Biomass Energy and Biofuels from Oregon's Forests

Prepared for:

OREGON FOREST RESOURCES INSTITUTE

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"Keeping America competitive requires affordable energy. And here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world. The best way to break this addiction is through technology. ... By applying the talent and technology of America, this country can dramatically improve our environment, move beyond a petroleum-based economy, and make our dependence on Middle Eastern oil a thing of the past."

President George W. Bush
January 31, 2006

"I want you to know that I am committed to making Oregon a national leader in forest biomass energy development…. Our forests make biomass a natural fit for Oregon. We will be able to reduce the risk of forest fires by removing dry debris – and then use that debris to generate energy, all the while creating jobs, attracting new businesses, and shifting our economy into a higher gear."

Governor Theodore R. Kulongoski
Closing Comments to 4th Annual Leadership Summit
January 9, 2006

"Across millions of acres of Oregon's forests, timber stands have become overcrowded with small trees, many of them in poor health and vulnerable to attack by insects, disease and fire. Instead of fueling more of the uncharacteristically severe wildfires that we've seen in recent years, this biomass could be used to generate energy or produce other economic value. Well-planned removal and use of this material holds the promise to restore resiliency to these forests and to boost the state's economy."

Marvin Brown
Oregon State Forester

"The prosperity of states has little to do with the mix of (economic) clusters in a region; it has everything to do with the sophistication and productivity of the clusters. For Oregon, this means focusing economic development efforts on the productivity and technological capability of industry clusters where the state has a critical mass – including traditional industries such as forestry…"

Dr. Michael Porter
Harvard Business School Professor
Opening Remarks to 4th Annual Oregon Leadership Summit
January 9, 2006

Preface

The Oregon Forest Resources Institute (OFRI) commissioned this study on the opportunities and barriers for Biomass Energy and Biofuels from Oregon's Forests. The timely study documented in this report identifies some short-term opportunities to move Oregon forward in developing a biomass industry. Key findings of the study include:

- The conversion of woody biomass to energy in Oregon presents a unique opportunity to simultaneously address three challenging needs: restoring forest health, fire resiliency and wildlife habitat, finding renewable energy alternatives, and revitalizing rural economies.
- An estimated 4.25 million acres (about 15% of Oregon's forestland) have the potential to provide forest biomass by thinning of forest stands to reduce risk of uncharacteristic fire.
- Thinning these acres over 20 years could produce 1.0 million bone dry tons (BDT) per year of woody biomass not including merchantable sawtimber.
- Delivering this 1.0 million BDT of biomass to processing facilities would cost an average of $59/BDT based on integrated harvesting and collecting which combines costs associated with biomass with the costs associated with merchantable timber. Harvesting and collecting costs for woody biomass would be much higher if only non-merchantable material is harvested.
- The most economically and technically feasible opportunity for woody biomass in the short term is for generation of electricity and production of heat from thinning dry southern Oregon forests. Longer-term, production of biofuels and bio-products to reduce reliance on fossil fuels may prove to be the more significant opportunity.
- One million BDT of biomass could produce about 150 MW of electricity.
- The cost of producing electricity from $59/BDT of woody biomass in stand-alone electricity generating facilities would be in the 8-9¢/kWh range.
- To produce electricity at stand-alone electricity generating facilities in the 6.5 – 7.5¢/kWh range of current markets, delivered fuel costs would need to be in the range of $45/BDT. An estimated 0.6 million BDT of delivered biomass per year and electric capacity of 81 MW could meet these current market parameters.
- Electricity produced in a combined heat and power facility, such as a lumber mill with co-generation would result in significantly lower kWh costs.
- The 1.0 million BDT per year of woody biomass created by thinning the 4.25 million acres identified in this analysis could be significantly increased through harvesting western juniper in rangeland restoration, harvesting logging slash in other timber harvests, urban wood waste, agricultural biomass and excess milling residue.
- Collaboration and agreement between stakeholder groups on forest management and industrial development issues will be necessary to develop a biomass industry in Oregon. Projects starting at Warm Springs and Lakeview provide examples of this.

The OFRI Board and staff appreciate the thorough and professional work done by the Bio-Energy project team including researchers and analysts from Mason, Bruce & Girard, Inc.; Pacific Energy Systems, Inc.; OSU Colleges of Forestry and Agricultural Sciences; and Dr. Jim Bowyer. We also appreciate the input of the Oregon Forest Biomass Working Group.

Mike Cloughesy
Director of Forestry

Executive Summary

Introduction

The Oregon Forest Resources Institute commissioned this study, *Biomass Energy and Biofuels from Oregon's Forests*, to better understand the potential for renewable energy development using biomass derived from Oregon's forests. The study's objectives are as follows:

- ***Review existing research*** on potential for production of biomass energy and biofuels from Oregon forests *(Chapter 1)*.
- ***Assess the potential*** in Oregon for production of electricity and biofuels from woody biomass, including available wood supply and environmental, energy, forest health, and economic effects *(Chapter 2)*.
- ***Review and summarizes efforts underway*** to promote electric energy and biofuels from wood biomass, and identify gaps in existing efforts *(Chapter 3)*
- ***Conduct interviews with Oregon biomass stakeholders*** to document the diverse perspectives of various groups concerning the opportunities for forest biomass-based energy production, its potential benefits, and challenges or barriers to development *(Chapter 4)*.
- ***Assess constraints and challenges*** to development of biomass energy and biofuels from Oregon forests, including economic, environmental, legal, policy, infrastructure, and other barriers *(Chapter 5)*.
- ***Develop recommendations*** on how Oregon can best overcome the barriers to production of wood-based bio-energy *(Chapter 6)*.

What Is Woody Biomass?

Biomass refers to the sum total of all organic material in trees, agricultural crops and other living plant material. Woody biomass is any biomass composed of wood. In Oregon, it arises from 3 sources:

- ***Wood products residue*** is the wood waste generated at Oregon sawmills and other wood products plants such as trim, shavings, woodchips, sawdust, bark, and other residues.
- ***Urban wood waste*** includes discarded wood and yard debris. This waste stream often ends up in landfills but it can be diverted for energy production.

- ***Forest biomass*** is the waste material generated from logging or thinning activities in forests. Although strictly speaking, biomass refers to the entire main stem, branches and tops of trees, the term is commonly understood to refer only to the small diameter waste material, less than 5 to 7" in diameter, that cannot be used for traditional timber products.

This report focuses primarily on forest biomass although it discusses current uses of wood products residue as a secondary topic. Increasing the use of forest biomass presents the largest opportunity for producing additional energy from woody biomass in Oregon.

What Is The Opportunity?

The conversion of woody biomass to energy in Oregon poses a unique opportunity to simultaneously address three challenging problems:

- The need to restore Oregon's forest health
- The need to find renewable energy alternatives
- The need to revitalize Oregon's rural communities

- **Forest Health**

Evidence indicates that many of our state's forests are out of balance with natural conditions and therefore more susceptible to insects, disease and wildfire than ever before. Fire suppression and other influences over the last several decades have created an accumulation of excess woody material, particularly in the dry forest types of eastern and southern Oregon. This places our forests at risk of wildfires that could cause significant ecological damage at a landscape scale and, no less importantly, places our nearby communities at risk as well. Wildlife habitat is adversely affected as well. Oregon's forests need to be restored ecologically.

Federal forest scientists have identified 12.2 million acres of forestland statewide in Fire Condition Classes 2 or 3. These conditions are found primarily on federal forestlands. In these forests, fire regimes are moderately to significantly outside the historic, natural range and the risk of losing key ecosystem components in the event of a wildfire are moderate to high. Treatments such as use of prescribed fire and mechanical thinning could be used to restore these forests to natural conditions. In some cases, fuel loads are so high that scientists believe that prescribed fire cannot be used without mechanical removal of fuels first.

The lack of markets for forest biomass material makes fuel reduction treatments a costly undertaking. Harvest and transportation of small diameter logs and biomass material is more expensive than larger timber. Federal land management agencies and other landowners lack resources to cover these costs. Yet, to reduce fire hazards, the material must either be physically removed from the site or burned on location. Providing markets for this material to help cover the costs of forest restoration treatments would help solve to forest health and habitat problems.

- **Renewable Energy**

With the peak of worldwide petroleum production in sight, interest in alternative energy sources is growing. Most people recognize that America is placing its economic future and national security at risk by continuing to rely on fossil fuels which are becoming increasingly expensive and often come from societies that are hostile to us. In addition, it is becoming increasingly evident that fossil fuels carry heavy environmental costs that must be addressed.

Bio-energy alternatives are emerging as substitutes for fossil fuels in power generation, transportation fuels (ethanol and biodiesel), steam heat, and production of biochemicals. Conventional technologies are available that can be applied immediately to produce electricity and heat from biomass. In fact, they have been applied for decades by the forest products industry to utilize mill wood wastes and generate a significant amount of energy. The total energy value of biomass fuel in Oregon was about 10% of non-transportation energy consumed in the state in 2003. About 37% of biomass-derived energy came from wood wastes. Another 46% came from combustion of spent pulping liquor, a byproduct of the papermaking process.

The potential payoff from production of liquid fuels from biomass is greater. Technologies to convert cellulosic biomass such as wood to ethanol, while not yet commercial, should be available within the next decade. Ethanol, a substitute for gasoline, can reduce our reliance on fossil fuels for transportation and help bring down fuel prices. Currently, the nation's ethanol supply comes almost entirely from corn. Production of ethanol from cellulosic biomass has many environmental and economic benefits. Production of biochemicals to replace petroleum-based chemicals is also an opportunity that deserves increased attention.

- **Rural Revitalization**

Oregon's rural communities, especially those that have long been dependent on the surrounding natural resources for economic health, are struggling. Many factors have contributed to this – one of which is the decline in timber harvest from federal lands. As timber harvesting has declined, family wage jobs have been lost, mills and supporting businesses have closed and economies have weakened. Rural Oregon communities need revitalization.

How Large Is The Opportunity?

The largest opportunity in Oregon is creation of an industry that is appropriately scaled to match forest restoration needs primarily on public forests in eastern and southern Oregon. Creating such an industry would provide a market for woody biomass material that could help pay the cost of ecosystem restoration.

Biomass utilization for energy should be considered a tool for improving the health of our forests. To ensure a sustainable, appropriate level of development, the needs for forest restoration should determine the scale of the forest biomass energy industry. The magnitude of this opportunity, then, hinges on the question of to what extent forest restoration treatments are needed and how much biomass material would be removed to support restoration goals.

Previously published estimates of forest biomass from forest health thinnings in Oregon vary widely, ranging from 0.8 – 7.3 million BDT annually depending on assumptions of area needing treatment, volume removed per acre, proportion of volume that is biomass versus commercial timber, and the number of years over which treatments are completed. This wide range of estimates naturally leads to a question about which is the most realistic.

