Biomass Resource Assessment and Utilization Options for Three Counties in Eastern Oregon

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ABSTRACT

This report documents a biomass resource and technology assessment focusing on Baker, Union and Wallowa counties in Northeastern Oregon funded through the U.S. Forest Service National Fire Plan and the Oregon Department of Energy. A significant amount of biomass that is not merchantable in wood products or other manufacturing industries is available from forest resource management, agriculture and wood products manufacturing in the region. Biomass energy facilities could provide a potential economic use for this material. The feasibility of using this material is enhanced by locating an energy facility close to the source of the material and sizing the facility appropriate to the volume of material available on a long-term, sustained basis. Using current and near-term technology, biomass energy facilities could convert surplus biomass into electricity, industrial steam energy and fuel ethanol. A barrier to private sector investment in biomass energy facilities is the lack of specific information about the amount of biomass feedstock available, the cost of feedstock delivered to the plant site and the best locations for proposed facilities relative to both feedstock supply and markets for energy products. There is a critical need for this information in view of both high fire-risk in the forest and the need for economic stimulus in rural communities. This report addresses that need for information

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Dr. Jim Kerstetter provided technical support to McNeil on this project. In addition, the authors want to thank all the stakeholders who participated in the focus group (held in November 2002) that explored issues surrounding biomass sustainability. The authors regret if there are any omissions to the above list.

Finally, despite our best efforts at editing and revisions, mistakes may remain within this document. Any mistakes or omissions are the sole responsibility of the authors. Any questions or comments should be addressed to McNeil Technologies Inc., 143 Union Blvd., Suite 900, Lakewood, CO 80228. McNeil staff members who worked on this project are Scott Haase, Tim Rooney and Jack Whittier.

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ABBREVIATIONS AND ACRONYMS

$	U.S. dollars
ASV	all surface vehicle
ATV	all terrain vehicle
BDT	bone-dry tons (0% moisture content); also referred to as oven-dry tons (ODT)
BEF	Bonneville Environmental Foundation
BFB	bubbling fluidized bed
BLM	U.S. Bureau of Land Management
Btu	British thermal units
C	Celsius
CCF	hundred cubic feet (ft^3)
CF	cubic feet (ft^3)
CFB	circulating fluidized bed
CFR	Code of Federal Regulations

Ch	chains; a chain is a U.S. survey unit that is the equivalent of 66 feet (20.1 meters)
CHP	combined heat and power
CLAMS	Coastal Landscape Analysis and Modeling Study
CO	carbon monoxide
CO_2	carbon dioxide
COIC	Central Oregon Intergovernmental Council
CORE4	Conservation for Agriculture's Future
CRP	Conservation Reserve Program
CSREES	Cooperative State Research, Education and Extension Service
CTIC	Conservation Technology Information Center
CVS	continuous vegetation survey
DBH	diameter breast height
DEQ	Department of Environmental Quality
DOE	U.S. Department of Energy
DOI	U.S. Department of Interior
DSL	Oregon Division of State Lands
E10	gasoline containing 10% ethanol by volume
E95	gasoline containing 95% ethanol by volume
EIA	U.S. DOE Energy Information Administration
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act
ETBE	ethyl tertiary butyl ether
EVG	existing vegetation
F	Fahrenheit
FEEMA	Financial Analysis of Ecosystem Management Activities
ft	feet
GAP	Gap Analysis Program
GRMWP	Grande Ronde Model Watershed Program
GT	green tons
H_2	hydrogen
HHV	higher heating value
ICBEMP	Interior Columbia Basin Ecosystem Management Project
in	inches
kW	kilowatt
kWh	kilowatt-hour
lb	pounds
LHV	lower heating value
MBF	thousand board feet
MC	moisture content
MCF	thousand cubic feet
MMCF	million cubic feet
mi^2	square miles
MMBF	million board feet
MMBtu	million British thermal units
MSW	municipal solid waste
MTBE	methyl tertiary butyl ether

MW	megawatt
MWh	megawatt-hour
NASS	National Agricultural Statistics Service
N	nitrogen
NO_x	oxides of nitrogen
NRCS	Natural Resources Conservation Service
NREL	National Renewable Energy Laboratory
ODF	Oregon Department of Forestry
ODT	oven-dry tons (0% moisture content); also referred to as bone-dry tons (BDT)
ORS	Oregon Revised Statutes
OSU	Oregon State University
psi	pounds per square inch
PURPA	Public Utility Regulatory Policy Act
RBEP	Regional Biomass Energy Program
REPA	Renewable Energy Production Incentive
RFG	reformulated gasoline
ROI	return on investment
SCI	Soil Conditioning Index
SDI	Stand Density Index
SO_x	oxides of sulfur
SSCF	simultaneous saccharification and cofermentation
S	sulfur
TPA	trees per acre
TSI	timber stand improvement
TVA	Tennessee Valley Authority
U.S.; USA	United States of America
USDA	United States Department of Agriculture
USFS	United State Forest Service
VOC	volatile organic compound
WRBEP	Western Regional Biomass Energy Program
wt %	weight percent
yr	year

EXECUTIVE SUMMARY

INTRODUCTION

The forests of Northeast Oregon are susceptible to increased risks of wildfire, caused in part by past forest management activities, decades of aggressive fire suppression and climatic conditions. These conditions have led to significant levels of biomass fuel in the forests. Wildfire threatens local communities with loss of life and property. Wildfire may also damage water quality, wildlife and the recreational and resource values associated with forestland.

Federal and state agencies, local government and private forest landowners are using thinning and prescribed burning in strategic locations to reduce forest fuels and wildfire risks. Most of the material generated from fuels reduction activities is not suitable for wood products manufacturing. In many cases, biomass from these activities is left on-site or piled and burned at an additional cost. An alternative outlet for this wood could help reduce the costs of thinning and mitigate environmental impacts associated with prescribed burning and wildfires. In addition, local agricultural producers are seeking to develop new income opportunities and looking for alternatives to burning crop residues, which contributes to air pollution. This study focuses on using these resources to develop biomass energy opportunities in Baker, Union and Wallowa Counties in Northeast Oregon. The Oregon Department of Energy and the U.S. Forest Service provided financial assistance to this project because it supports their mutual interests in renewable energy development, natural resource protection and safeguarding communities.

