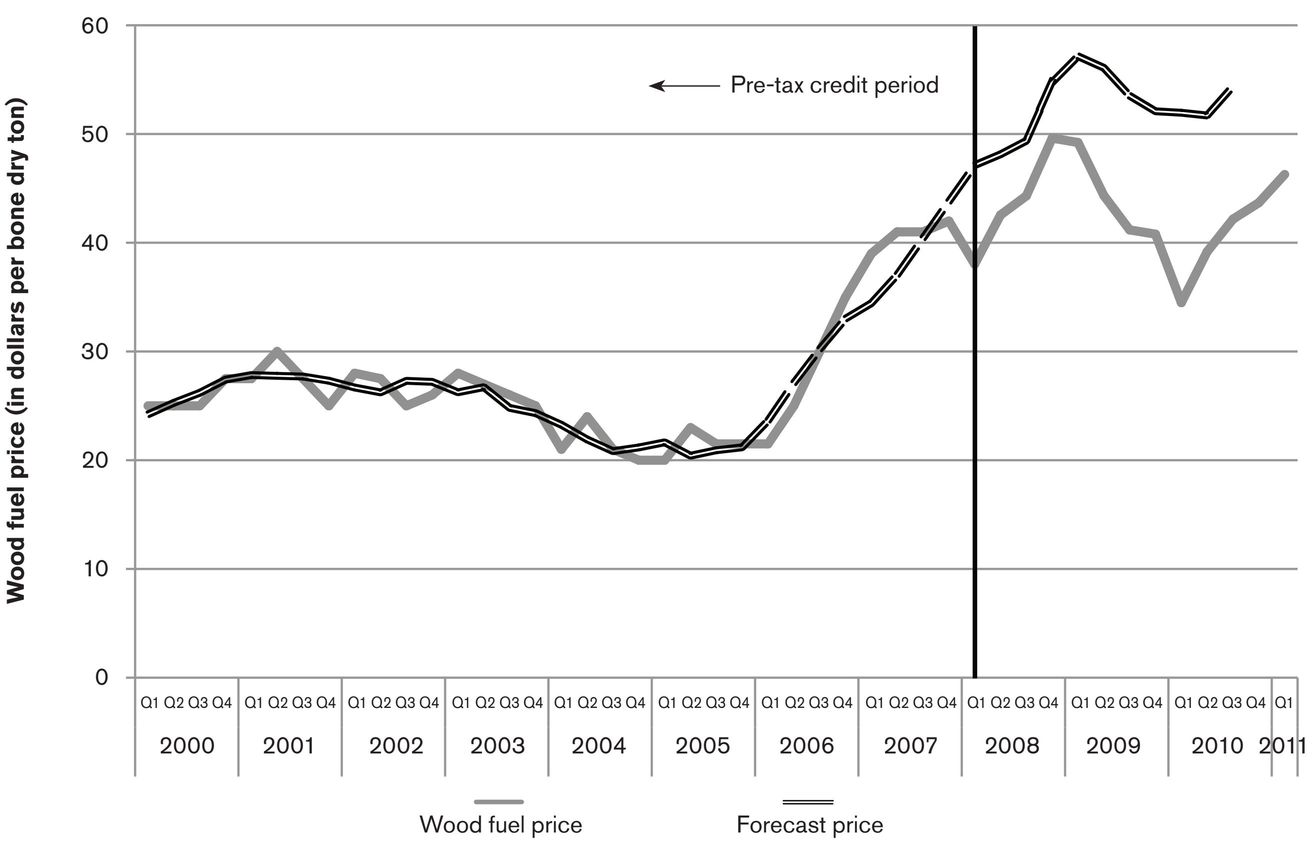
The forecast values suggest that, given market dynamics alone, prices would have been about 20 percent higher and the volume of forest biomass would have been approximately 20 percent to 30 percent lower than what was actually recorded in the price and volume data series. Both findings suggest that the tax credit may have affected the wood fuels market by keeping prices from rising further than they otherwise did and elevating the volume of forest biomass above what would have otherwise occurred.

## Economic impacts of biomass production

A number of biomass producers and the Oregon Department of Forestry supplied expenditure data for recent jobs that qualified for the tax credit (see Table 2 on page 15). We used the expenditure profile data to create a basic production function for forest biomass collection activities. Most of these data reflected jobs that included slash collection, grinding, and material hauling conducted from private industrial forestland. We assume a market value of $301,100 per 10,000 BDT based on the ODOE-certified average 2010 tax credit application price of $30.11 per BDT. Also, given the $10 per green ton value of the tax credit, and assuming an average moisture content of 44 percent (based on ODOE-certified 2010 tax credit applications), we estimate that 10,000 BDT of forest biomass is eligible for $178,571 in tax credits.

The economic impact models estimate that the collection and delivery of 10,000 BDT of forest biomass to energy facilities supports approximate 5.1 jobs in Oregon, $241,000 in wages and benefits, and $868,000 in direct, indirect, and induced economic activity at a net tax expenditure cost of approxi-

**Figure 7 Quarterly observed and forecast wood fuel prices**



mately $143,000 (see Table 3 below). On a regional scale, the impacts of forest biomass production activities are greatest in northwestern Oregon and smallest in eastern Oregon. Forest biomass production activities in southern and central Oregon generate similar impacts. Regional differences reflect underlying structural differences in Oregon's regional economy, where economic activity leaks more quickly out of some regions than others. Northwestern Oregon's economy is relatively more self-sufficient than eastern Oregon's economy, which is more dependent on businesses and resources from outside of the region. Finally, the economic impact models indicate that for the tax credit program to generate more economic activity than it costs, only about 20 percent of the volume of biomass that qualifies for the tax credit would have to be directly attributed to the tax credit. Even if the other 80 percent would have occurred without the program, the program would still generate one dollar of economic activity in Oregon's economy for every dollar of tax expenditure.

### Table 2 Forest biomass collection and transportation costs per bone dry ton

| Production costs | Average total costs | Maximum total cost | Minimum total cost |
|---|---|---|---|
| **Logging** | **$37.62** | **$66.74** | **$25.72** |
| Slash collection | 16.58 | 41.86 | 2.72 |
| Grinding | 21.04 | 34.49 | 14.17 |
| **Transportation** | **15.74** | **31.43** | **6.45** |
| Truck and haul | 14.52 | 25.79 | 6.45 |
| Mobilization | 1.22 | 6.71 | 0 |
| **Overhead** | **2.80** | **5.33** | **0** |
| Administration and fees | 2.80 | 5.33 | 0 |
| **Total** | **$56.15** | **$90.43** | **$41.46** |

Note: Reported production costs are based on reports from twenty-eight individual jobs that qualified for the tax credit as reported by tax credit applicants and the Oregon Department of Forestry.