We analyzed potential biomass supply from fuel reduction treatments across 20 eastern and southern Oregon counties in the dry, inland forest region of Oregon using the Fuel Treatment Evaluator 3.0, a computer model for assessing fuel reduction opportunities. The analysis was based on the best available forest inventory data from on-the-ground sample plots and quantitative, stand-level criteria were used to delineate the area needing treatment.

The eligible area was defined as public and private timberland with high fire risk outside of designated roadless areas, Wilderness areas, parks and other forestlands where harvesting is excluded. High fire risk areas were defined as those classified as Fire Condition Classes 2 and 3 having either Crowning Index or Torching Index below 25 mph.

A mix of thinning treatments was applied on the eligible treatment area to estimate removals. Trees were removed until Crowning and/or Torching Index values indicated a significant reduction in fire risk.

Results of this analysis suggest that a biomass supply of approximately 20 million BDT would result from treatment of 4.25 million acres of eligible forestland, or approximately 27% of the total timberland area in the 20 counties. About 71% of the eligible forestland is publicly owned and nearly all of this is federal. Private lands account for 29% of the eligible treatment area.

If treated over a 20 year period, approximately 1 million bone dry tons

(BDT) would be produced annually assuming no allowance for growth. Average delivered cost would be $59/BDT in today's dollars based on integrated harvesting and collection costs and assuming processing facilities were well distributed across the region. Over the entire landscape, revenues from sale of merchantable timber and biomass could cover direct treatment costs (harvesting and hauling) if sawtimber revenues were allowed to subsidize biomass harvest and transport costs.

In addition to the statewide analysis, we also conducted two sub-state assessments within a 75-mile radius of Klamath Falls in southern Oregon and La Grande, in northeast Oregon. Comparisons illustrate dissimilarities in forest types and conditions in the two areas. The Klamath Falls analysis found 1.1 million acres eligible for treatment within 75 miles. Treatment would produce 9.4 million BDT at an average delivered cost of $76/BDT. In the La Grande area, 292,000 acres were eligible for treatment yielding 1.0 million tons of biomass at average delivered cost of $73/BDT. These volumes are from forest types that typically experience surface and mixed fire severities. An additional 2.9 million tons for Klamath Falls and 1.5 million tons could be delivered to Klamath Falls and La Grande, respectively, from treatment of forest types that tend to have high intensity fires under natural conditions.

How Much Energy Would This Produce?

- **Electricity**

One million tons of feedstock under the assumptions shown below would be capable of producing about 150 MW of electrical power. Assuming eight plants at the hypothetical locations used in the analysis, average capacity would be about 18 MW. By comparison, the 2004 total installed electrical generation capacity in Oregon was 5,734 MW, with load growth expected to be a little over 100 MW per year.

The average net cost of the biomass-produced electricity would be 8.1¢ per kWh for the first five years by taking advantage of the federal production tax credit (PTC) and 9.0¢ for the next five years. This net cost is competitive with alternatives such as natural gas but is not competitive with other renewables such as wind.

To produce electricity in the 6.5 – 7.5¢/kWh range of current markets, fuel costs would need to be in the range of $45/BDT. At an average delivered cost of $45/BDT, electricity production cost drops to 7.9¢/kWh and the net production cost for the first five years, after the PTC, would be 7.0¢/kWh. However, based on our supply curve, only 0.6 million BDT per year could be delivered at that cost. Total electric capacity falls to 81 MW when average delivered cost is limited to $45/BDT.

Cost savings from these estimates are possible depending on additional subsidies that may be available from the Energy Trust or federal development grants. In some ways, this is a worst-case scenario since it is based on a stand-alone power plant with no market for the steam produced by the process. A power plant associated with a lumber products mill, especially an expansion of existing power facilities, could result in significantly lower costs. Fuel savings are also possible from the combined use of mill residues and chipped forest thinnings.

- **Ethanol**

Assuming the entire 1.0 million annual BDT supply was to be directed to ethanol production when technology becomes available, it would produce approximately 61 – 66 million gallons per year. To put this into perspective, the ODOE estimates that in 2002, up to 60 million gallons of ethanol were used to oxygenate over 1.5 billion gallons of gasoline consumed by Oregonians.

What About Other Sources Of Woody Biomass?

Other sources of woody biomass were also considered. In total, it is conceivable (though not proven economical) that these three additional sources could provide another 1.0 million BDT of woody biomass supply annually over at least a 20-year period.

The potential to increase energy production from woody mill residues in Oregon is limited by available supply. In 2002, 6.8 million BDT of mill residuals were produced in Oregon. Sixty-four percent was subsequently used in the production of secondary products, 25% was used as fuel, and less than 1% was un-used. Secondary products such as pulp, paper, particleboard, and other products currently represent higher value uses than energy production, so diversion of the fiber used for these products into energy production is unlikely, at least in the near future.

The largest source of forest biomass, other than fuel treatment of overstocked forestlands, is the 3.6 million acres of western juniper forest in 14 eastern Oregon counties. The control and eradication of juniper is a significant issue for range management and ecology. Juniper biomass has a high fuel value and few alternative uses. Control over a 20-year period would involve treatment of 178,000 acres per year, producing 0.60 million BDT of juniper biomass annually. The delivered cost per BDT is unknown. Control of juniper is an expensive undertaking but experience in California suggests that further investigation into the use of juniper for energy production in Oregon is warranted.

Logging slash from commercial timber harvests other than fuel treatments could also contribute to the forest biomass supply. Much of this volume is located in westside counties outside our 20-county study area but up to 0.45 million BDT/yr could be available within the 20-county study region.

What Are The Environmental Benefits?

Science on the environmental issues surrounding use of forest biomass for energy production indicates environmental benefits arise from reducing the risk of catastrophic wildfire, restoring overcrowded forests to conditions that are more natural, and from replacing non-renewable energy with renewable energy. Benefits include air quality improvement, reduction in greenhouse gases, soil and water conservation, and protection and restoration of wildlife habitat and biodiversity. Some benefits accrue from both forest restoration and fossil fuel replacement. For example, air pollution and greenhouse gases emissions are reduced by reducing wildfire likelihood and by reducing emissions from energy production as biomass replaces fossil fuel. Other impacts are characterized in terms of short-term versus long-term risk.

Environmental benefits of biomass energy are estimated at 11.4¢/kWh. The value of avoided forest overgrowth is estimated as 20.2¢/kWh. The estimated net benefit of fuel reduction treatments is $606 - $1,402+ per acre. These results suggest that the environmental benefits of forest biomass use for energy are well in excess of the market value of the electricity produced.

What Are The Other Benefits?

A primary benefit is an improvement of forest health and fire resilience, which should reduce resource losses to wildfires, improve public safety, and reduce wildfire suppression expenses. As measured by Crowning and Torching Indices, fuel treatments modeled in our analysis significantly reduced fire risk on 4.25 million acres. Losses to insect and diseases should be reduced also as general forest health conditions are improved.

Woody biomass energy can help Oregon achieve its goal of supplying 25 percent of the state's energy needs from renewable resources by 2025. Reducing our dependence on fossil fuels and foreign oil supplies supports national goals of lowering the trade deficit and may help alleviate national security concerns related to the political conflicts of the Middle East and parts of South America.

Closer to home, a direct economic impact related to forest biomass utilization is job creation, predominantly in the rural areas of Oregon. Production of 150 MW of electricity from woody biomass would create about 900 jobs. This does not count indirect job creation, which is usually in the range of 2 - 3 indirect jobs per direct job.

What Is Being Done Already?

Activities promoting woody biomass to energy conversion are occurring at many state, federal levels and in the private sector. These are documented in Chapter 3.

- **State**

Within Oregon state government, there are several efforts underway promoting renewable energy in general as well as forest biomass utilization specifically. Many of these efforts have been initiated only within the last one or two years. We reviewed them under the following framework:

- Policy and legislation
- Working Groups and Initiatives
- Agency Activities
- Incentives
- Research and Development

Key policies include the Renewable Energy Action Plan, Oregon Business Plan, and Senate Bill 1072, which was signed into law in 2005. A series of interagency working groups, which also involve outside stakeholders, have been formed for the purposes of promoting action on renewable energy. A key group is the Forest Biomass Working Group, which is exploring how utilizing biomass can improve forest health and create a viable biomass industry. The 35+ member Group represents diverse interests: forest and energy industries, resource agencies, environmental organizations, elected officials, tribes, labor representatives, and local communities. State agencies including the Departments of Energy, Forestry, and Agriculture are active in various ways to promote renewable biomass energy.

- **Federal**

At the federal level, we focused on outlining key policies, incentive and grants programs, and research and development efforts. Key policies include the National Energy Policy, National Fire Plan, and forest stewardship contracting. An important tax incentive is the federal Production Tax Credit, which was recently extended to "open loop biomass," a category that includes forest biomass. Oregon projects have benefited from the use of several of the grant programs including the USFS Woody Biomass Grants and Economic Action Program grants. Other programs have not had use in Oregon related to forest biomass.

- **Other Activities in Oregon**

In addition to reviewing state and federal efforts, Chapter 3 lists private sector efforts and describes a number of specific biomass projects in various stages of development in Lakeview, central and southwest Oregon, Warm Springs, LaPine, Sisters, Prineville, and Wallowa.

- **Activities in Other States**

Chapter 3 also provides information on state incentives for renewable energy, and recent biofuels legislation in other states.

How Do Various Stakeholders View This Opportunity?

Most of the 40 participants in a semi-structured interview opinion study, detailed in Chapter 4, held the general opinion that converting forest biomass to energy in Oregon is a beneficial policy direction. Almost all of the participants saw this as a possibility in eastside and southwestern forests where fire suppression has altered the fire regime of the forest. However, it is important to note that there was a wide range of opinions on whether this is a good idea or not expressed within the conservation organizations. On one end of the spectrum were organizations actively promoting projects and research that would convert forest biomass to energy. On the other end were organizations that are highly skeptical of, and in some cases opposed to, the idea, particularly if the majority of material would come from federal forests.

Opportunities for converting forest biomass to energy most commonly fell under the headings of forest restoration, rural economic development, and renewable energy. Forest restoration was generally seen as the most important driver of the momentum to convert forest biomass to energy in Oregon.

Barriers to converting forest biomass to energy typically fell into eight categories: supply issues, general lack of supportive public policies, public perceptions and trust, institutional issues within the federal agencies, market access, technical issues, costs, and potential negative environmental impacts. The most common barriers were under the general categories of obtaining supply, public policies, and public perceptions and trust.