The study area is of particular interest because it is the focus of the Grande Ronde Model Watershed Program (GRMWP), a unique group of public and private stakeholders that are collaborating to help improve watershed conditions in the region. GRMWP projects, include but are not limited to, riparian habitat protection, upland and mixed habitat protection (including thinning), road improvement and closure, fish habitat passage improvement and irrigation diversion improvement.[1] In addition, the Oregon Governor's Office, with the assistance of the U.S. Forest Service Pacific Northwest Research Station, has completed a vegetation assessment targeting small diameter timber potential in the Blue Mountains that complements the potential for biomass energy development in the area.[2]

Project goals and objectives

The goal of this study is to promote the cost-effective, sustainable use of biomass for power and/or ethanol manufacturing in Baker, Union and Wallowa Counties in Northeast Oregon (see Figure ES-1). The objectives of the study are to:

- identify how much biomass is generated in the region
- determine how much biomass is available, where it is located, its physical and chemical characteristics and the cost
- provide information on best locations for a potential biomass site in each county
- evaluate the economic and environmental impacts of biomass use; and

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[1] Grande Ronde Model Watershed Program, *GRMWP Restoration Projects* (http://www.fs.fed.us/pnw/modelwatershed/grmwp-project-page.html).

[2] Oregon Office of the Governor and Oregon Department of Agriculture, *Assessment Of Timber Availability From Forest Restoration Within The Blue Mountains Of Oregon* (http://www.fs.fed.us/bluemountains/pubs.htm, Blue Mountains Demonstration Area, November 14, 2002).

- provide an overview of biomass energy technologies, feedstock requirements, and the economic potential to convert biomass to electricity or ethanol.

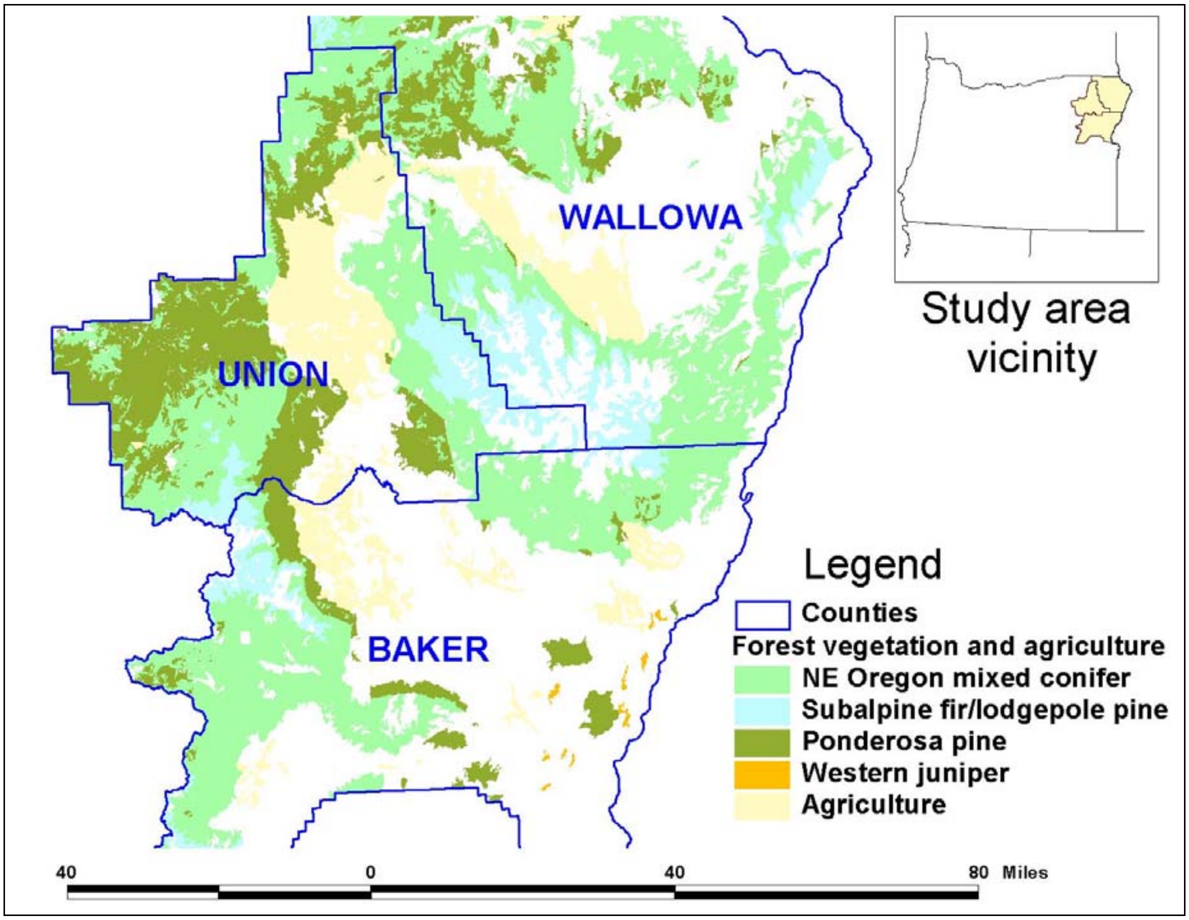


Figure ES-1. Study area

The study area includes 8,280 square miles of territory.[3] Forests cover 48%, agricultural land comprises 9%, and shrub and grassland make up 39% of the total area. The remaining 4% of the study area cover consists of urban, alpine, wetland and open water.[4] Public land makes up 52%, with the U.S. Forest Service owning and managing 45% of the total land area.[5] The counties are largely rural, with a historic economic base dependent on agriculture, forestry and tourism. The estimated combined population of the three counties in 2002 was 48,350; the 2001 average unemployment rate was 8.5 percent.[6]

[3] U.S. Census Bureau, *State & County Quickfacts* (http://quickfacts.census.gov/qfd/states/41000.html).
[4] R. Eber, Rural Lands Database, *Gap Analysis Program (GAP) Vegetation Cover Database* (Oregon Department of Land Conservation and Development).
[5] U.S. Forest Service area land from U.S. Department of Agriculture Forest Service, Wallowa-Whitman National Forest, *Forest Facts,* accessed September 22, 2003 (http://www.fs.fed.us/r6/w-w/forest_facts.htm) and Umatilla National Forest, *Total Forest Acres,* accessed September 22, 2003 (http://www.fs.fed.us/r6/uma/acres.htm). Total land area from U.S. Census Bureau, *State & County Quickfacts* (http://quickfacts.census.gov/qfd/states/41000.html).
[6] U.S. Census Bureau, *State & County Quickfacts* (http://quickfacts.census.gov/qfd/states/41000.html).