### Table 3 Economic impacts from biomass collection and delivery in Oregon and by region

| | Impact per ten thousand bone dry tons | | | | | |
|---|---|---|---|---|---|---|
| **Region** | **Jobs** | **Wages** | **Economic activity** | **State and local taxes** | **Net tax expenditure** | **Economic leverage threshold[1]** |
| Oregon | 5.1 | $241,007 | $867,984 | $35,116 | $143,455 | 20% |
| NW Oregon | 5.3 | 243,661 | 876,396 | 37,092 | 141,479 | 19% |
| S Oregon | 4.4 | 190,754 | 710,143 | 28,114 | 149,095 | 24% |
| C Oregon | 4.7 | 197,732 | 731,335 | 27,199 | 150,056 | 24% |
| E Oregon | 4.2 | 170,591 | 629,802 | 23,271 | 154,172 | 27% |

Note: Regions follow Oregon Department of Forestry district boundaries, with eastern Oregon split into two regions. Economic value of the biomass input is based on the assumption that (1) the average moisture content of delivered biomass is 44 percent, and (2) the average delivered price per bone dry ton is $30.94. Both assumptions were developed and based on analysis of 2010 tax credit application data.

[1] The economic leverage threshold measures the percent of the biomass activity that must be attributed to the tax credit to ensure that the economic benefit to Oregon is greater than the net cost of the tax credit.

## The impact of the BPC tax credit on Oregon's economy

We used a mix of empirical data and assumptions to develop scenarios to explain the economic impacts of the BPC Tax Credit Program (see Table 4 below).

As of June 2011, ODOE had certified a total of about $6,600,000 of tax credits in the 2010 tax year.[8] Of this amount, 83 percent ($5,500,000) was certified for forest biomass, a volume equivalent to about 308,000 BDT given the reported average 44 percent moisture content. The margin of biomass directly attributable to the tax credit program is unknown. However, our analysis indicates that the basic dynamics of the wood fuels market cannot explain 188,000 BDT of forest biomass that entered the market in 2010. To analyze the potential impacts of the BPC Tax Credit Program, we developed three scenarios. Our first scenario assumed that 141,000 BDT, or 75 percent of the unexplained volume, is the result of the tax credit. As there may be other explanations for the difference between observed and forecasted volumes, this is the least conservative scenario. Our second scenario assumed that 95,000 BDT, or 50 percent of the unexplained volume, is the result of the tax credit. Our third and most conservative scenario assumed that 61,000 BDT is the result of the tax credit, or 32 percent of the unexplained volume in 2010. Scenarios one, two, and three equate to 49 percent, 35 percent, and 20 percent, respectively of the total amount of certified tax credits in 2010.

For the above scenarios, we found that the woody biomass portion of the tax credit likely supported between thirty-two jobs (scenario three) and seventy-three jobs (scenario one) in 2010. Scenario one generates about $3.4 million in wages and benefits, and more than $12 million in total economic activity. Scenarios two and three generate fewer jobs, wages, and benefits, and less economic activity than scenario one. For comparison, applying our economic impact models to the wood fuels market data, we find the wood fuels market in 2010 likely supported about 300 jobs, more than $14 million in

### Table 4 BPC Tax Credit Program 2010 characteristics and economic impact scenarios for Oregon's economy

**A. Actual 2010 BPC forest biomass program characteristics**

| | |
|---|---|
| BPC tax expenditures on forest biomass ($) | $5,507,700 |
| Percent of total BPC Tax Credit Program | 85% |
| BPC forest biomass volume (BDT) | 308,431 |

**B. Scenario-based economic impacts of the forest biomass component of the BPC tax credit**

| | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| Forest-based biomass generated by the tax credit (BDT) | 141,000 | 95,000 | 61,000 |
| Percent of forest biomass unexplained by the market | 75% | 50% | 32% |
| Percent of total 2010 certified tax credits | 46% | 31% | 20% |
| Jobs supported by the tax credit | 73.2 | 49.3 | 31.7 |
| Wages and benefits (in thousands) | $3,398 | $2,290 | $1,470 |
| Total economic activity attributed to the credit (in thousands) | $12,239 | $8,246 | $5,295 |
| Net tax expenditures (in thousands) | $5,012 | $5,174 | $5,294 |
| Tax credit multiplier | 2.4 | 1.6 | 1.0 |

Note: Actual program characteristics and scenario assumptions are based on ODOE program certification data. We used a standard market value of $30.11 per BDT and moisture content of 44 percent for each scenario.

wages and benefits, and more than $50 million in economic activity in Oregon. All three scenarios generate at least as much economic activity as the program costs. The tax credit multiplier for each scenario is 2.4, 1.6, and 1.0, indicating that under scenario three the program generated one dollar of economic activity in Oregon for each dollar the program cost taxpayers in lost tax revenue. In contrast, scenario one resulted in 2.4 dollars of economic activity in Oregon for each dollar the program cost.

# Discussion: market and policy implications from the BPC tax credit

Our analysis does not provide evidence of a causal link between the tax credit and the conditions in the wood fuels market. Instead, we have sought to construct an explanation for the differences between the observed and forecasted market conditions that is grounded in empirical data. We find the BPC tax credit to be a compelling part of the explanation; and, as such, our analysis forms a plausible theory to explain the effect of the BPC tax credit on the wood fuels market.

We analyzed three scenarios to evaluate the possible impacts of the BPC tax credit. The scenarios assume that a range between 35 percent and 75 percent of the unexplained 2010 forest biomass volume is attributable to the BPC tax credit. The first scenario implies that roughly half of the volume represented by the 2010 certified tax credits would have entered the market without the BPC Tax Credit Program. This may be a liberal assumption, as other factors could explain the differences between the observed and forecast volumes; however, the forecasts do account for growth in the market as new facilities added to the demand for wood fuels, competition from other markets, and decline in supply from conventional sources. On the other hand, the third scenario assumes that only a third of the unexplained volume in the forecast model is attributed to the tax credit, which leaves more than 130,000 BDT still unexplained by the model and suggests that 80 percent of the volume represented by the 2010 certified tax credits would have entered the market without the BPC Tax Credit Program. Nonetheless, all three scenarios indicate that the program is an economic lever, stimulating at least as much economic activity as it costs (potentially leveraging 2.4 times the cost of the program in economic activity in Oregon), and that the program supports a nontrivial number of jobs.