Strategies to overcome the barriers tended to be specific to an individual's experiences and knowledge. Two that came up frequently: at a broad scale, most participants indicated that a collaborative approach would be essential to overcoming the barriers. More specific to biomass conversion to energy, many participants felt a renewable portfolio standard (RPS), with a specific target for biomass energy, would help ensure competitive prices for biomass-generated power assuming that unintended adverse consequences can be avoided. An RPS is a policy set by state or federal government requiring that a certain percentage of a utility's overall or new generating capacity or energy sales must be derived from renewable resources.

Guidelines that should be in place if this policy direction were to continue to move forward were related to sustainable forest management and scaling the facility to ensure that the projects were driven by local forest restoration needs and not the needs of an energy industry.

What Are The Constraints And Challenges?

A number of constraints and challenges need to be addressed if biomass energy development is to help achieve forest restoration goals. We classified these as public acceptance, biomass supply, market constraints, public policies, institutional issues, and technical issues. The state should take a leadership role in addressing these challenges.

Constraints and challenges have been organized into the following categories and detailed in Chapter 5:

- **Public Acceptance –** Without a social license from the public, development of a woody biomass energy industry will not proceed very far. Many of the questions the public have are related to the environmental impacts of biomass energy in general and forest biomass harvesting in particular.

- **Biomass Supply** - Assured access to an affordable, long-term supply of suitable woody biomass for fuel or feedstock is often identified as a major challenge in biomass energy projects.

- **Markets –** Market-related issues including the overall competitiveness of biomass energy, project startup and energy market entry barriers, and other issues also rank high in terms of importance.

- **Public Policies –** Both the state and federal government have made strides over the last few years in putting into place public policies supporting renewable energy. However, there remain some challenges in the public policy arena that need to be addressed.

- **Institutional Issues –** Since a large portion of the potential woody biomass supply from Oregon originates from forest restoration treatments on federal lands, the policies and capabilities of the two primary federal land management agencies, the USDA Forest Service and Bureau of Land Management, are critical to building a successful woody biomass energy industry.

- **Technical Issues** - There are technical issues that require research and development attention. These include research on emerging energy technologies, forest restoration and fuel treatments, harvesting technologies, biomass supply, and alternative uses of harvested material.

What Are The Recommendations?

Resolve Forest Restoration Questions

Public acceptance of a forest biomass energy industry hinges on support for the forest restoration treatments on public lands. The lack of consensus on management of the nation's public lands has led to extended controversy, which has greatly reduced the opportunity for active management of federal lands. Regardless of the worthiness of other goals such as renewable energy and rural development, growth of a forest biomass energy industry will not proceed until the public reaches a consensus on what management strategies are appropriate on these public lands. Scientific evidence and demonstrated results are needed to restore public confidence and support.

On-going collaborative efforts and continued multi-party monitoring of the results will be key to maintaining this momentum. Based on our interviews with stakeholder groups, we believe there is potential for further strengthening public support for restoration treatments. The keys are collaboration and science-driven policy.

Address Other Challenges

As forest restoration issues are resolved, if forest biomass removal is part of the forest health solution, there are other challenges to be addressed by policymakers. If Oregon is to proactively develop a renewable energy industry as a means of achieving forest restoration goals it will need to find ways to address the many constraints and challenges we have identified. It must also use care to design appropriate incentives and policies that promote forest restoration goals and encourage an industry that is scaled appropriately based on these goals.

Guiding Principles for Forest Restoration & Woody Biomass Energy Development in Oregon

- Use collaborative, transparent decision-making processes
- Rely on best available science and adaptive management
- Start small and monitor the results
- Assure a sustainable level of development
- Promote the highest use of forest biomass
- Reduce market risk to attract private investment
- Environmental benefits of biomass energy should be paid for by the beneficiaries

The following is a complete list of recommendations, which are described in Chapter 6.

Recommendations to Promote Forest Restoration

1. Build forest restoration programs on scientific understanding of restoration needs and treatments, and increase knowledge through research, monitoring and adaptive management.
2. Encourage community collaboration and multi-party monitoring.
3. Initiate an outreach effort to build awareness of forest restoration needs, science-informed treatments and bio-energy op-

portunities among the Oregon public.

4. Where consistent with management objectives, encourage integrated forest management across all diameter classes of trees.
5. Build federal land management agency capacity.
6. Develop larger scale, long term, fully funded forest stewardship contracts and restoration programs.
7. Promote long-term research efforts into the methods and effects of forest restoration and juniper control.

Recommendations to Promote Biomass Energy Development

8. Explore development of a Renewable Portfolio Standard for Oregon that creates a market for woody biomass energy and resolves concerns about unintended adverse consequences to ratepayers.
9. Explore development of a Renewable Fuels Standard for Oregon that resolves concerns about unintended adverse consequences to the Oregon economy.
10. Level the playing field vs. other renewables and non-renewables.
11. Adopt a comprehensive state policy on renewable energy.
12. Promote the goals of sustainable biomass energy development.
13. Promote increased use of incentives and grant programs.
14. Look for synergies that make biomass energy economically sustainable.
15. Build community and workforce capacity
16. Promote establishment of a pilot cellulose-to-ethanol plant.
17. Promote small-scale uses of biomass, where appropriate.
18. Encourage involvement of existing bio-energy producers.
19. Engage the state pulp and paper industry in examining the potential for co-production of biochemicals and biochemical feedstocks.
20. Promote needed research and development efforts.
21. Recognize the role of woody biomass in achieving the Governor's 2025 carbon emission goal.
22. Encourage local governments to adopt the ODOE model land use standards for small-scale energy development.

Summary

Development of an appropriately scaled forest biomass energy industry in Oregon has the potential to address three important issues: the need to restore Oregon's forest health, find renewable energy alternatives, and revitalize Oregon's rural communities.

Chapter 1
Background

1.1 Introduction

The conversion of woody biomass to energy in Oregon poses a unique opportunity to address three challenging problems:

- The need to restore Oregon's forest health
- The need to find renewable energy alternatives
- The need to revitalize Oregon's rural communities

Evidence indicates that many of our state's forests are out of balance with natural conditions and therefore are more susceptible to insects, disease and wildfire than ever before. Fire suppression and other influences over the last several decades have created an accumulation of excess woody material, primarily in eastern and southern Oregon forests. This has placed our forests at risk of significant ecological damage at a landscape scale and no less importantly, places our nearby communities at risk as well. These forests need to be restored ecologically.

Most people also recognize, especially given recent fuel price trends, that America is placing its economic future and national security at risk by continuing to rely on fossil fuels which are becoming increasingly expensive and often come from societies that are hostile to us. In addition, it is becoming increasingly evident that fossil fuels carry heavy environmental costs that must be addressed. America needs energy alternatives.

Oregon's rural communities, especially those that have long been dependent on the surrounding natural resources for economic health, are struggling. Many factors have contributed to this – one of which is the decline in timber harvest from federal lands. As timber harvests declined, family wage jobs were lost, mills and supporting businesses closed and economies weakened. Rural Oregon communities need revitalization.

1.1.1 Purpose of the Study

The purpose of this study was to:

- Identify and describe the opportunities for biomass energy and biofuels derived from Oregon's forests, and

- Identify the constraints and challenges that limit woody biomass energy development and develop recommendations to overcome these.

Specific objectives included the following:

- ***Review existing research*** on potential for production of biomass energy and biofuels from Oregon forests.

- ***Assess the potential*** in Oregon for production of electricity and biofuels from woody biomass, including available wood supply and environmental, energy, forest health, and economic effects.

- ***Review and summarizes efforts underway*** to promote electric energy and biofuels from wood biomass, and identify gaps in existing efforts.

- ***Conduct interviews with Oregon biomass stakeholders*** to document the diverse perspectives of various groups concerning the opportunities for forest biomass-based energy production, its potential benefits, and challenges or barriers to development.

- ***Assess constraints and challenges*** to development of biomass energy and biofuels from Oregon forests, including economic, environmental, legal, policy, infrastructure and other barriers.

- ***Develop recommendations*** on how Oregon can best overcome the barriers to production of wood-based bio-energy.

1.1.2 Project Team

The members of the Project Team included the following individuals:

Roger Lord	*Project Manager* *Forest Economist*	**Mason, Bruce & Girard, Inc.** ***Portland, OR***
Carl Ehlen	Principal	Mason, Bruce & Girard, Inc. *Portland, OR*
David Stewart-Smith	Director of Energy Policy Development	Pacific Energy Systems, Inc. *Portland, OR*
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Dr. Mike Penner	Associate Professor	OSU College of Agriculture *Corvallis, OR*
Dr. Jim Bowyer	Wood Science and BioProducts Consultant	*Shoreview, MN*

A Project Advisory Group provided a thorough review of the Project Team's work during the course of the study and added significant expertise to the project. The Advisory Group included the following individuals:

Jamie Barbour	PNW Research Station
Chuck Burley	Oregon House of Representatives
Linc Cannon	Oregon Forest Industries Council
Nils Christofferson	Wallowa Resources
Mike Cloughesy	Oregon Forest Resources Institute

Dennis Creel	Hampton Tree Farms
Jim Geisinger	Associated Oregon Loggers
Mark Kendall	Oregon Department of Energy
Leslie Lehmann	Oregon Forest Resources Institute
Greg Miller	Weyerhaeuser Company
Mike Milota	OSU Wood Science & Engineering Dept.
Joe Misek	Oregon Department of Forestry
Blair Moody	Bureau of Land Management
Adam Serchuk	Energy Trust of Oregon
Bill von Segen	USDA Forest Service

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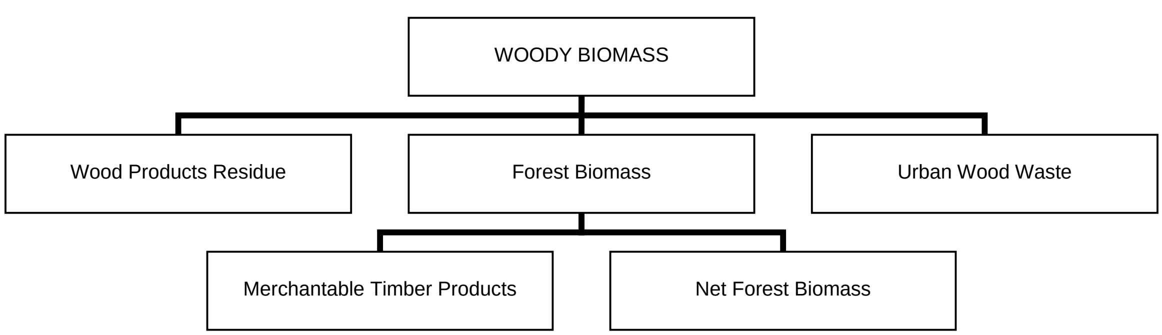
1.1.3 What is Woody Biomass?

There are many definitions of woody biomass. Most generally, biomass refers to the sum total of all organic material in trees, agricultural crops and other living plant material. Woody biomass, then, is any biomass that is composed of wood.