BIOMASS RESOURCE GENERATION AND AVAILABILITY

The plant-based biomass resource in Northeast Oregon consists of forest biomass, wood products manufacturing residues and agricultural crop harvesting residues. Forest biomass is generated because of forest fuels reduction, commercial timber harvest, non-commercial thinning and timber stand improvement (TSI) activities. Non-commercial thinning includes pruning and tree removal designed to help shape and guide development of forest stands to meet a variety of goals, but it generally does not result in removal of trees that can be used to manufacture products. Timber stand improvement can accomplish similar goals, but it often results in removal of some commercially valuable trees. Wood manufacturing residues consist of bark, sawdust, chips, and veneer cores. Agricultural residues consist of straw, grass and leaves left over after harvesting the major crop types in the region, including grass seed, spring wheat, winter wheat, oats and barley. Currently, the material is left on-site, burned or in some cases used for animal feed.

Data sources and analytical approach

The overall approach to assessing the biomass resource was to first estimate the quantity of material generated from forestry and agricultural practices in the area. We then evaluated the quantity of material that could be recovered from these practices taking into account technical and environmental constraints associated with slope, soils, wildlife habitat and other site factors. Data sources for forest management on federal land included monitoring and reporting information from Wallowa-Whitman and Umatilla National Forests for fuels reduction, noncommercial thinning and TSI activities. Oregon Department of Forestry long-term timber harvest data from all landowners were used to estimate residue from timber harvesting.

We calculated agricultural residue generation based on annual average acres harvested, yield values per acre, and estimated residue generation factors. Data sources for harvest and yield values were from the U.S. Department of Agriculture National Agriculture Statistics Service. Residue generation factors were calculated for barley, spring wheat and winter wheat based on methods developed by the Natural Resources Conservation Service.[7]

Biomass availability was determined based on a variety of factors. Forest biomass availability was determined based on slope constraints on forestland. Forest biomass removal is technically more difficult and costly on land with steep slopes. We estimated the forestland area that is less than 30% slope for each county, based on U.S. Forest Service Forest Inventory & Analysis plot data. We then multiplied estimated biomass generation by the percentage of forestland in each county that is less than 30% slope. Other factors limit forest biomass availability, including the need to leave materials on-site for soil conservation and wildlife habitat. These constraints provided a conservative estimate of the quantity of biomass that could be removed on forestland, given current levels of forest management intensity.

Agricultural biomass availability is limited by the estimated quantity of material that must be left on site to maintain soil productivity. We used a computer model developed by the U.S. Department of Agriculture called the Soil Conditioning Index (SCI) to estimate the quantity of residues that could be removed while preserving soil productivity. The results of the SCI calculations showed that the quantity of residue that could be removed without resulting in a

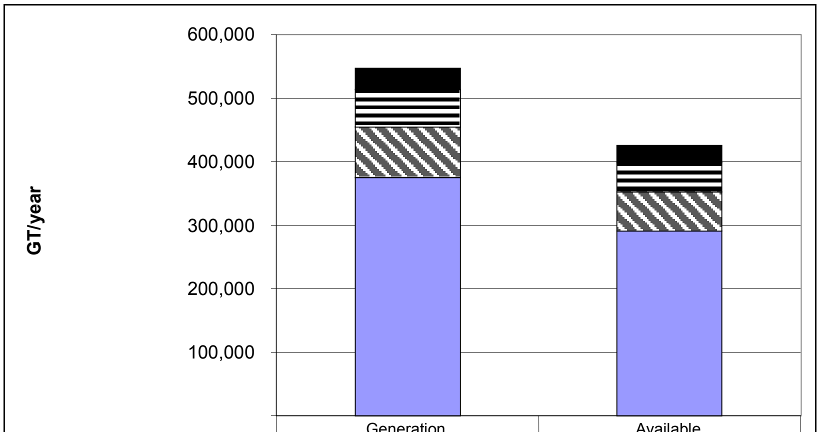
[7] NRCS, *National Agronomy Manual* (ftp://ftp.nssc.nrcs.usda.gov/pub/agronomy/SCIfiles/Latest_revisions/Training%20Materials/NAM508.pdf).

decrease in soil organic matter varied from 1 to 1.5 tons per acre. We then calculated agricultural residue availability by multiplying the total harvested acres in each county by the residue availability factor for each county. The SCI does not apply to grass straw. We relied on regional expertise to provide us with the assumption that 85% of grass straw could be recovered. However, unless a biomass facility could afford to pay at least $10/ton to landowners, Kentucky Bluegrass straw is considered not available because it is sold for feed.

Manufacturing residue availability was based primarily on the existence of competing uses for the residues. In the study area, most sawmill residue is used internally by Boise Cascade facilities. Bark is used for energy; shavings, sawdust and planer trim are all used for making particleboard. Because these materials are fully utilized internally by Boise Cascade, they are not considered available for purposes of this study. Chips, however, are sold for pulp, and could be available if the price paid for the material is competitive.

<u>Forest biomass generation and availability</u>

The estimated quantity of forest biomass generated is 547,620 green tons (GT) per year. The estimated quantity available is 425,934 GT/year (see Figure ES-2). The majority of the biomass available, 69%, is from timber harvesting residues. Fuels treatment, TSI and non-commercial thinning comprise the remaining 31% of the available resource.