There may be several other explanations for those outcomes. The Biomass Crop Assistance Program (BCAP), which the U.S. Department of Agriculture (USDA) Farm Service Agency administers,[9] is another possible contributor to the difference between observed and forecast prices and volume in the wood fuels market. BCAP provides matching payments for the collection, harvest, storage, and transportation of biomass to qualified bioenergy facilities. In Oregon, BCAP payments were available in 2009 and the beginning of 2010, and may account for the downward price spike observed in actual 2010 quarterly prices that the forecast model did not predict. Critics of the BCAP program have suggested that the program effectively distorted the wood fuels market, causing stockpiling and the diversion of materials from higher-value markets. Although a price spike is evident in the 2010 wood fuels quarterly data, the annual volume of wood fuels produced in 2010 is only slightly greater than in 2009, a difference of less than 4 percent.

Federal land management agencies have also increased the volume of forest biomass made available to the wood fuels market. This may explain some of the difference between observed and forecasted volumes in the wood fuels market. The U.S. Department of the Interior's Bureau of Land Management (BLM) and the USDA Forest Service (USFS) offered increased volumes of forest biomass to the market using a combination of stewardship contracting and funding from the American Recovery and Reinvestment Act (ARRA), which allowed for the removal of biomass for restoration purposes whose value would not normally cover the costs of removal and transportation. The BLM and Forest Service both used stewardship contracts to offer biomass in which contractors bought material at minimal prices and received payments for restoration activities, sometimes including removal of the material. In federal fiscal year 2010, the BLM and USFS offered more than 150,000 green tons of material through this type of mechanism.[10] The volume of material added to the market through these types of mechanisms was greatest in federal fiscal year 2010, when ARRA funds peaked for federal land management agencies. With the end of ARRA funds, the volume of forest biomass that federal land management agencies offer will likely decrease and market dynamics will play an increased role in determining the volume that is actually delivered to bioenergy facilities.

The effect the BPC tax credit may have had on the wood fuels market is likely the result of timing. The BPC Tax Credit Program began in 2007 just as demand for bioenergy was increasing and the supply of sawmill residuals (historically the source of nearly 90 percent of wood fuels in Oregon) fell 50 percent due to the downturn in domestic lumber and housing markets. Although there was likely also a reduction in demand for wood energy from heating and cogeneration applications at sawmills, the limited availability of sawmill residuals to the market probably increased the amount of forest biomass in the broader wood fuels market. In addition, the availability of biomass from federal land management agencies at reduced prices as a result of ARRA also may have increased demand for forest biomass. The increased demand for forest biomass, higher prices for wood fuels, and the value of the BPC tax credit likely led some forestland owners and forestry contractors to consider utilizing slash and forestry byproducts for bioenergy.

As forest owners, forestry contracting businesses, and the bioenergy industry navigate the supply chain to ensure adequate fuel supply, decision-makers will undoubtedly ask what role the government should have in this market. Demand for renewable energy will continue to grow as the state of Oregon continues to support policy to increase its renewable energy portfolio. Currently, several biomass energy projects are planned in Lake, Klamath, and Crook counties, among others, and northwestern Oregon may double its capacity for biomass energy production in the near future. In the near term, it is unlikely that the supply restriction for mill residuals will abate, which will maintain the increased demand for forest-based and other feedstocks. The 2011 Oregon legislature reduced the value of the credit from $10 per green ton of delivered forest biomass material to $10 per BDT. This change decreases the value of the credit substantially. Given an average 44 percent moisture content as recorded in ODOE tax credit records, a truck with a twenty-five-ton payload will be eligible for a credit of about $140 rather than the $250 available under the green ton policy. The implication of this change is uncertain. If demand for bioenergy production continues to grow and the constrained supply of sawmill residuals continues, the increased costs of delivery may pass to bioenergy producers, resulting in higher prices for wood fuels. If the lumber market rebounds, or pace of growth in bioenergy production slackens, the impact could simply be less forest biomass available to the market.

Moving the wood fuels market closer to forest supply areas is another approach to influencing the relative competitiveness of forest biomass compared to other wood fuel sources. Incentives for rural thermal energy facilities could help to support local community and economic development, fire hazard reduction, and forest restoration, and reduce the amount of logging slash that is pile burned.[11] Adding incentives or redirecting limited incentive dollars toward institutional or district heating facilities based in rural forest communities would help to reduce transportation costs, increase the demand for forest-based wood fuels, and reduce reliance on imported energy sources.

# Limitations

This project does not provide a causal model of the tax credit program. Instead, we examined what actually happened in the wood fuels market, and proposed an explanation of those trends. A more comprehensive analysis would use price and volume data by wood fuel source, require a better understanding of the cost structure and opportunity costs for biomass production over time and under different treatment and market conditions, and add interviews with tax credit applicants and bioenergy facility managers. This analysis has several limitations.

First, the project assumes that the wood fuels market data is a good proxy for the market that the tax credit effects. The discrepancies between the volume of forest biomass that we could observe through the certified tax credit applications and the volume of forest biomass estimated in the wood fuels data series suggests that the two data sets represent overlapping but not completely consistent markets. For example, the tax credit certified the equivalent of about 308,000 BDT of forest biomass in 2010. However, the wood fuels market data indicates that 595,000 BDT were sourced from Oregon forests in 2010. There are three potential reasons for the discrepancy:

1. Some forest biomass is delivered to facilities that do not meet the efficiency criteria required for eligibility for the tax credit (e.g., standalone electricity-generation facilities, charcoal-producing facilities). Although Oregon has relatively few standalone electricity-generating facilities, some material sourced from southern and south central Oregon forests is transported to electrical facilities in northern California.
2. Some producers of biomass do not participate in the program because they are not aware of the program, they do not have the resources or time to apply for the tax credit, or because they do not wish to be involved in a government program.
3. Some producers of biomass are ineligible for the program because they are not a taxable entity.

Although it is unlikely that these three explanations completely cover the discrepancy in the volume that the tax credit certified and the volume in the wood fuels data series, the wood fuels data series is the best source of information currently available. We also note that other data sources, such as the facility fuel use that ODOE occasionally collects (see Figure 2 on page 5) indicates facilities in Oregon used 418,000 BDT of forest biomass in 2008. The ODOE facility fuel use data is collected from industry surveys. Fourteen respondents from previous years did not respond to the call for 2008 data, indicating that the ODOE may have underestimated 2008 forest biomass use in Oregon. Survey-based data will always be subject to nonresponse problems; however, we suggest that increasing the regularity of surveys (e.g., annually) and improving the consistency of data collected in those surveys (e.g., fuel-use data by source) would provide better information for policy, business, and community development decision-makers.