Other definitions are narrower, however. For example, Senate Bill 1072 defines woody biomass as "material from trees and woody plants, including limbs, tops, needles, leaves and other woody parts, grown in a forest, woodland, farm, rangeland or wildland-urban interface environment that is the by-product of forest management, ecosystem restoration or hazardous fuel reduction treatment" (SB 1072 – Section 3 – paragraph b). The focus of this definition is on biomass recovered as by-products of specific forest management treatments.

For our purposes, a definition somewhere in between is needed. Woody biomass generally arises from three sources in Oregon:



Wood products residue is the wood waste generated at Oregon sawmills and wood products mills. Residue from the wood products industry includes trim, planer shavings, veneer cores, woodchips, sawdust, bark and other residues.

Urban wood waste includes discarded wood and yard debris. This waste stream often ends up in landfills but more and more is being diverted for energy production.

Forest biomass is material generated from logging or thinning activities in forests. Strictly speaking, forest biomass refers to the entire main stem, branches and tops of trees. However, the portion of a tree's wood volume that is merchantable for use in traditional timber products such as saw logs and veneer logs is usually excluded. Because this volume clearly has a higher value use, it is generally not considered for use in energy production. Usually, only the residual portion of large trees (tops, branches) and the volume of smaller trees less than 5 to 7" in diameter is included when considering biomass for energy use. In the diagram above, this is shown as "net forest biomass."

A complication arises because net forest biomass can be put to various uses besides energy production. Small-diameter logs, generally 7 to 9" in diameter, which until recently were considered too small for traditional wood products, can now be sawn into small lumber products as sawmills adopt technologies that can process smaller log sizes. Alternatively, they can be used for applications such as posts and poles, landscape timbers, erosion-control products, pulp chips, engineered structural panels, and more. Both small diameter logs and slash can also be used for energy production; they can be burned directly as fuel, processed into fuel pellets, or converted into energy by any of a number of more advanced processes.

Another potential source is dedicated energy crops - those cultivated specifically for energy production. This source is sometimes referred to as ***closed loop biomass***. Oregon currently has no sources of woody biomass from dedicated energy crops. ***Open loop biomass*** is any biomass source other than dedicated energy crops.

Readers will find that most of the focus of this report is on the forest biomass component of woody biomass. That is because wood products residues in Oregon are already being used for energy production or other products and urban wood waste constitutes a relatively small volume of material. Most of the opportunity for increase the use of woody biomass to produce energy in Oregon is found in the forest biomass segment of the woody biomass supply.

1.2 Outline

This report is organized into six chapters:

- The remainder of **Chapter 1** consists of a series of literature reviews around seven topics including:
    - Current energy trends and the emergence of bio-energy alternatives
    - Biomass and biofuels technology
    - Market conditions for woody biomass in Oregon
    - Forest biomass supply in Oregon
    - Biomass harvesting and transportation technologies

    - Environmental impacts of forest biomass harvesting and use for energy production
    - Public perceptions on woody biomass utilization in Oregon

- **Chapter 2** presents an assessment of the potential for production of electricity and biofuels from woody biomass in Oregon. This includes an assessment of forest biomass supply and discussion of the implications of collecting and using this resource for energy and biofuels production.

  The focus of the biomass supply analysis is characterizing the potential supply that could result from implementation of fuel reduction thinning treatments across forests that have been identified as having the highest risk of catastrophic wildfire. We developed a statewide supply estimate as well as local estimates for Klamath Falls and La Grande.

- **Chapter 3** documents the many efforts underway relating to biomass energy at all levels of government and in the private sector. We also assess the effectiveness and applicability of these efforts to forest-based biomass energy and biofuels, and identify opportunities to increase focused effort on forest biomass use alternatives that will likely result in direct biomass energy use, liquid fuels and biomass-derived chemical manufacturing in Oregon.

  We also summarize forest biomass energy development projects underway in Oregon and review incentives available in other states. This information is used to help identify opportunities that impact all areas of biomass development, and to identify criteria for prioritizing action.

- **Chapter 4** presents the results of a series of forty interviews with individuals from nine different stakeholder groups. The purpose of this effort was to identify, from the perspective of stakeholders, the barriers to and opportunities for converting forest biomass to energy in Oregon, as well as potential strategies that could be employed to overcome the barriers, and guidelines that should be in place if this policy direction continues to move forward.

- **Chapter 5** identifies the major constraints and challenges that must be overcome if the potential for woody biomass to energy conversion is to be realized in Oregon. In this Chapter, we identify what we believe are the most important challenges. These have been drawn from a range of sources including the scientific and policy literature (see Chapter 1), stakeholder interviews (Chapter 2), an assessment of potential (Chapter 3), an evaluation of current efforts (Chapter 4), as well as discussions among the project team.

- **Chapter 6** summarizes our major conclusions and presents a number of recommendations in the areas of forest restoration and biomass energy development. These are intended to address the constraints and challenges identified in Chapter 5.

A **Glossary** of many of the technical energy and forestry related terms used in this report, and a **List of Acronyms**, is provided in the Appendix.

1.3 Literature Reviews

Current Energy Trends & the Emergence of Bio-Energy Alternatives

Dr. James Bowyer, Wood Science and BioProducts Consultant

Abstract: With the peak of worldwide petroleum production in sight, interest in alternative energy sources is growing. Bio-energy alternatives are emerging as substitutes for fossil fuels in power generation, transportation fuels (ethanol and biodiesel), steam heat and production of biochemicals. The potential contributions of biomass to domestic energy production far exceeds present levels. The total energy value of biomass fuel in Oregon was about 10% of non-transportation energy consumed in the state in 2003. About 37% of biomass derived energy came from wood wastes. Another 46% came from combustion of pulping liquor. Yet, biomass energy provides a only small portion of electricity supplied to the State's energy grid. Estimates of potential suggest cellulosic feedstocks could supply over 1,100 MW including 421 MW from forest thinnings. Accelerating thinning rates would increase this further. The potential payoff from production of liquid fuels from biomass is greater, with the caveat that the technology is as yet commercially unproven. The potential benefits and public policy issues related to bio-energy development are also discussed.

Current Energy Trends

Changes in Regional, National and Global Energy Markets

Petroleum Outlook Changing

After decades of debate about how long the age of petroleum abundance might last, it now appears that the year of peak petroleum production worldwide may be in sight. With the peak now likely to occur within one to three decades, complacency is beginning to be replaced by a sense of urgency. Alternative fuels and energy sources will soon be needed. So too will alternative sources of chemicals and industrial feedstock now provided as by-products from liquid fuels production.

Petroleum was discovered in Iran in 1908, in Iraq in 1927, and in Saudi Arabia in 1938. The first U.S. oil well went into operation in 1859. Exactly 100 years later U.S. petroleum reserves peaked. In 1970 domestic petroleum production peaked, beginning a steady decline that continues today (Harper 1977).

Within three years of the U.S. peak in petroleum production, a reduction of petroleum production and an embargo on energy shipments to the U.S. and other nations by a number of Arab nations created energy supply problems and chaos in world economies. Marked price increases by principal oil-exporting nations again caused economic problems only several years later. Within the U.S. these developments helped to spur domestic energy conservation programs, development of nuclear energy, and the initiation of alternative energy research on a broad scale. Unfortunately, the obvious political maneuverings that led to the 1970s oil shortages also led to a widely held public view that shortages were not real, but only manufactured by governments and multinational corporations motivated by greed. After only a few years, interest in energy conservation and alternative energy research waned and robust growth of U.S. petroleum consumption resumed. Domestic consumption is now approximately 20.8 million barrels/day (EIA 2006). The U.S. petroleum import reliance, which was 29 percent at the time of the oil embargo, has now grown to 58 percent, with this number expected to rise (Figure 1). Growth in net imports, combined with recent price increases, has significantly impacted the U.S. trade deficit, with a large and growing imbalance (Figure 2).

Figure 1 indicates net imports at 68 percent of domestic consumption in 2025. However, this figure has been revised downward in the latest EIA Annual Energy Outlook (EIA 2006) to 60 percent. The new estimate is based on the projected impact of dramatically higher prices on domestic consumption, exploration, and technology development.

Numerous projections of petroleum reserves and depletion dates over the several decades following the 1970s oil shocks were mostly discounted by business and government leaders and by the general public. So too were rather sobering projections offered in the 1990s by several highly credible research organizations (Table 1). For example, the energy section of the Organization for Economic Cooperation and Development forecast that peak production would occur sometime between 2010 and 2020. Jonathan Edwards, who predicted within one year the U.S. peak, put the peak globally at 2020. However, what began to draw the attention of doubters was a year 2000 study by the U.S. Geological Survey, done at the request of the U.S. Department

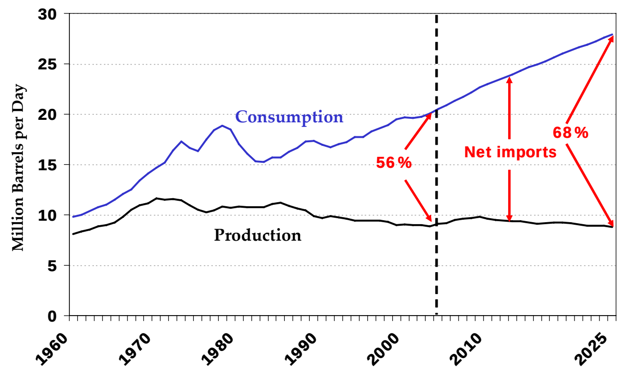


Figure 1 – U.S. Petroleum Supply, Consumption, and Imports, 1970-2025. (Source: EIA Annual Energy Outlook, 2005)

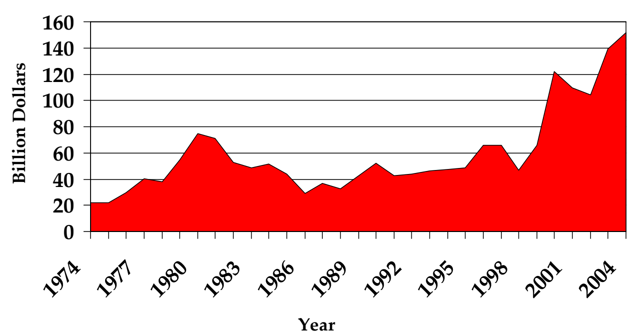


Figure 2 - U.S. Trade Deficit, Energy Products, 1974 – 2004. (Source: USDOE, Energy Information Administration 2005)

of Energy. This was the most comprehensive petroleum forecast ever undertaken and involved assessments of known reserves, estimation of original and remaining stocks, and predictions of future expansion of reserves resulting from discovery of new oil fields and new technology development (EIA 2000a). Using 2 percent annual growth in global consumption as the most likely scenario, the USGS study concluded that peak production would likely occur in 2037. It was the first time that an entity of the U.S. government had predicted that peak production would be reached within the relatively near term. Subsequently, in early 2005, the 2 percent annual consumption growth figure was revised upward by DOE, to 3 percent. The effect was to lower the USGS peak production estimate to 2030. Subsequent analysis of the USGS study (Wood *et al.* 2004) concluded that peak production is likely to occur closer to the middle of the 21st century than to the beginning.