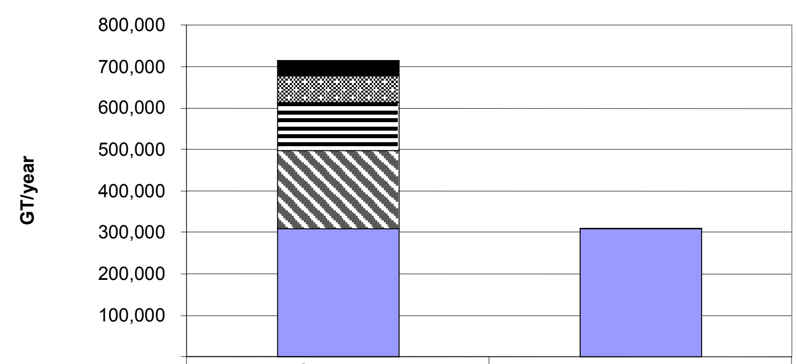


	Generation	Available
Non-commercial thinning	33,710	26,355
Fuels treatment	58,807	45,976
TSI	79,120	61,857
Timber harvesting residue	375,983	291,745

Figure ES-2. Forest biomass generation and availability

<u>Wood products residue generation and availability</u>

A total of 714,852 GT of wood product residue are generated each year. Of this, 310,252 GT could be available if the price paid were competitive with existing markets (see Figure ES-3).

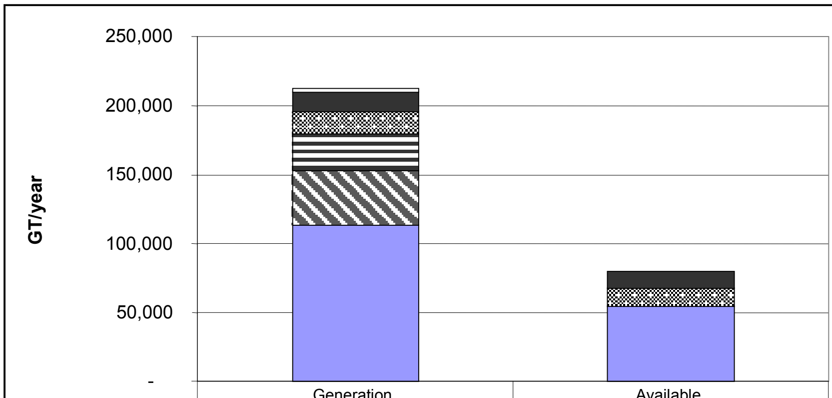


	Generation	Available
Veneer cores	1,458	1,458
Plywood trim	33,875	-
Planer shavings	64,603	-
Sawdust	115,961	-
Hog fuel	190,160	-
Chips	308,794	308,794

Figure ES-3. Wood products manufacturing residue generation and availability

Agricultural residue generation and availability

The estimated quantity of agricultural residues generated in the study area each year is 212,661 GT. The estimated quantity available, that which can be removed without diminishing soil productivity, is 80,009 GT/year (see Figure ES-4).



	Generation	Available
Oats	2,649	-
Kentucky bluegrass	14,287	12,144
Other grass	15,917	13,529
Spring wheat	26,608	-
Barley	39,907	-
Winter wheat	113,294	54,335

Figure ES-4. Agricultural residue generation and availability

Winter wheat straw makes up 68% of the total quantity available, while grass straw from Kentucky Bluegrass and other grass seed production makes up the remaining 32%.

Summary of biomass generation and availability – all sources

Total estimated annual biomass generation is 1,475,133 GT; 55% of that total quantity or 816,195 GT could be available for use at a biomass facility annually (see Figure ES-5).

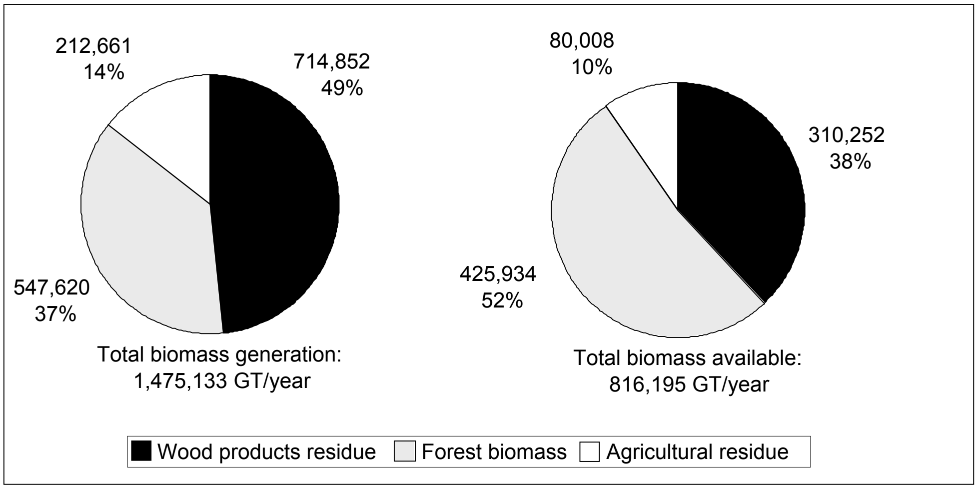


Figure ES-5. Biomass generation and availability – all sources

FACILITY SITING

Prior to developing an estimate of the cost and quantity of the biomass supply delivered to a biomass power or bioethanol plant, we identified potential sites that have adequate infrastructure and other characteristics to support such a plant. This task was not meant to recommend one site over another; rather the intent was to identify one potential site in each study area county where, upon preliminary investigation, a biomass conversion facility could be located. These three sites were used as the basis for a more detailed investigation of the delivered biomass costs to the plants in the area. There are other sites in the study area that are geographically very close to the sites chosen in each county that also could support a biomass energy facility, and the results for the supply analysis in many cases are applicable to these sites as well.

Three sites were selected with favorable characteristics:

- Baum Industrial Park, located in La Grande (Union County)
- Elkhorn View Industrial Park, located in Baker City (Baker County); and
- Bates Mill site, located in Wallowa (Wallowa County).

Figure ES-6 shows the locations of each of these sites.