A second limitation of the project is that it relies on relatively few data points on the cost structure of biomass collection and delivery. A more robust sample from a wider variety of treatment types, locations, and periods would offer a better opportunity to quantify the impacts of the biomass production.

A third limitation of the project is that the economic impact models and our BPC tax credit impact scenarios rely on a static model. The economic impact modeling software we used, IMPLAN, is a linear model that assumes no supply constraints, no economies of scale, constant prices, and no shifts in production technology. In the growing market for bioenergy, each of these assumptions is problematic. Nonetheless, our research draws from the best available data about the wood fuels market and biomass production, and the results of our analysis suggest plausible propositions about the Biomass Producers or Collectors Tax Credit.

# Conclusion

State and federal governments have been actively fostering the bioenergy sector through programs like the Oregon Biomass Producer or Collector Tax Credit. However, the effects of these programs on biomass utilization and markets for biomass materials are not very well understood. This project aimed to fill that gap by describing the BPC Tax Credit Program, how producers and collectors have used it, and its impacts on the wood fuels market and Oregon's economy more broadly.

Persistent weakness in the housing and forest products markets coinciding with the worst economic recession in decades caused the decline in volume of mill residuals entering the wood fuels market in 2007 when the BPC Tax Credit Program began. Any effect the BPC tax credit may have had on the wood fuels market was likely because it improved the margin on forest biomass production and offered a competitive advantage at a time when broader market supply constrictions would have been expected. Our models suggest that without the BPC Tax Credit Program, wood fuel market prices would have risen higher and total market volume fallen lower than it did. Forest biomass volume increased between 100,000 and 190,000 BDT more than the forecast models predicted, and prices were about $7 per BDT less than predicted after the BPC tax credit became available. Although the models are not causal models, we suggest that the BPC tax credit is a plausible explanation for at least some of the unexplained differences between the forecast models and observations from the wood fuels market.

At a time of high unemployment, government budget deficits, and market weakness, our economic impact scenarios suggest that the BPC tax credit is likely an economic lever that provides incentives for more economic activity than it costs. The impact models indicate that per 10,000 BDT of forest biomass delivered to an energy facility, Oregon's economy produces about five jobs, $250,000 in wages and benefits, and more than $850,000 in total economic activity. Based on our scenarios, we estimate that the BPC Tax Credit Program likely supported between thirty-two and seventy-three jobs in Oregon in 2010.

The Biomass Crop Assistance Program and American Recovery and Reinvestment Act funding are other likely contributors to the unexplained volume or price in the wood fuels market. The BPC tax credit combined with these other government interventions appear to have provided incentives for forestry contracting businesses and the bioenergy industry to navigate the forest biomass supply chain.

The 2011 Oregon legislature reduced the value of the credit from $10 per green ton of delivered forest biomass material to $10 per BDT, decreasing the value of the credit substantially. The implication of this change is uncertain, but may hinge on whether a constrained supply of mill residuals continues and whether demand for bioenergy production continues to grow. Supporting the development of wood fuels markets in closer proximity to the forest supply may help maintain the relative competitiveness of forest biomass compared to other wood fuel sources. Incentives for the development of institutional and district heating facilities in rural forest communities would help to strategically increase the bioenergy market, continue to reduce transportation costs, and reduce reliance on imported energy sources. However, until that time, the BPC Tax Credit Program appears to be an important and effective incentive for the development of a forest biomass supply chain in the wood fuels market.

## Appendix 1: Forecast models development

This appendix provides technical details on the data and methodology we used to develop forecast models for wood fuel prices and forest biomass volume. We outline our data sources, modeling procedures, and provide detailed results. The results presented here are summarized and interpreted in the body of the report.

**Wood fuel prices and forest biomass data**

We worked with Forest2Market, a private for-profit wood products industry data aggregation and analysis firm, to develop two data series for the Oregon wood fuels market spanning 2000–10:

1. Oregon average quarterly wood fuel market price (price)
2. Oregon total annual wood fuels market volume by source (volume)

Price data for 2008–10 is based on actual transaction data collected from subscribers to the Forest2Market delivered price benchmark service.[12] The companies that report to the Forest2Market service include ten industrial forest product and bioenergy buyers and sellers of wood fuels for combustion. To estimate the 2000–7 prices, Forest2Market Pacific Northwest region manager Gordon Culbertson interviewed managers from six companies actively buying or selling wood fuels during this period. The entire volume series was compiled through a review of industry production archives and interviews with industry managers. The total wood fuels market volume series is further broken into several categories: 1) mill residuals, 2) urban wood waste, and 3) forest biomass. A significant volume of mill residuals are sold at a premium for landscape products and the series reflects this as a reduction in the mill residuals available to the wood fuels market. We use the term "internal market dynamics" to refer to the specific mix of products entering the wood fuels market at a given time. We did not attempt to differentiate price or volume differences for forest biomass that originates west versus east of the Cascade Mountains.

**Forest products and energy market data**

To develop forecast models, we also gathered data on a variety of market indices for forest products and energy markets external to the wood fuels market, but which plausibly influence wood fuels market. In conjunction with representatives from the Oregon Department of Forestry and the Oregon Department of Energy, we developed a list of potential markets. We collected external market data for forest products markets including softwood lumber production, softwood timber production, pulpwood production, softwood lumber exports, and softwood log exports; and from energy markets including domestic and imported crude oil, natural gas, coal, and industrial electricity. Housing-start data was also collected. Staff members at the University of Oregon's Ecosystem Workforce Program identified specific market indices in conjunction with the University of Oregon library research staff. Indices included data from the Bureau of Labor Statistics, U.S. Energy Information Administration, the U.S. Census Bureau, and Random Lengths, a private forest products industry information company (see Table 5 on page 22).

**Data analysis and forecast modeling**

To allow for basic integration of the wood fuels volume and price data, we interpolated quarterly data points for the wood fuels volume series by fitting a continuous cubic spline curve to the wood fuels volume data. The spline is constrained so that the quarterly totals equal the annual total volume for each wood fuel source. We then used the interpolated quarterly volume data as an independent variable for estimating and forecasting wood fuel prices.