Table 1
Consensus is Emerging that Peak Petroleum Production is in Sight

Organization	Predicted Year of Peak Production
OECD International Energy Agency	2010-2020
World Resources Institute	2007-2014
J. Edwards, Colo. School of Mines	2020
U.S. Department of Energy	2037

Source: Kerr, R. 1998. The Next Oil Crisis Looms Large – and Perhaps Close. Science 281 (August 21), pp. 1128-1131.

Part of the reason for growing pessimism about the longevity of petroleum supplies can be traced to the rapid emergence of China as an economic power. A net importer of fewer than 10,000 barrels of oil daily in 1970, China had net imports more than 200 times that by 2004. By 2025 China's daily net imports will approximate current U.S. net imports – more than 9 million barrels daily (Table 2). Increasing oil consumption is not, of course, limited to China; other growing economies, including those of India and other Asian nations, are exerting pressure on world oil supplies.

As part of the USGS study, scenarios were developed regarding depletion of supply following peak production. The scenario depicted in Figure 3 is based on a rate of decline such that the reserve to annual production ratio remains constant at 10. All scenarios show a steep reduction as increasing consumption collides with a declining supply, suggesting chaotic conditions in world markets absent of the development of energy alternatives. As noted earlier, Wolf *et al.* (2004) discounted the likelihood of peak production occurring within the next several decades.

Table 2
China Petroleum Imports, 1970-2030

Year	Average Daily Imports (barrels/day)
1970	< 10,000[a]
1997	800,000[a]
2004	2,100,000[b]
2025 (est.)	9,400,000[b]

Source: [a] Drennen, T. and Erickson, J. 1998.

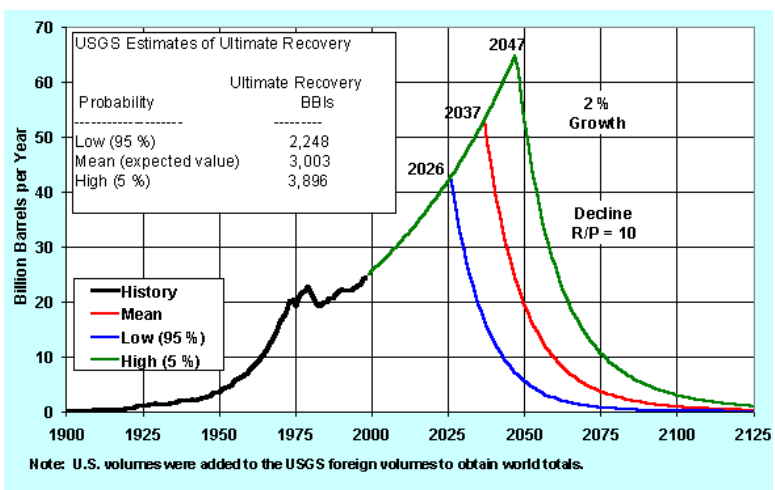


Figure 3 – Annual Petroleum Production Scenarios with 2 Percent Growth Rates and Different Resource Levels. (Source: Energy Information Administration, USDOE 2000a).

Outlook for Natural Gas Supplies Positive

In recent years petroleum supplies have tightened and concerns about coal combustion-related environmental impacts have increased. In response, the industrial sector in the U.S., including the commercial energy industry, has made a significant shift toward use of natural gas. At the same time, increases in population and a robust housing industry have translated to growing demand for natural gas for residential use. The net effect has been the end of a long-standing natural gas demand/supply balance that existed in the United States through the late 1980s, and growing import dependence since then. Currently about 15 percent of U.S. natural gas consumption (22.9 trillion cubic feet in 2005) is provided by imports from Canada and Mexico; this figure is likely to double by 2030 (Figure 4). Through about 2020 the use of natural gas for electricity generation is expected to increase as a percentage of all forms of energy consumed for that purpose. Thereafter, the rate of increase in natural gas consumption is expected to slow (EIA 2006).

Globally, natural gas is projected to represent the fastest growing component of world primary energy consumption, with consumption increases expected to average 2.3 percent annually through 2025. In comparison, annual rates of increase in consumption of petroleum and coal are forecast at 1.9 and 2.0 percent, respectively, over the same time frame (EIA International Energy Outlook 2005).

The world natural gas reserves-to-production ratio is currently estimated at 66.7 years, a number that is little changed from a decade ago. In addition, the mean estimate for worldwide undiscovered natural gas is 4,301 trillion cubic feet, a number that is roughly double the world cumulative consumption forecast through 2025. The bottom line is that global natural gas reserves appear adequate for the foreseeable future, even given rapidly rising consumption (EIA International Energy Outlook 2005).

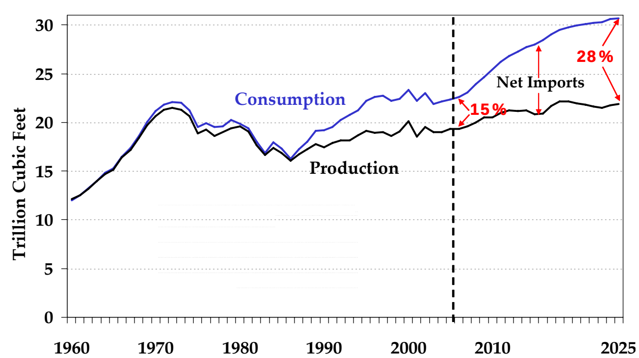


Figure 4 – U.S. Natural Gas Production, Consumption, and Net Imports, 1960-2025. (Source: EIA, Annual Energy Outlook 2005).

Coal Abundant

Coal accounted for 24 percent of total world energy consumption in 2002, with two-thirds of coal consumption used in production of electricity and most of the remainder used by industrial consumers. Only 4 percent of world coal consumption was attributable to the residential and commercial sectors.

Although coal consumption globally is expected to rise substantially in the decades ahead – from 5,262 million short tons in 2002 to 8,226 million short tons in 2025 - the relative share of global energy production that is provided by coal is expected to remain in the 24-26 percent range through 2025. Total recoverable reserves globally are estimated at 1,001 billion tons, a supply sufficient to supply the current level of consumption for about 190 years. The U.S. has more coal reserves than any other country, with recoverable coal reserves sufficient to meet the current level of consumption (1.143 billion tons annually) for over 250 years (EIA International Energy Outlook 2005).

Emergence of Bio-Energy Alternatives

Many Options Are Available

Current interest in bio-energy is driven primarily by near and longer-term concerns vis-à-vis petroleum supplies and the impact of energy imports on the U.S. trade balance. Thus, while plant materials can be used in at least several ways to produce energy, it is the growing need to develop options for liquid transportation fuels that represents the greatest need, and not coincidentally the greatest opportunity.

Bio-energy options include such things as waste wood and pulping liquor from paper production, methane gas from old landfill sites or from manure collected at feedlot or dairy operations, organic materials recovered from wastewater, and municipal solid waste. The volume of manure alone, considering only the volume in excess of that which can be applied for on-farm soil improvement, is estimated at 106 million dry tons annually. However, in terms of volumes available, the bio-material with potential for use as an energy source is overwhelmingly biomass[1]; a recent report suggests the annual availability of over 1.3 billion dry tons in the United States (Perlack *et al.* 2005).

Current technology provides a number of options for conversion of biomass and other biomaterials to energy and these include direct firing for electrical generation, production of ethanol and bio-diesel, and use as a fuel in steam generation for either large-scale district heating or for powering manufacturing operations. In the longer term, biomass may provide an economically viable source of hydrogen fuels (Czernik *et al.* 2004).

Potential Contributions Far Exceed Present Levels

United States

Biomass currently provides less than 3 percent of U.S. energy needs, but almost one-half of the energy produced from renewable energy sources (Figures 5, 6). Today in the U.S., some 190 million tons of biomass is used annually for production of energy or bio-products that directly displace petroleum-based feedstocks. Some 96 million tons, or slightly more than 50 percent of energy from biomass, is produced by the forest products industry for use in powering manufacturing operations. As a result, this industry has a high degree of self-sufficiency, as over one-half of all energy used in the primary forest products industry is self-generated. The U.S. forest products industry self-generates more electricity than any other U.S. manufacturing sector (EIA 1998; Mayes 2003).

[1] Biomass includes a wide variety of plant materials such as forest thinnings, waste wood, fiber crops (switchgrass, reed canary grass), and agricultural residues.

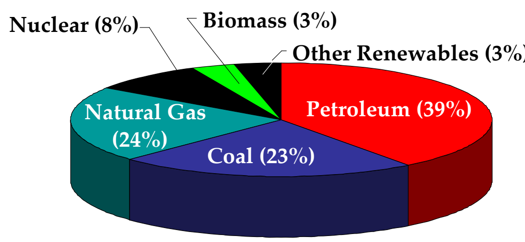


Figure 5 – U.S. Energy Consumption by Fuel Type, 2003. (Source: Perlack *et al.* 2005)

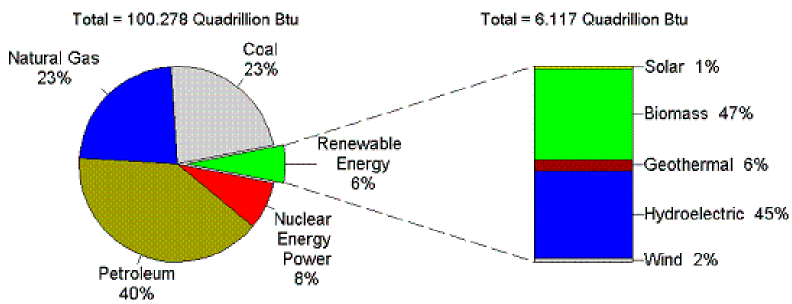
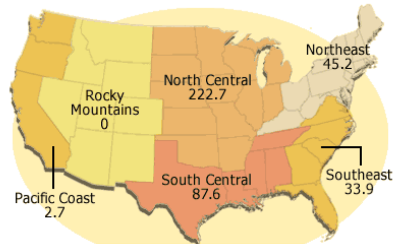


Figure 1 – The Role of Renewable Energy in U.S. Energy Supply. 2004
(Source: U.S. Department of Energy, Energy Information Administration 2005)

The potential contribution of biomass to domestic energy production is far greater than the current level. For instance, there are about 392 million acres in the continental U.S. that are not being used for food production that have the capacity of producing significant quantities of biomass without the need for irrigation (Figures 7, 8). Of these, some 55 million acres have been identified as available and having high potential for production of energy crops such as switchgrass, reed canary grass, poplar, eucalyptus, and other species. An estimated 377 million dry tons of biomass crops could be produced annually from these 55 million acres. In addition, an estimated 428 million dry tons of agricultural residues in excess of that needed for conservation tillage could be removed annually from U.S. farmland for production of bio-fuels (Perlack *et al.* 2005). Another 368 million dry tons of woody biomass could be sustainably removed annually from the nation's forest lands and gleaned from current waste streams; a part of the woody biomass would come from non-commercial forest thinnings conducted for the purpose of reducing wildfire danger.