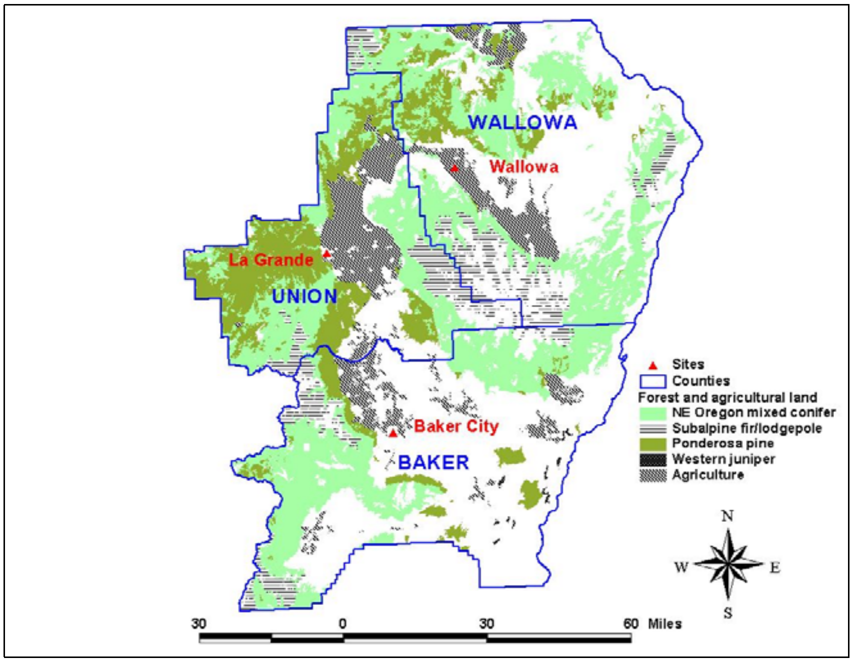


Figure ES- 6. Location of potential facility sites

Baum Industrial Park is located four miles northeast of La Grande. Total acreage at the site is 80 acres. The Baum site is adjacent to a Borden Chemical plant and a Boise Cascade particleboard processing facility. A Boise Cascade sawmill is less than two miles away from the site. Sustainable Energy Development Inc. has purchased property at the Baum Industrial Site as a possible cellulosic ethanol plant location.

Elkhorn View Industrial Park is located near U.S. Highway 30 in Baker City. It has a total area of 71 acres. Ellingson Lumber sites in Baker City and South Baker City are both very similar in siting potential to the Elkhorn View Industrial Park. The results of the supply analysis could be modified slightly to be applicable to these other sites, which also merit attention.

The Bates Mill site is a former sawmill, adjacent to wastewater treatment facilities and a rail line. There are ongoing efforts to redevelop portions of adjacent parcels for small-scale forest products enterprises. Wallowa Resources is working with a number of parties to evaluate possible siting of firewood and post-and-pole manufacturing businesses on the property, which could complement a bioenergy facility at the site.

BIOMASS SUPPLY

Collection and processing cost estimates are based on published values for forest and agricultural biomass. Forest biomass costs include the costs to cut, process and forward biomass materials to the roadside for transportation to the point of use. These costs can range from $30 to $46/GT, based on regional time and motion studies of forestry operations; a value of $38/GT is assumed for this analysis. Agricultural biomass collection costs include swathing, baling and stacking costs and can range from $24 - $26/field dry ton, based on custom contractor rates in the study area. A value of $24/field dry ton is assumed for wheat straw for this analysis. Costs for Kentucky bluegrass straw are $34/field dry ton because they include a $10/field dry ton payment to farmers to compensate them for the fee they are currently paid for their straw.

Table ES-1 shows estimated supply quantity and average biomass costs delivered to potential plant locations within the study area. The total quantity is the same for all three potential locations since each potential site would be drawing from the available quantity in all three of the counties. We developed two supply curves: one for biomass ethanol and one for biomass power. Agricultural residue is not included in the biomass power supply, due to technical issues associated with burning large quantities of agricultural residue in biomass boilers.

A biomass power plant may use only a limited quantity of agricultural residue due to the potential for boiler slagging and fouling associated with agricultural residue alkali content. The exclusion of agricultural residue brings the average resource cost for a biomass power plant slightly above that for a biomass ethanol plant, but not enough to significantly impact plant feasibility. The average delivered costs differ slightly between the three potential facility sites. Specifically, the biomass resource cost is lowest in Union County, primarily due to the fact that transportation costs for sawmill chips are much lower than for Baker and Wallowa.

Table ES-1. Biomass supply quantity and weighted average biomass cost delivered to potential plant sites in Baker, Union and Wallowa Counties

Supply type	Quantity (GT/year)	Average cost ($/GT delivered)		
		Baker County	Union County	Wallowa County
Biomass ethanol				
Agricultural residue	80,009	35.24	31.39	34.31
Forest biomass	425,934	48.66	48.20	49.49
Mill chips	308,794	25.39	15.93	27.15
Veneer cores	1,458	12.46	3.00	14.22
Total	816,195	38.47	34.26	39.51
Biomass power				
Forest biomass	425,934	48.66	48.20	49.49
Mill chips	308,794	25.39	15.93	27.15
Veneer cores	1,458	12.46	3.00	14.22
Total	736,186	38.22	34.57	40.19

The average costs shown in Table ES-1 are the most important from a facility planning perspective, but the price will vary based on the type of material the facility receives, how much material is required and the source of the material.

A biomass facility will first utilize the lowest cost material, which is frequently generated closest to the facility. Lower cost feedstocks include clean wood waste from veneer manufacturing, sawmill chips and agricultural residue. These resources range in cost from $3 - $14/GT delivered for veneer cores up to $26 - $37/GT for agricultural residues, depending on the facility location. In total, these feedstocks represent an estimated 390,261 GT of biomass per year that could be available for a biomass facility. Sawmill chips make up 79% of this quantity. As the quantity demanded increases, a facility will purchase forest biomass at higher cost than other residue sources. The lowest delivered cost for forest biomass is $45/GT; the estimated upper bound on forest biomass costs is $58/GT. A biomass power plant that needs more than 300,000 GT of material per year would need to purchase forest biomass. Alternatively, if a facility uses forest biomass exclusively, its average feedstock costs would be significantly higher than if it used a blend of manufacturing residues and forest biomass.

SUSTAINABILITY OF BIOMASS UTILIZATION

To ensure local support, several community concerns related to sustainability of biomass use should be addressed if a biomass power or ethanol manufacturing facility is developed in the area. Based on the results of a November 2002 focus group held in La Grande, Ore., we developed a list of issues associated with forest management, agriculture and economic viability that concern local stakeholders. The focus group included a wide variety of participants, including representatives from state and federal resource management agencies, environmental organizations, farmers, economic development agencies and local residents.