We then developed two basic theoretical models for the wood fuels price and forest biomass volume data. Forest biomass volume was theorized as a linear function of the internal dynamics of the wood fuels market (i.e., the overall volume and mix of sources in the wood fuels market). Wood fuels price was theorized as a linear function of internal and external market dynamics (i.e., the market trends in other forest products and energy markets).

Prior to regression modeling, we conducted a correlation analysis to identify potential explanatory variables and potential multicollinearity among the explanatory variables. The aim of the correlation analysis was to make a preliminary identification of the internal and external market indices that would perform the best in a regression analysis, eliminating duplicative and redundant data.

To account for potential unexplained autocorrelation and seasonal or longer-run trends in the price and volume data, we first tested for the presence of autocorrelation and trends. Autocorrelation and trends can bias ordinary least-squares regression models by underestimating the standard errors of the regression coefficients. We also estimated cross-correlation among the independent and dependent variables at the current period and several lags to help identify potential empirical models. Analysis of autocorrelation and partial autocorrelation plots identified first order autocorrelation for both the dependent variables, but that significant cross-correlations exist between the independent variables in recent periods and the dependent variables. Statistically important seasonal and longer-run trends were not identified. Due to the potential autocorrelation bias, we first fit autoregressive integrated moving average (ARIMA) (1,0,0) models using maximum likelihood estimation with interventions from specific internal and external market dynamics. In the presence of the independent variables, regression coefficients for the autocorrelation factor were not significant (ARIMA models are available upon request, but are not displayed in this paper). Because independent variable regression coefficients were highly significant and no significant unexplained autocorrelation remained in the dependent variables when controlling for the internal and external market dynamic variables in the ARIMA (1,0,0) models, we chose to rerun the models as standard ordinary least squares regression to improve the analytic transparency and interpretive clarity.

## Table 5 Wood fuels market regression data sources and description

| Variables | Data type | Data interval[1] | Source |
|---|---|---|---|
| Wood fuels | Price/Volume | Quarterly/Annual | UO/Forest2Markets |
| Coal[2] | Price | Annual | Producer price index—Series 051 |
| Industrial electricity[2] | Price | Annual | Producer price index—Series 543 |
| Natural gas[2] | Price | Annual | Producer price index—Series 055 |
| Domestic crude oil[2] | Price | Annual | Producer price index—Series 056 |
| Softwood lumber[2] | Price | Annual | Producer price index—Series 0811 |
| Softwood timber[2] | Price | Annual | Producer price index—Series 085 |
| Pulpwood[2] | Price | Annual | Producer price index—Series 085103 |
| Imported crude oil[3] | Price | Annual | U.S. Energy Information Administration |
| U.S. lumber exports[4] | Volume | Annual | Random lengths (MBF) |
| U.S. housing starts[5] | Volume | Annual | Census, new housing starts (thousands) |

[1] Annual series were interpolated to quarterly values for regression models 3, 4, and 5.
[2] Producer price index commodity data available from data.bls.gov/pdq/querytool.jsp?survey=wp.
[3] Energy price data available at www.eia.gov/emeu/steo/realprices/index.cfm.
[4] Lumber export data available from Random Lengths. 2005 and 2010. *Forest Products Market Statistics Yearbook*.
[5] U.S. housing-start data available from census.gov/const/www/newresconstindex.html.

We then fit both the price and volume models using the pretax credit data (2000–6). We conducted a test for multicollinearity to minimize potential bias in the regression coefficients due to the correlation structure of the independent variables. Model fit was evaluated by examining the predicted residuals for the 2000–6 periods and the $R^2$ value for each model. As each model was assessed to be a strong fit to the price and volume data, the observed internal and external market data values from the tax credit period were then used to forecast wood fuels market prices and forest biomass volumes for 2000–10. Forecast values were plotted with the observed values and differences between the forecast and observed value are the basis for our analysis of the effects of the tax credit program. As such, our analysis forms a plausible theory to explain the effect of the Biomass Producers or Collectors Tax Credit on the wood fuels market. Our analysis does not provide evidence of a causal link between the tax credit and the observed differences between the observed and forecasted data. Instead, we suggest the tax credit is a plausible explanation for the observed differences. We are open to alternative explanations to the extent that they may be more persuasive. All data were analyzed in SAS 9.1.[13]

**Supplementary results**

Wood fuels prices are strongly correlated with a number of external market factors (i.e., forest products and energy market indices; see Table 6 below and Figure 8 on page 24). The volume of mill residuals and forest biomass is strongly negatively correlated in the wood fuels market (see Table 7 on page 24) indicating a strong influence of internal market dynamics on forest biomass volume.

## Table 6 Correlation between wood fuel price and related market indices

| | Wood fuels market index covariates | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Wood fuel price | U.S log exports | U.S. lumber exports | U.S. housing starts | Domestic crude | Industrial electricity | Softwood lumber | Natural gas | Imported crude oil | U.S. wood pulp | Coal |
| U.S. log exports | 0.22 | | | | | | | | | | |
| U.S. lumber exports | 0.26 | **0.41** | | | | | | | | | |
| U.S. housing starts | **-0.85** | **-0.39** | **0.46** | | | | | | | | |
| Domestic crude | **0.63** | 0.21 | 0.25 | **-0.52** | | | | | | | |
| Industrial electricity | **0.82** | 0.24 | 0.15 | **-0.70** | **0.84** | | | | | | |
| Softwood lumber | **-0.76** | -0.18 | -0.25 | **-0.79** | -0.24 | **-0.46** | | | | | |
| Natural gas | **0.43** | 0.14 | -0.10 | -0.26 | **0.76** | **0.72** | -0.03 | | | | |
| Imported crude oil | **0.78** | 0.26 | 0.11 | **-0.70** | **0.86** | **0.98** | **-0.40** | **0.75** | | | |
| U.S. wood pulp | **0.78** | **0.41** | **0.56** | **-0.74** | **0.78** | **0.79** | **-0.41** | **0.56** | **0.79** | | |
| Coal | **0.81** | **0.31** | 0.26 | **-0.83** | **0.74** | **0.93** | **-0.51** | **0.56** | **0.94** | **0.80** | |
| Softwood timber | **0.55** | 0.29 | **0.43** | **-0.42** | **0.77** | **0.64** | -0.05 | **0.62** | **0.68** | **0.79** | **0.56** |

Note: **bold** values indicate a significant correlation ($p<0.05$)