392 million acres of land in the U.S. is potentially available/suitable for energy crops.

Figure 7 – Available Acreage for Energy Crops. (Source: Tuskan *et al.* 1994)

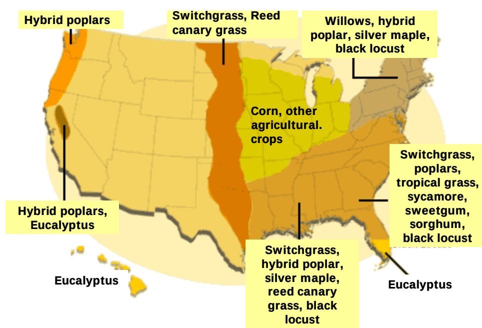


Figure 8 – Geographic Suitability for Energy Crops. (Source: Tuskan *et al.* 1994).

As noted by Perlack *et al.* (2005), if considering only agricultural and forest land, the two largest potential biomass sources, there is potential for annual production of over 1.3 billion dry tons of biomass in the U.S., a volume more than seven times the current volume of biomass consumed for production of bio-energy and bio-based products.

Translating the potential for biomass production to the potential for production of biomass-derived energy. Zerbe (2006) calculated that the woody biomass alone is sufficient to produce about 6.7 exajoules (6.4 quads) of energy. He further noted that through expanded use of existing timber inventories, achieved in part by increasing accessibility to forest biomass, it would be possible to obtain about 10 quads of energy, or about 10 percent of U.S. energy needs. The Perlack *et al.* report sets forth a vision for increased production of biomass energy based on all available forms of biomass. Goals as set forth in this report are based upon use of 1.0 billion dry tons of biomass annually: by 2030 biomass will supply 5 percent of the nation's power, 20 percent of its transportation fuels, and 25 percent of its industrial chemicals and chemical feedstocks. This goal is equivalent to 30 percent of current petroleum consumption.

Not only is the energy production potential from such material substantial (Table 3), but combustion of such material is close to carbon neutral (Haq 2002). The growth of replacement crops following harvest sequesters atmospheric carbon in a quantity equivalent to that released when the harvested crop is burned. This represents a substantial advantage over the combustion of fossil fuels.

Table 3
Average Heat Content of Selected Biomass Fuels

Fuel Type	*Heat Content*	Units
Agricultural byproducts	8.248	Million Btu/Short ton
Black liquor	11.758	Million Btu/Short ton
Digester gas	0.619	Million Btu/Thousand cubic feet
Landfill gas	0.490	Million Btu/Thousand cubic feet
Methane	0.841	Million Btu/Thousand cubic feet
Municipal solid waste	9.945	Million Btu/Short ton
Paper pellets	13.029	Million Btu/Short ton
Peat	8.000	Million Btu/Short ton
Railroad ties	12.618	Million Btu/Short ton
Sludge waste	7.512	Million Btu/Short ton
Sludge wood	10.071	Million Btu/Short ton
Solid byproducts	25.830	Million Btu/Short ton
Spent sulfite liquor	12.720	Million Btu/Short ton
Tires	26.865	Million Btu/Short ton
Utility poles	12.500	Million Btu/Short ton
Waste alcohol	3.800	Million Btu/Barrel
Wood/Wood waste	9.961	Million Btu/Short ton

Source: Energy Information Administration, Form EIA0860B (1999), Annual Electric Generator Report – Non-utility 1999.

Considerable potential exists for development of at least several forms of energy, and for a myriad of chemicals and chemical feedstocks that are currently produced from petroleum:

- **Ethanol**

In 2004, the production capacity of the U.S. corn ethanol industry reached about 3.4 billion gallons per year, continuing a pattern of accelerating growth (Figure 9). The industry is concentrated in the Midwestern states (Figure 10), with Illinois, Iowa, and Minnesota the top producers (Table 4). The vast majority of current ethanol production is based on corn starch, explaining the concentration of ethanol producers in the heart of the nation's corn-belt. The top five producing states currently account for 81.5 percent of the ethanol producing capacity nationwide. There is, however, considerable room for growth of this industry. It is estimated that production from biomass could eventually reach about 50 billion gallons annually (Smith *et al.* 2004), a sizeable quantity when compared to current annual gasoline consumption of about 138 billion gallons (EIA 2005a). Using current technology, production of this quantity of ethanol would require the consumption of the equivalent of approximately 30 billion gallons of gasoline, giving a net gain of some 20 billion gallons. Soon to be implemented technologies would raise the net gain to about 39 billion gallons. At current prices this would translate to a reduction in transfer payments to oil exporting nations of over $115 billion.

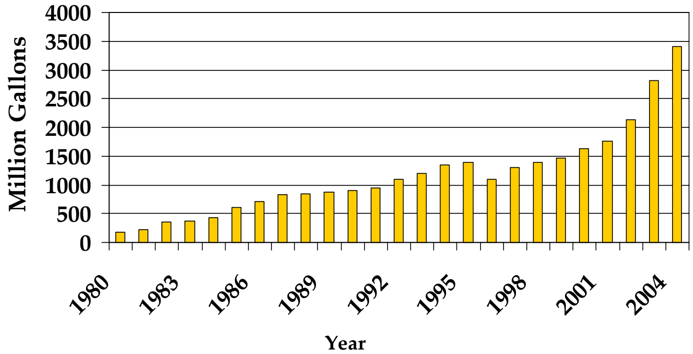


Figure 9 – U.S. Ethanol Production, 1980 – 2004. (Source: Renewable Fuels Association 2005a)

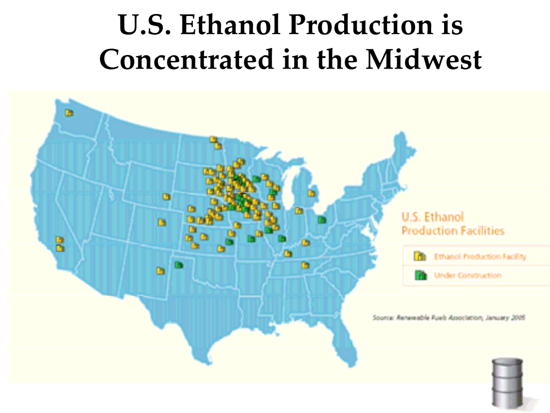


Figure 10 – Geographic Location of U.S. Ethanol Production Facilities, 2005. (Source: Renewable Fuels Association 2005a)

Table 4
U.S. Ethanol Production Capacity by State, 2005*

State	***Annual Ethanol Production Capacity (million gallons)***	Percent of U.S. Production Capacity
Iowa	1,262.5	28.7
Illinois	816.0	18.6
Minnesota	523.6	11.9
Nebraska	523.0	11.9
South Dakota	456.0	10.4
Wisconsin	210.0	4.8
Kansas	149.5	3.4
Indiana	102.0	2.3
Missouri	100.0	2.3
Tennessee	67.0	1.5
Michigan	50.0	1.1
North Dakota	33.5	0.8
New Mexico	30.0	0.7
Texas	30.0	0.7
Kentucky	25.4	0.6
California	8.0	0.2
Wyoming	5.0	0.1
Ohio	4.0	0.1
Colorado	1.5	--
Washington	0.7	--
	4397.7	100.1

* Includes capacity under construction as of January 2005
Source: Renewable Fuels Association, 2005a.

Although current U.S. ethanol production is almost totally based on corn starch, future expansion of ethanol production is expected to be based on a cellulose-to-ethanol processing technology. In part this expectation is based on the view that the production of ethanol from corn is a mature technology that is unlikely to yield significant future reductions in production costs (DiPardo 2002). A larger part of the equation is the expectation that cellulose-based processes will yield more gallons of ethanol per dry ton of material produced, leading to substantial improvements in the net energy balance realized in conversion. For instance, corn-based ethanol is reported to have a net energy balance of 20,000 – 25,000 Btu/gallon whereas the balance for cellulose-derived ethanol is expected to exceed 60,000 Btu/gallon (Wang *et al.* 1999). Expectations are based on a near-term ethanol yield of 76 gallons/dry ton of hardwood biomass, and a yield figure that will reach 98 gallons/dry ton by 2010 (Wang *et al.* 1999); both of these numbers are well above the 66 gallons per dry ton assumed for forest thinnings in a 2000 study commissioned by the Oregon Department of Energy (Graf and Koehler 2000).

It is important to note that ethanol has a lower fuel density than gasoline, 2348 kJ/m3 or 84,250 Btu/gal., as compared to 3456 kJ/m3 or 124,000 Btu/gal. for gasoline (Zerbe 2006). Thus, ethanol does not substitute gallon for gallon for gasoline.

Despite the widely shared positive outlook for cellulosic ethanol it is worth noting that the technology is currently not commercially viable, with production thus far only within laboratories and several pilot plants. As reported by BioCycle (Greer 2005), a major limitation has been the high cost of cellulose enzymes. One enzyme producer, Genencor, who received DOE funding to study the problem announced in October 2004 a 30-fold reduction in the cost of enzymes, to a range of $0.10 to $0.20 per gallon of ethanol. Additional research efforts are focused on biomass pretreatment to allow improved yields of sugars without material degradation. Thus, progress is being made to bring cellulose-to-ethanol production from the laboratory and pilot plant to commercial production. Until commercialization becomes reality, however, projections of future production are highly speculative and must be kept in perspective (California Energy Commission 2004). In addition, in the short run at least, ethanol development is projected based on an assumption of continued federal subsidies, which at this writing extend only through December 2007. An encouraging message regarding cellulosic ethanol development was the mention of this technology in President Bush's State of the Union Address in January 2006; the President indicated substantial increases in R&D funding and called for commercialization of cellulosic ethanol within six years.

- **Biodiesel from Biomass**

Biodiesel is an alternative to petroleum diesel, used in both pure form, or more commonly as a 20 percent blend with petroleum diesel. It can also be used in boilers or furnaces designed to use heating oils or in oil-fueled lighting equipment. Biodiesel has been in common use in Europe for over 20 years. U.S. biodiesel production in 2005 is expected to total about 30 million gallons, with much of this made from soybean oil. An increase in domestic production, to perhaps as much as 200 million gallons is expected by the end of 2007.