The major issues associated with the use of forest biomass include potential effects on soil productivity, long-term availability of forest biomass, economics of forest biomass (i.e., who pays for thinning), overall costs and benefits of forest biomass utilization and whether energy from biomass would be considered environmentally friendly. Issues raised relating to agricultural residue utilization include difficulties of quantifying acreage devoted to particular crops, annual variability in resource availability, soil productivity impacts, competing markets for crop residues and an overall need to ensure that residue use will help farmers economically.

ECONOMIC AND ENVIRONMENTAL IMPACTS OF BIOMASS UTILIZATION

The net economic benefits include increased employment in a rural, natural resource-based economy. An estimated six jobs are created for each megawatt (MW) of biomass power capacity that is installed. These jobs include positions at the plant and also in the fuel processing and delivery sectors.[8] A 5-MW stoker-fired biomass power plant would use an estimated 123,000 green tons of fuel per year and would create an estimated 16 new jobs at the plant with payroll and benefits equal to $600,000. A 25-MW stoker-fired biomass power plant would use an estimated 430,000 green tons of biomass per year, but would only require one additional employee at the plant, for a total of 17 employees. Total payroll and benefits for the 25-MW biomass power plant would equal $641,250. This does not include employment in the fuel supply and delivery sectors. A 5-MW stoker-fired plant will employ approximately 18 people in fuel procurement. A 25-MW plant will employ 54 people in fuel procurement. Therefore, total new jobs from a 5-MW plant are 34, while a 25-MW plant would support 71 new jobs.

A 15-million-gallon per year biomass ethanol facility would employ approximately 30 people at the plant; approximately 70 people would be employed in feedstock supply and delivery systems, bringing the total economic impact to approximately 100 jobs. The biomass ethanol plant would require approximately 600,000 green tons of biomass per year. The higher feedstock requirements and sophistication of plant equipment result in a higher employment impact for a biomass ethanol plant than for a biomass power plant.

The positive environmental impacts in the region include improved forest resilience to disease and insect infestation, reduced threats to communities and watersheds associated with lower risks of wildfire, improved water quality and clarity for consumption and for wildlife, reduced air emissions from wildfire and open crop residue burning and increased reliance on renewable energy resources. In particular, using biomass in a controlled combustion system such as a boiler or converting it to fuel ethanol both result in a significant net reduction in air emissions relative

[8] For California bio-power facilities, in 2003, there are 3,600 direct jobs that support 588 MW of capacity. California Biomass Energy Alliance, *Benefits of California's Biomass Renewable Energy* (http://www.calbiomass.org/technical4.htm).

to wildfire or crop residue burning. Potential environmental risks include loss of soil productivity in forests and on agricultural crop land if excessive biomass is removed. Wildlife habitat impacts include possible habitat reduction or deterioration if appropriate levels of dead and dying trees are not left for habitat or if forest density is reduced too aggressively.

BIOMASS TECHNOLOGY

Biomass power generation is a proven, mature technology with over 7,000 MW of installed capacity in the U.S. It is one of the largest sources of renewable energy, second only to hydroelectric power.[9] Biomass installations range in size from very small units (e.g., 5-10 kW) to large facilities up to 50 MW. The two primary biomass energy conversion technologies are direct combustion and gasification. Because direct combustion is commercially available today, it is the primary focus of this study.

Estimated total biomass feedstock requirements for a 5-MW stoker-fired biomass facility are 123,415 GT/year. Efficiency improvements in larger units make estimated feedstock requirements for a 25-MW unit equal 429,577 GT/year, and a 50-MW facility will consume 723,205 GT/year (see Table ES-2). Thus, a facility that is ten times the installed capacity of a 5-MW facility only uses 5.8 times as much fuel.

Estimated biomass power generation costs are $0.1429/kWh for the 5-MW unit, $0.1552/kWh for a 25-MW plant and $0.1478/kWh for a 50-MW plant.

Table ES-2. Comparison of estimated biomass power fuel use, capital and operating costs

Variable	5 MW plant	25 MW plant	50 MW Plant
Installed plant capacity (MW)	5	25	50
Fuel consumption rate (GT/hour)	15.7	54.5	91.7
Operating hours (hours/year)	7,884	7,884	7,884
Feedstock requirements (GT/year)	123,415	429,577	723,205
Capital costs ($/kW)	2,400	2,248	2,096
Total capital costs ($)	12,000,000	56,200,000	104,800,000
Fuel Costs ($/GT)	28.00	46.50	53.00
Total power generation (MWh/year)	39,420	197,100	394,200
Levelized cost of electricity ($/kWh)	0.1429	0.1552	0.1478

Figure ES-7 shows the impact of biomass fuel cost on the levelized cost of energy for three different sized power plants. As fuel costs decrease, the levelized costs of energy also decrease. The figure shows that if fuel costs are equal across the various plant sizes, the costs of energy from the larger plants will be significantly lower than that produced at smaller plants. For example, at $23/GT, the cost of energy from a 5-MW plant will be about $0.13/kWh, whereas the cost from the 50-MW plant will be about $0.085/kWh. These costs do not include transmission costs that the generator would have to pay to interconnect to the grid or to wheel power outside of the study region. It is clearly important to reduce the cost of forest biomass if biomass power plants are to be economically viable.

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[9] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Biopower Program, *Biopower Basics* (http://www.eere.energy.gov/biopower/basics/).