**Figure 8 Quarterly forest products and related energy market indices (2000–10)**

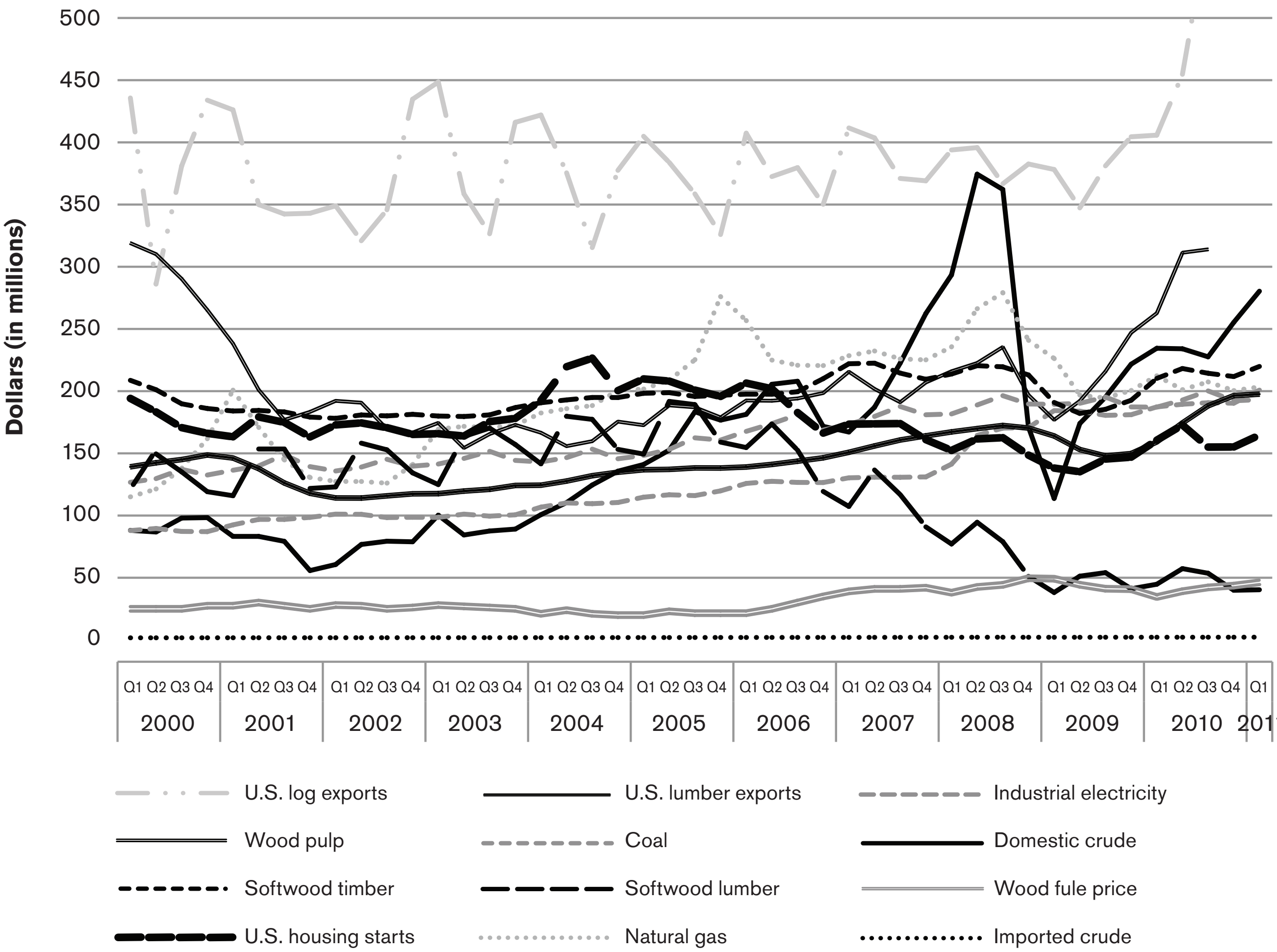



**Table 7 Correlation between wood fuel prices and wood fuel volume by source**

| | | Wood fuel volume by source | | |
|---|---|---|---|---|
| **Volume** | **Wood fuel prices** | **Total wood fuels** | **Mill residuals** | **Forest biomass** |
| Total wood fuels | 0.11 | | | |
| Mill residuals | **-0.85** | 0.26 | | |
| Forest biomass | **0.89** | 0.38 | **-0.79** | |
| Urban wood waste | 0.25 | **0.79** | -0.11 | **0.56** |

Note: bold values indicate a significant correlation (p<0.05).

Forecast models were significant for the price and volume series, exhibiting good statistical fits, highly significant parameter estimates, and interpretable coefficient values (see Table 8 below). Wood fuel prices are highly predictable given the volume of wood fuels available to the market and interactions with other wood products and energy markets ($R^2$ = 0.81). Wood fuel prices are significantly positively influenced by the total wood fuel volume available to the market and pulpwood prices, suggesting that demand in the wood fuels market is growing faster than supply and that the wood fuels and pulpwood markets may compete for supply. Wood fuels prices are significantly negatively influenced by the volume of mill residuals and lumber exports, and prices for softwood lumber and natural gas. The greater the availability of less expensive mill residuals and the more lumber production occurring, the more affordable wood fuels are to consumers. The volume of forest biomass available to the market is also highly predictable given the total volume of wood fuels on the market and the volume of mill residuals ($R^2$ = 0.98). Over the past decade, as the market for wood fuels has increased, so has the volume of forest biomass supplied to the market. However, all else begin equal, the greater the volume of mill residuals available to the market, the less the need for forest biomass.

## Table 8 Regression models (unstandardized coefficients) of Oregon forest biomass market volume and wood fuel market prices

| | Wood fuel price model | | Forest biomass volume model | |
|---|---|---|---|---|
| Intercept | 69.23 | *** | 14.36 | |
| Total wood fuels volume | 0.05 | ** | 0.56 | *** |
| Mill residuals volume | -0.16 | *** | -0.37 | ** |
| Mill residuals volume t-1 | - | | -0.20 | ** |
| U.S. lumber export volume | -0.05 | * | - | |
| Softwood lumber prices | -0.06 | ** | - | |
| Wood pulp price | 0.19 | * | - | |
| Natural gas price | -0.04 | | - | |
| n | 28.00 | | 27.00 | |
| Model F | 14.79 | *** | 504.13 | *** |
| $R^2$ | 0.81 | | 0.98 | |

*p<0.05 **p<0.01 ***p<0.001

Note: ARIMA (1,0,0) regression models were identified and fit for both wood fuel prices and forest biomass volumes to account for dependent variable autocorrelation; in both cases the AR (1) model components were not significant in the presence of the above listed independent variables and both models were then reestimated as generalized linear models.