Biodiesel can be made from almost any kind of oil or grease, with waste vegetable oil the favored raw material. However, the volume of used cooking oil is far smaller than that needed to produce significant quantities of transportation fuel – thus the focus on soybeans and other sources of oil.

- **Electricity from Biomass**

Sampson *et al.* 2001, citing a DOE database, reported a U.S. biomass electrical generating capacity of about 7,800 megawatts in 2000, with 350 plants spread across 39 of the 50 states. As noted by Zerbe (2006) most of these are equipped with steam-driven turbine generators. Another 650 generators in the nation's industrial plants were in operation. Overall, the biomass electricity industry is estimated to have employed over 66,000 people in 1999, with an investment base of about $15 billion. A biomass electricity generating capacity of some 50,000 megawatts was said to be a possibility by as early as 2010. The report noted that if all available biomass were converted to electricity, a capacity of over 70,000 average MW could be supported, a large number when compared to U.S. electric consumption of 425,000 MW in 2004.

The earlier projection notwithstanding, because of relatively high costs associated with production of biomass electricity, the U.S. Department of Energy forecasts little growth in the biomass generating industry nationally through at least 2020. Current projections are for about 15.3 billion KWh of biomass generation in 2020, or only 0.3 percent of U.S. electric generation. Biomass energy, including cogeneration of electricity, is likely to continue to provide a major portion of energy consumed by the forest products industry – over one-half at present (Mayes 2003).

That production of electricity from wood biomass is costly compared to other fuel sources was underscored by a December 2005 report for the American Forest and Paper Association that examined costs of biomass- vs. coal- generated energy nationwide. Estimated national average costs of producing electricity from wood in 50 and 100 MW plants were estimated to be 80 to 90 percent higher than current retail electricity costs in Oregon and about 50 percent higher than electricity production in new coal facilities.

Interest in biomass as a raw material for electricity generation is stimulated primarily by environmental concerns and in particular the carbon neutrality (or near neutrality) of a biomass-to-energy system. From strategic and economic points of view, biomass electricity is rather less interesting than production of bio-based liquid fuels.

- **Steam from Biomass**

One use of biomass is to produce hot water or steam for facility or district heating. Woody and other forms of biomass are often burned alone, or in combination with municipal solid waste, to produce steam. This kind of use is common in northern Europe and increasingly so in the U.S. In St. Paul, Minnesota, for example, one woody-biomass fired district heating system serves many buildings in the central downtown area; however, increasing competition for biomass has necessitated co-firing with natural gas. Another St. Paul facility serves a large industrial park, making use of municipal trash for production of steam.

Zerbe (2006) describes several facilities that use biomass to generate steam for use in facility heating and air conditioning. An increasing number of facilities are being converted to hot water/steam heat fueled by biomass combustion.

- **Biochemicals from Biomass**

Biomaterials are one potential source of energy and chemicals. In a period in which a great deal of attention has been focused on development of cost-effective means of capturing and using solar energy, bio-materials as a source of energy have, until fairly recently, remained below the radar of policy-makers. However, biomass produced by plants through solar-energy-driven photosynthesis and subsequent growth processes has the potential to provide significant quantities of energy, as well as a wide array of chemical compounds useful to industry. Because many such chemicals today are derived from petroleum (Figure 11), the prospect of a petroleum peak within the relatively near term provides both a need and an opportunity for production of industrial chemicals and chemical feedstocks from biomass.

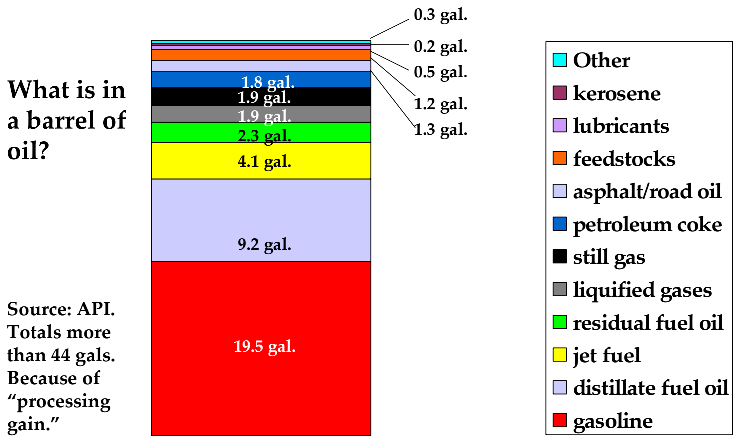


Figure 11 – A Myriad of Industrial Chemicals are Derived from Petroleum.

The Department of Energy has forecast that some 10 percent of industrial chemicals and materials will be produced from renewable resources by as early as 2020, with this number approaching 50 percent by 2050 (Figure 12). Even at a 10 percent share, such chemicals would have an annual value of about $400 billion (1999 dollars), or about twice the value of all forest products produced in the U.S. in that year. The opportunities would appear to be substantial.

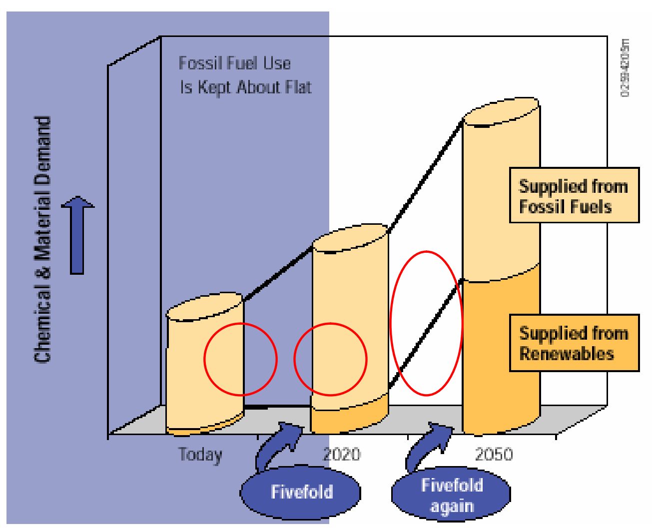


Figure 12 - Chemical and Material Demand 10% from Renewable Resources by 2020. (Source: US Department of Energy 1999)

Oregon

Oregonians spent $7.6 billion on energy in 2000, not including energy used to generate power or to transport natural gas in pipelines. Transportation fuels accounted for the greatest quantity of energy consumed, followed by electricity and natural gas (Figure 13). Renewable fuels such as firewood accounted for 12 percent of energy consumption. Total energy use increased 15 percent from 1990 to 2000.

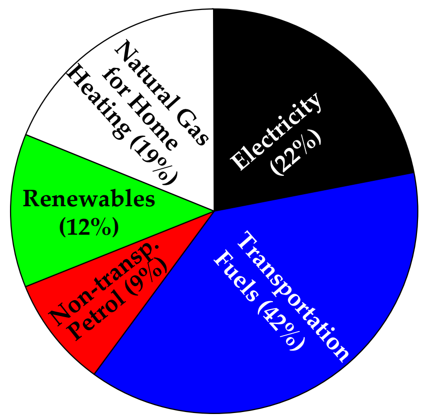


Figure 13 – Forms of Energy Consumed in Oregon, 2000. (Source: Oregon Department of Energy, Energy Plan 2005-2007, 2005 (January)

The total energy value of biomass fuel consumed in Oregon was 79 trillion Btu in 2003. This was about 10 percent of the total non-transportation energy consumed in the state and about 9 percent of all industrial energy consumed. The vast majority of this energy was in the form of industrial wood fiber and pulping liquor – with both of these produced and largely consumed by the State's forest products industry (Figure 14).

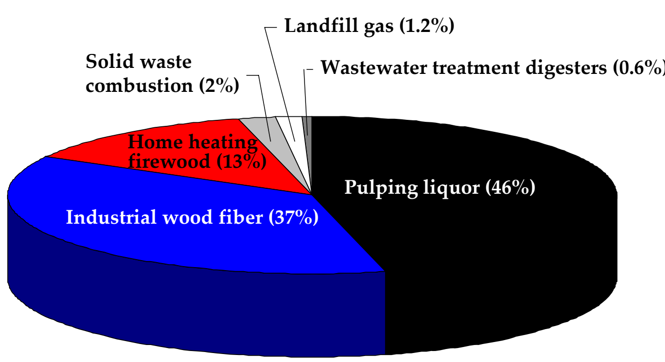


Figure 14 – Oregon's Biomass Energy Sources, 2003 (79 trillion Btu). (Source: Oregon Department of Energy 2004f)

About 37 percent of biomass derived energy came from wood wastes burned at 49 industrial sites. In addition to producing steam and process heat, ten of these sites generate power, totaling about 866,000 MWh of electricity in 2003. Another 46 percent of biomass-derived energy came from combustion of pulping liquor at six pulp mills. Two mills produced 310,000 MWh of electricity in 2003 (Source: Oregon Department of Energy. 2005. Energy Plan 2005-2007, January).

Yet, biomass energy currently provides a very small portion of electricity supplied to the State's energy grid (Figure 15).

- **Electricity from Biomass**

In the mid-1990s the Oregon Office of Energy began looking at biomass availability in Oregon for possible use in energy production. The largest single source of potential biomass was determined to be in the form of small diameter trees that could be obtained from thinning 140,000 acres of the state's forests annually (Table 5); wheat straw and other agricultural residues were also identified as significant potential sources of biomass fuel. Using the modest assumption that small diameter thinnings would be available from stand treatments on 140,000 acres annually it was determined that biomass could supply over 1,100 average MW (Table 6), a significant number when compared to the 2004 total electric generation installed capacity in Oregon of 5,734 MW.

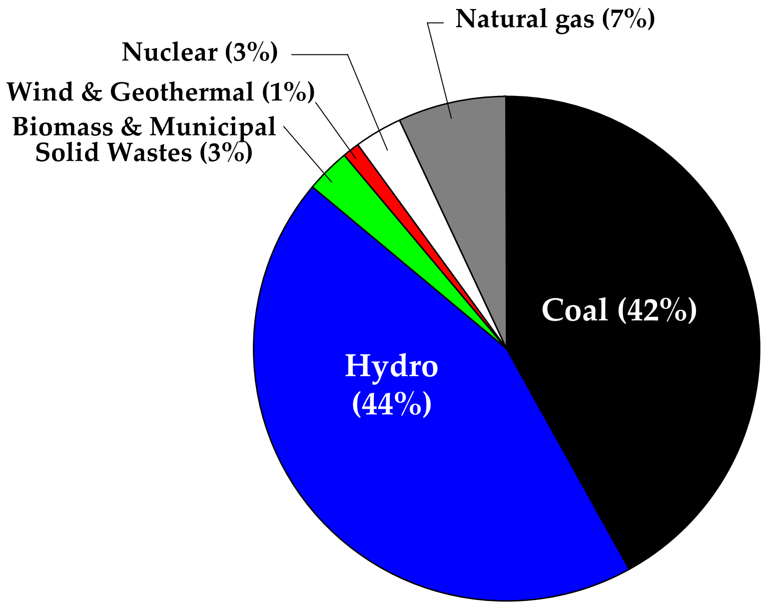


Figure 15 – Oregon's Sources of Electricity Generation, 2003. (Source: Oregon Department of Energy, Energy Plan 2005-2007, 2005 (January)).