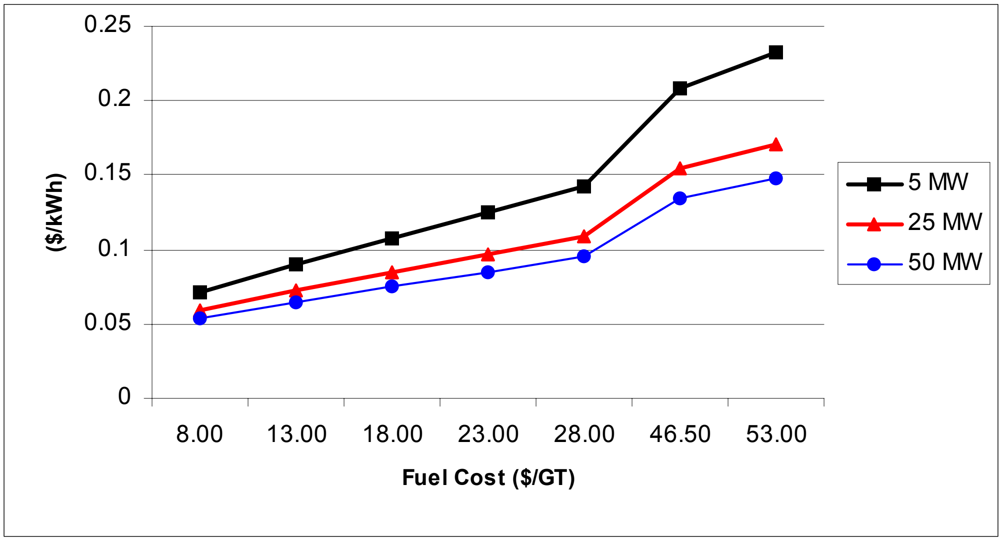

Figure ES-7. Impact of biomass fuel cost on cost of energy

There are potential incentives for developers that could help the economics of a biomass power plant. The U.S. Congress could expand the 1.5 ¢/kWh renewable energy production tax credit under Section 45 of the Internal Revenue Code for biomass power to include biomass resources such as forest biomass and mill residues. Currently, this tax credit extends only to biomass from crops grown specifically for energy production. The Healthy Forests Restoration Act of 2003 also contains language that will facilitate biomass power development. In addition, the U.S. Department of Agriculture Rural Business Cooperative Service provides a wide array of programs for rural communities to develop renewable energy resources both for biomass power and alternative fuels such as ethanol.[10]

Nearly all ethanol consumed in the U.S. is produced from the starch component of grain crops. Manufacturing ethanol from the lignocellulosic components of biomass (commonly referred to as "biomass ethanol") is an emerging technology. There are no commercial biomass ethanol facilities in the U.S., only demonstration scale or scale-up plants designed to prove the technical viability of cellulose-to-ethanol technology. The facility closest to a full-scale operation is the Iogen Corporation facility in Ottawa, Canada. This facility is currently converting 50 tons of wheat straw to fermentable sugars per week, and Iogen is in the process of completing construction on distillation columns for the plant in 2004. When completed, the plant is expected to be able to manufacture 700,000 liters (184,940 gallons) of ethanol per year using an enzymatic hydrolysis process.[11]

In contrast with the Iogen facility, a commercial-scale plant would produce 15 million gallons or more of ethanol per year. However, for any proposed facility, an economic optimum plant size would be determined based on feedstock (and other operating) costs, ethanol yield and capital costs. Figure ES-8 shows how estimated cellulose ethanol production costs change with plant size.

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[10] U.S. Department of Agriculture, Rural Business – Cooperative Service, *Rural Business – Cooperative Service Home Page*, http://www.rurdev.usda.gov/rbs/.
[11] Tania Glithero, Iogen Corporation (personal communication with Tim Rooney, McNeil Technologies, Inc., November 21, 2003). More information on Iogen Corporation can be obtained on-line: http://www.iogen.ca.

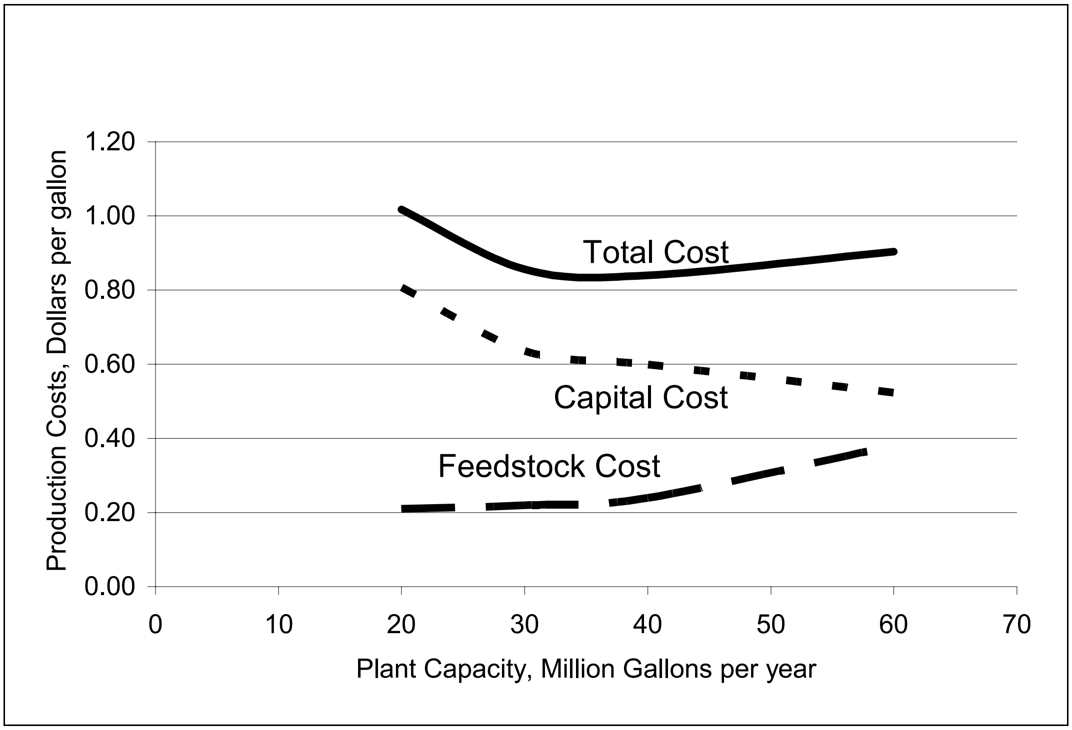

Figure ES-8. Cellulose ethanol production costs

The biomass ethanol technologies that are closest to commercialization include concentrated acid hydrolysis, dilute acid hydrolysis and enzymatic hydrolysis. A technology that has promise for possible smaller-scale applications is biomass gasification, followed by catalytic conversion to ethanol. Most cellulose ethanol facilities are assumed to generate power in excess of their needs by burning the lignin left over from processing biomass into sugars.

The feedstock requirements for a biomass ethanol plant can be significantly higher than for biomass power generation. Figure ES-8 shows that a 15 million gallon per year biomass ethanol plant would need an estimated 600,000 green tons of biomass per year to operate, the majority of the available supply in the study area. However, the positive regional economic impacts of biomass ethanol are also greater than for biomass power.