## Appendix 2: Input-output model and impact development

This appendix provides technical details on the methodology we used to develop economic impact models for forest biomass production, our data collection procedures, and our use of these models to examine the financial impact of the Biomass Producers or Collectors Tax Credit.

**Input-output model**

The input-output model is a tool to measure the economic impact of any change in an economy. Input-output models represent the complex interindustry exchange that occur in an economy whereby industries respond to changes in demand by changing production levels and adjusting the consumption of intermediary products purchased from other industries. Input-output analysis defines how interindustry transactions between different components of regional production are translated into various components of regional income.[14] The general input-output model for an economy in which each sector produces one product, $x_i$, can be written thus:

$$\sum_{i=1}^{n} d_i = (I - A) \sum_{i=1}^{n} x_i$$

Where $\sum_{i=1}^{n} d_i$ is the total final demand for all $i$ sectors in an economy, and A is a matrix of coefficients $x_{ij}$ representing the requirements from sector $j$ to produce one unit of product $x$ in sector $i$. Roughly translated from mathematical notation, the above formula indicates that the total final demand in an economy is equal to the total value of the goods and services produced in the economy plus the total value of the interindustry exchange needed to produce those goods and services.

We used the economic impact modeling software IMPLAN 3.0[15] to describe the impacts from forest biomass production on Oregon's economy. We used 2008 Oregon data from the Minnesota IMPLAN Group (MIG) as the basic economic structure of Oregon's economy. MIG data are calibrated to national and local data from a number of sources. The Bureau of Economic Analysis (BEA) develops national input-output matrices every five years using data collected from the U.S. Census Bureau's Economic Census and other programs. MIG estimates local and state level input-output matrices by calibrating the BEA national input-output matrices with data from the Bureau of Labor Statistics, the Census Bureau, and the BEA. All national and local data is classified according to IMPLAN's industrial sectoring scheme, which has its origins in the North American Industrial Classification System sectoring scheme. We used the 2008 MIG state and county dataset for Oregon, adjusted to 2010 dollars.

**Biomass production data**

To develop a customized forest biomass economic impact model for use with IMPLAN 3.0, we collected data from several sources including forest biomass producers, the Oregon Department of Forestry (ODF), and the Oregon Employment Department.

*Forest biomass production function*

We collected expenditure profile data from forest biomass producers and the ODF to generate a production function for use with IMPLAN 3.0. The ODF data was supplied by John Pine and was collected from producers in Douglas and Coos counties as a requirement of an ODF grant aimed at better understanding the costs of biomass production. We also collected data directly from forest biomass producers through a collaborative survey implemented by the Oregon Departments of Energy and Forestry and the University of Oregon's Ecosystem Workforce Program (EWP). Data collection was done through an electronic form developed to match the data collected by the ODF in Douglas and Coos counties, and respondents were asked to fill in data from as many as five recent jobs that qualified for the BPC tax credit. Requests for participation were e-mailed three times with a cover letter explaining the survey and one follow-up phone call was completed to fifteen tax credit applicants in April 2011. Three surveys were returned with complete data that, together with the ODF data, reported on the detailed costs of thirty-one recent biomass production jobs. Twenty-nine jobs were conducted west of the Cascade Mountains, and twenty-eight jobs were described as slash collection and removal from private industrial timber ownerships. Results from the

ODF Douglas and Coos county data and from our survey responses were similar.

We developed a forest biomass expenditure profile from the twenty-eight private industrial slash collection and removal jobs and from occupational wage data from the Oregon Employment Department. The two eastside thinning and stewardship projects have not yet been analyzed. The expenditure profile consists of labor and nonlabor costs for slash collection, grinding, equipment mobilization, transportation, and overhead. For each line item respondents reported, the total cost of that line item and number of person hours corresponding to the line item. We used the person hours reported for each line item multiplied by the median wage rate for the region in which the job occurred to estimate the labor portion of each line item. The nonlabor portion was then calculated as one minus the labor portion. We created an average expenditure profile by averaging the labor and nonlabor portions of each line item across all twenty-nine jobs (see Table 9 below).

We then cross-walked our expenditure profile with the IMPLAN 3.0 industrial sectoring scheme, associating the nonlabor coefficients in the expenditure profile with the commodity codes for logging, truck transportation, and a custom aggregated administrative services commodity. We inputted labor separately into the model for calculating induced impacts, and calculated direct labor impacts for each line item using the labor coefficients and annual occupational wage rates that the Oregon Employment Department reported.

*IMPLAN scenarios*

We designed economic impact models for biomass production as a function of 10,000 delivered BDT. We used ODOE 2010 BPC tax credit certification data for the average 2010 market price and average moisture content for qualified forest biomass production to estimate the average market value and the average value of the tax credit for 10,000 delivered BDT of forest biomass. We used IMPLAN 3.0 to simulate the economic impacts of 10,000 delivered BDT of forest biomass to employment, wages and benefits, taxes, and overall economic activity to Oregon's economy. Although the report focuses on the statewide impact model results, we also used MIG 2008 county-level data to construct regional models (northwestern Oregon, southwestern Oregon, central Oregon, and eastern Oregon) for which to evaluate the impact of biomass production on a re-

**Table 9 Line item production costs as a percentage of total production costs for forest biomass collection and transportation**

| Production costs | Labor | Nonlabor | Total costs |
|---|---|---|---|
| **Logging** | **0.11** | **0.56** | **0.66** |
| Slash collection | 0.07 | 0.20 | 0.27 |
| Grinding | 0.03 | 0.36 | 0.40 |
| **Transportation** | **0.11** | **0.17** | **0.28** |
| Truck and haul | 0.11 | 0.15 | 0.26 |
| Mobilization | 0.00 | 0.02 | 0.02 |
| **Overhead** | **0.01** | **0.04** | **0.05** |
| Administration and fees | 0.01 | 0.04 | 0.05 |
| **Total** | 0.23 | 0.77 | 1.00 |

Note: Production costs were averaged from twenty-nine individual forest biomass jobs reported by biomass producers and the Oregon Department of Forestry. Production coefficients are percentages and indicate how a dollar of biomass production costs is allocated to different labor and nonlabor expenditures.

gional scale. Regional results are reported in addition to the statewide results (see Table 3 on page 15).