There is an existing market for ethanol as a fuel additive. In addition, as California phases out the use of methyl tertiary butyl ether (MTBE) as a fuel additive, regional ethanol markets will expand. Cellulose ethanol can help meet that demand in California and elsewhere. The California Energy Commission provides detailed information about the MTBE phase-out on its website.[12]

CONCLUSIONS AND RECOMMENDATIONS

The project conclusions and recommendations fall within three overall categories:

- resource availability, supply planning and communication,
- opportunities and barriers for biomass utilization and
- recommendations for next steps.

[12] California Energy Commission, *Ethanol in California* (http://www.energy.ca.gov/ethanol/).

Resource availability, supply planning and communication

Biomass resource availability in the region is adequate to support the development of one large or several smaller biomass energy facilities. Modification of existing forest and agricultural practices will be required in order to make the biomass available, and sufficient assurances for both forestry professionals and farmers will be required to attract investment in new equipment and expansion of existing operations.

Significant community input and communication will be required in order to develop support for large-scale biomass resource development. The larger the annual resource requirement, the more significant will be concerns from stakeholder groups and individuals in local communities, industry and government.

Opportunities and barriers for biomass utilization

The two potential applications evaluated for this project are:

- biomass power or cogeneration; and
- ethanol manufacturing from cellulosic biomass sources.

The available resource, as discussed previously, is capable of supporting either of these two options. Clearly, the high cost of forest biomass is a major barrier to the development of cost-effective biomass energy outlets in the region. The biomass power option presents less risk since it is a proven technology and it requires a lower proportion of the available resource. Because it uses less of the available resource, it is more sheltered from unanticipated supply variability, and fuel costs will, in general, be lower. However, ethanol may have a growing market outlet as gasoline refineries phase out MTBE in favor of ethanol as an automotive fuel additive in California. Also, the market value of ethanol is higher than the value of electricity.

A technology focus that was not considered in detail for this study, but should be mentioned, is the potential for small- to mid-scale biomass heating for institutions such as schools, hospitals, commercial buildings, government and other community facilities. Such systems require a smaller biomass resource, have lower capital cost requirements and can serve as a valuable hedge against volatile natural gas prices. Since these systems are smaller and there is a broader spectrum of applications, many systems can be installed throughout an area, reducing transportation distances and fuel costs. The Fuels for Schools Program, in which a biomass heating system is being installed at a school in Darby, Montana, is one example of how biomass heating technology can contribute to community-level fuels reduction.[13] In this project, the local school district teamed up with the USFS to install a biomass heating system that will save the district money on its heating bills and promote community engagement in renewable energy development and forest stewardship. Similar projects are planned in Nevada, Colorado and California. Vermont has been heating schools and public buildings with wood for many years.

Estimated biomass power generation costs exceed local retail power rates as well as the expected buyback rate from regional electric utilities by a significant margin, and it is unclear whether local and regional markets for green power or green tags will cover the gap between generation costs and the retail power costs or buyback rates. Development of green power and green tag markets in the future could improve the economics of biomass power generation. This report was

[13] Bitter Root Resource Conservation & Development Area, Inc., *Fuels for Schools* (http://www.fuelsforschools.org/).

not meant to provide a detailed economic analysis of biomass energy opportunities. Potential projects in the region must conduct their own site-specific, technical and economic feasibility studies. The information developed in this report can be used to feed into site-specific studies.

In the case of cellulose ethanol, corn-based ethanol is currently less expensive than cost projections for cellulose ethanol, though no real cost information exists for cellulose ethanol since it has not been commercially demonstrated. Future market growth for ethanol as it expands to meet the gap left by MTBE exceeds current corn-based ethanol capacity, which could create a niche for cellulose ethanol as demand grows.

Recommendations for next steps

Several recommendations regarding resource planning can help facilitate development of the biomass resource in the region:

- Federal forest management officials and private landowners should investigate the costs and benefits of removing biomass from forest management sites as an alternative to piling and burning wherever possible
- There should be greater cooperation across forest landowners (federal, state, private and local) on planned thinning projects and biomass product offerings through a regional database managed by a multi-agency governmental group, local non-profit organization or resource advocacy group
- Multi-year forest resource planning should be conducted to enable long-term biomass supply planning; and
- Outreach to farmers should be realistic and emphasize where and how residue utilization can help reduce burning costs and generate new revenue sources, while being compatible with best practices for maintaining soil productivity.

In order to overcome local concerns regarding sustainability and the impacts of biomass utilization, the following steps should be taken to garner community support from a wide array of interests:

- A multi-agency governmental group, local non-profit organization or resource advocacy group should develop an annual monitoring process in cooperation with (and with the support of) project developers. The monitoring process should document the resources affected and the results of biomass removal, using measures such as the total extent and the proportion of land actually affected by management in each vegetation type and potential land use; and
- Project developers should consider installing multiple smaller systems over a period of time rather than a single large system that would immediately draw from a large land area and continue to do so each year.

Now that the preliminary technical, economic and environmental impacts of biomass resource development have been evaluated, we recommend the following steps to further evaluate the cost-effectiveness of biomass power and cellulose ethanol in the area:

- Build on the forest resource data and information developed for this study by working with resource advisory groups to develop more detailed, multi-year project level data showing biomass availability and locations for forest management projects for federal, state and private landowners

- Identify agricultural producers and conduct a more detailed assessment of their willingness to collect and bale crop residues
- Begin a formal discussion with Boise Cascade regional management to evaluate their heating and power purchase requirements, and determine if they are willing to investigate a cogeneration facility
- Further evaluate the production costs and markets for a cellulose ethanol facility in light of future market growth for ethanol as a fuel additive in the wake of the California MTBE phase-out
- Further evaluate biomass facility and district heating and cooling technology potential
- Network with regional non-profit organizations to take advantage of the analytical expertise, resource analysis and marketing support these groups can offer a developing industry. Two such regional organizations are Renewable Northwest Project (http://www.rnp.org/) and NW Energy Coalition (http://www.nwenergy.org/).
- Develop an annual monitoring report for biomass collection and utilization showing the impacts and benefits of biomass utilization; and
- Identify and pursue potential grant opportunities to help reduce the costs of biomass fuel.

It should be noted that developing the biomass resource and large-scale markets is a multi-year process. This should be taken into account when making business decisions.