IMPLAN 3.0 is a linear model and, therefore, the results from the regional or statewide models are scalable to greater or lesser volumes of biomass or different market prices. For example, the economic impact from 20,000 delivered bone dry tons of forest biomass would be twice that of the results from the 10,000 delivered bone dry tons scenario. As such, the IMPLAN results are a useful tool for policymakers, producers, and others wishing to understand the economic impacts of biomass production activities. However, due caution is noted as the linear relationship assumes there are no production efficiencies gained or lost at different scales and that changes in market prices result from evenly distributed increases to all line items in the production function.

## Endnotes

1 Becker, D.R., C. Moseley, and C. Lee. 2011. A supply chain analysis framework for assessment state-level forest biomass utilization policies in the United States, *Biomass and Bioenergy* 35: 1429–1439.

2 United States Energy Information Administration. 2011. Electric Power Industry Generation by Primary Energy Source, 1990 Through 2009. URL: www.eia.gov/cneaf/electricity/st_profiles/Oregon.html.

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4 United States Energy Information Administration. 2010. State Renewable Electric Power Industry Net Generation, by Energy Source, 2005–9. URL: www.eia.gov/cneaf/solar.renewables/page/state_profiles/oregon.html.

5 Forest2Market®, Inc. 2011. Historical Data for Oregon Wood Fuels and Biomass, 2000–10.

6 Ibid.

7 About half of the certified applications included usable location information. Applications that included multiple originations and multiple destinations were not included in the distance estimation as the specific shipments could not be separated.

8 Memo from Matt Krummenauer to ODOE director Bob Repine, March 7, 2011, updated September 26, 2011.

9 For more information on BCAP, visit www.fsa.usda.gov/FSA/webapp?area=home&subject=ener&topic=bcap.

10 Personal communications with Lindsey Babcock, BLM (September 13, 2011), and Mike Daugherty, USFS (September 13, 2011), and Tracy Beck, USFS (September 19, 2011).

11 Jones, G., D. Loeffler, E. Butler, W. Chun, and S. Hummel. Emissions, Energy Return and Economics from Utilizing Forest Residues for Thermal Energy Compared to Onsite Pile Burning. In: Jain, T.B.; R.T., Graham, and J. Sandquist (Eds). Integrated management of carbon sequestration and biomass utilization opportunities in a changing climate: proceedings of the 2009 National Silviculture.

12 For more information, visit www.forest2market.com/f2m/us/f2m2/bioenergy/deliveredfeedstockprices.

13 SAS Institute, Cary, North Carolina. URL: www.sas.com.

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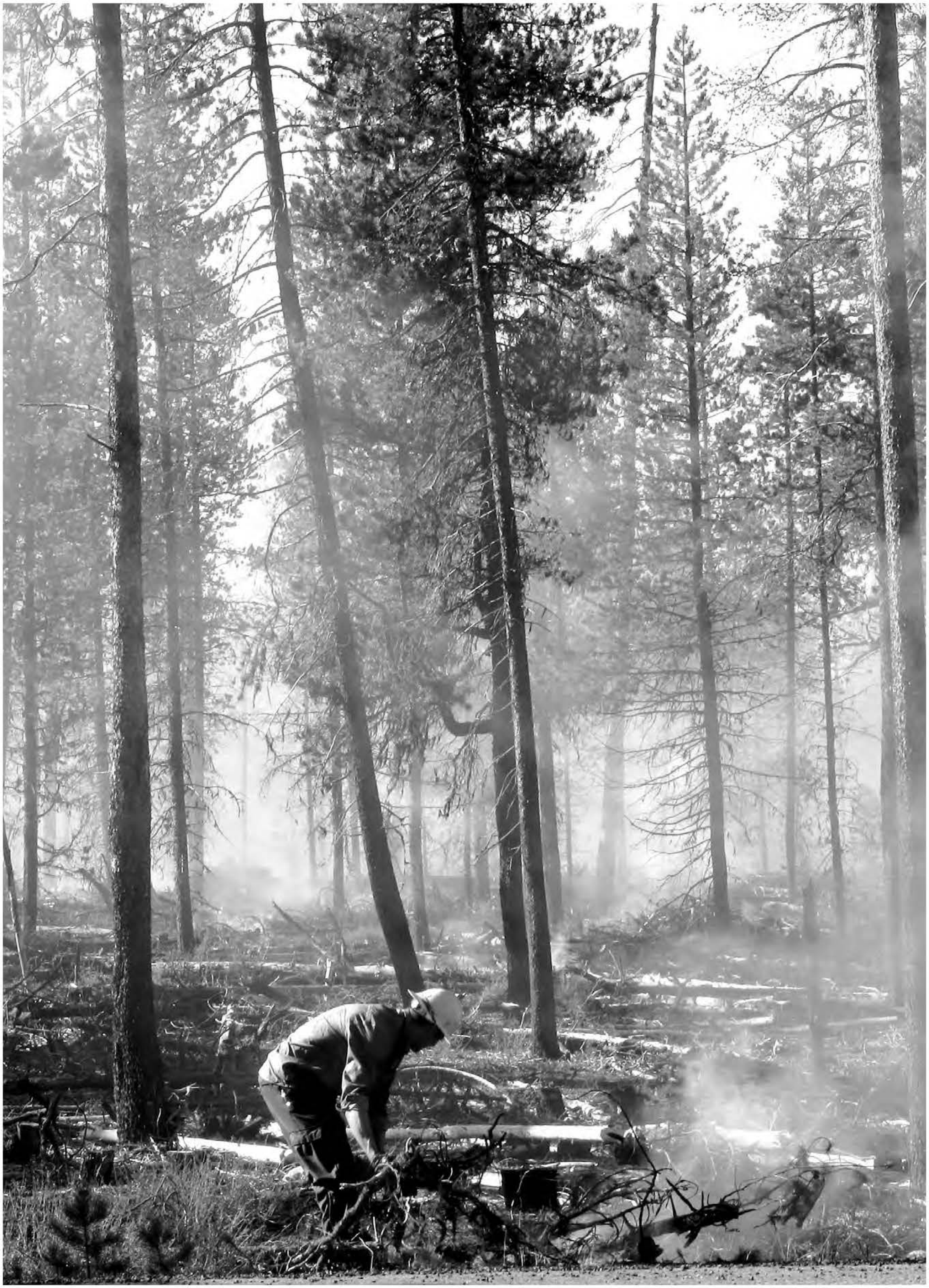

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