Table 5
Cellulosic Biomass Availability in Oregon, 1998

Feedstock	BDT / Yr	% of Total
Greenwaste	278,750	3
Mixed waste paper	652,536	8
Wood and lumber	326,688	4
Paper mill sludge	183,960	2
Grass straw	1,000,000	12
Wheat straw	2,100,000	25
Agricultural residues	1,018,842	12
Forest thinnings*	2,940,000*	35
Total	8,500,776	

* Based on thinning 140,000 acres/ year
Source: Oregon Department of Energy 1998

Table 6
Gross Electric Generating Potential in Oregon from Cellulosic Feedstocks, 1998

Feedstock	BDT/Yr.	% of Total	Electricity Gen. Pot. (MW)
Greenwaste	278,750	3	13
Mixed waste paper	652,536	8	93
Wood and lumber	326,688	4	47
Paper mill sludge	183,960	2	15
Grass straw	1,000,000	12	141
Wheat straw	2,100,000	25	296
Agricultural residues	1,018,842	12	143
Forest residues	2,940,000*	35	421
Total	8,500,776		1,169

* Based on thinning 140,000 acres/ year
Source: Oregon Department of Energy 1998

The 2,940,000 BDT/yr. of forest residues indicated in Table 5 implies a delivered price for biomass of up to $40/dry ton (1998 dollars) according to a 1999 study by Walsh *et al.* These researchers estimated annual forest residue availability of 1.3 million tons at a price of $30 or less per dry ton, 1.9 million tons at a price of $40 or less per ton, and 2.5 million tons at $50 or less per dry ton. These costs are far lower, however, than those reported by the Oregon Energy Trust (Itron 2004) for Baker, Union, and Wallowa counties; here, delivered costs of forest biomass were estimated at $48.20 to $49.49 per green ton (or approximately $95-100 per dry ton).

A more recent assessment of electric generating potential within Oregon (Oregon Department of Energy 2004d), that considered slightly different biomass sources than the earlier study, and which did not consider forest residues, yielded an estimate of 504 aMW of biomass generating capacity; adding the electric generating capacity from the 1998 report yields an estimate of 931 aMW of generating capacity (Table 7). In the latest study, the volume of agricultural residues determined to be available is considerably lower than in the 1998 study, and municipal solid wastes were included for the first time. The 931 average MW shown in Table 6 is again a significant number compared to the 2004 total electric generation installed capacity in Oregon of 5,734 MW. Overall, the potential for electricity generation from renewable sources other than hydro was estimated to be about 1.7 times the 2000 level of electric generation within Oregon (Figure 16).

Table 7
Electric Generating Potential from Oregon's Biomass Resources, 2003, Assuming Forest Thinning at the Rate of 140,000 Acres Annually

Resource	Quantity Avail.	Energy Potential (TBtu)	Electric Potential (aMW)
Wood	0.6 million BDT	11	86
Pulping liquor	2.0 million BDT	25*	82**
Municipal solid waste	1.3 million BDT	18	122
Wastewater treatment	500 million cf	0.3	2
Organic waste digesters	3.4 billion cf	1.7	13
Landfill gas	4.6 billion cf	2.3	22
Agricultural residue	1.3 million BDT	23	183
Forest residues	2.9 million BDT	53	421
Total		81.3	931

Source: Oregon Department of Energy, 2005. (http://www.energy.state.or.us/biomass/Resource.htm)

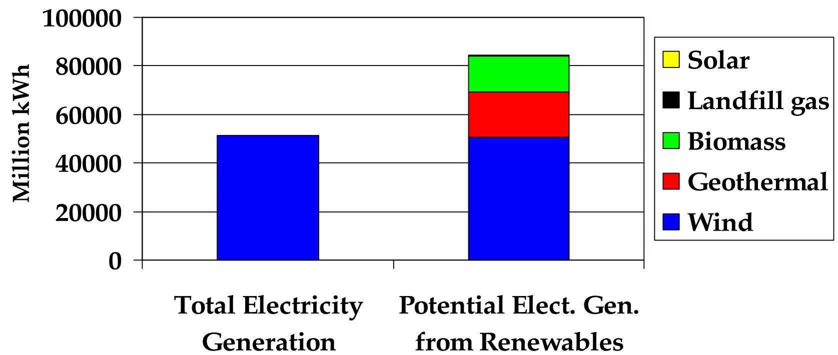


Figure 16 - Oregon's Electricity Generation vs. Potential Generation from Renewables, 2000. (Source: Oregon Department of Energy 2005).

As impressive as the estimated potential for biomass-derived electric generation is, it appears that the estimates thus far have been quite conservative in view of the fact that there is both an opportunity as well as a need for annual thinning of far more than 140,000 forested acres, the figure used in both the 1998 and 2005 assessments of electric generating potential from Oregon's biomass resources (Bowyer 2005). Although the estimate of available biomass is based on thinning 140,000 acres per year, it is worth noting that Oregon, for instance, has 16.9 million acres of forest rated as treatable and in need of thinning; over 5.6 million of these acres are in a severe fire risk category, with another 6.6 million in a high fire risk category (Rummer *et al.* 2003). As noted in a recent report from E.D. Hovee & Company, this problem is growing due to very high mortality rates in forests statewide, and especially those under federal management (Hovee 2005).

If the number of acres thinned each year were to approximate 488,000 (a number derived by dividing the number of acres in the high and severe fire risk categories by 25), some 10.2 million tons of forest biomass would be available on an annual basis, pushing the potential for biomass-based electric generation from 926 to 1,960 MW (Table 8). At a thinning rate of 610,000 acres annually (a number derived by assuming that all high and severe fire risk lands would be thinned in a 20 year period), the electric generation potential jumps to 2,323 MW (Table 9). Thus, at electric rates prevailing within Oregon in mid-2005, the gross value of energy obtainable from biomass resources ranges from about $400 million to over $1 billion annually, depending upon the availability of forest thinnings.

Table 8
Electric Generating Potential from Oregon's Biomass Resources, 2003, Assuming Forest Thinning at the Rate of 488,000 Acres Annually

Resource	Quantity Avail.	Energy Potential (TBtu)	Electric Potential (aMW)
Wood	0.6 million BDT	11	86
Pulping liquor	2.0 million BDT	25*	82
Municipal solid waste	1.3 million BDT	18	122
Wastewater treatment	500 million cu.ft.	0.3	2
Organic waste digesters	3.4 billion cu.ft.	1.7	13
Landfill gas	4.6 billion cu.ft.	2.3	22
Agricultural residue	1.3 million BDT	23	183
Forest thinnings	10.2 million BDT	184.7	1,450
Total		266.0	1,960

Table 9
Electric Generating Potential from Oregon's Biomass Resources, 2003, Assuming Forest Thinning at the Rate of 610,000 Acres Annually

Resource	Quantity Avail.	Energy Potential (TBtu)	Electric Potential (aMW)
Wood	0.6 million BDT	11	86
Pulping liquor	2.0 million BDT	25*	82
Municipal solid waste	1.3 million BDT	18	122
Wastewater treatment	500 million cu.ft.	0.3	2
Organic waste digesters	3.4 billion cu.ft.	1.7	13
Landfill gas	4.6 billion cu.ft.	2.3	22
Agricultural residue	1.3 million BDT	23	183
Forest thinnings	12.8 million BDT	231	1,813
Total		312.3	2,323

Several recent studies have estimated costs of electricity generation and associated wholesale prices in Oregon when using various resources. A series of interviews conducted by the Oregon Energy Trust (Itron 2004) revealed a near consensus that the price of electricity in Oregon is not sufficient to support the cost of building and operating a biomass energy plant; in addition, capital costs of system development were found to be high, especially for smaller-scale operations. The Oregon Department of Energy (2004c) estimated costs of electrical generation from forest biomass to be considerably higher than from natural gas or from hydrogenation systems (Table 10), indicating a need for subsidies for biomass-derived power. A more recent assessment (Searle 2005), that also examined solar and photovoltaic sources, showed higher costs of electric generation from natural gas (2.7 to 6.4 cents) than the earlier study, narrowing somewhat the production cost gap.

Table 10
Potential Generation of Electricity in Oregon and Estimated Wholesale Cost

Resource	***Cost (cents per kilowatt-hour)***	**Region-Wide Potential for Generation (average megawatts)**
Hydroelectric	1.1 to 7.0	170
Chemical recovery boilers	2.6	195
Natural gas	2.7	7,400
Industrial cogeneration (natural gas)	2.7 to 6.4	4,600
Landfill gas	3.1	94
Wood residue	4.3 to 5.4	300
Geothermal	5.2 to 6.5	390 to 1,070
Wind	5.3 to 8.1	700+
Forest biomass	5.5 to 6.6	300 to 1,000

Source: Oregon Department of Energy (2004c)

- **Ethanol**

It is clear that there is considerable potential for generating electricity from forest and other forms of biomass in Oregon. However, the potential payoff from production of liquid fuels from biomass is far greater, with the caveat that the technology needed to bring about that payoff is as yet unproven from a commercial standpoint.

Over 40 percent of Oregon's annual energy consumption is in the form of liquid transportation fuels. All of this is imported. A 2000 assessment of ethanol production potential in Oregon yielded an estimate of over 500 million gallons annually (Table 11); the significance of this number becomes apparent when compared to the magnitude of gasoline consumption in the State in 2003 – 1.53 billion gallons.

As in the case of estimated potential for electricity generation from biomass within Oregon, estimates were based on the assumption that forest biomass availability is limited to the volume of wood that would come from annually thinning 140,000 acres. As noted earlier, this is a very conservative assumption (Bowyer 2005). Re-evaluation of ethanol production potential based on thinning 462,000 and 602,000 acres annually yields values of 953 million and 1.15 billion gallons annually, respectively with gross sales potential on the order of $2.5 – 3.0 billion annually (Tables 12 and 13).

Table 11
Ethanol Production Potential from Oregon's Biomass Resources, 1998, Assuming Forest Thinning at the Rate of 140,000 Acres Annually

Feedstock	BDT / Yr.	% of Total	Ethanol Yield (gal./BDT)	Ethanol Potential (mill. Gpy)
Greenwaste	278,750	3	46.6	12.9
Mixed waste paper	652,536	8	54.0	35.2
Wood and lumber	326,688	4	45.6	14.9
Paper mill sludge	183,960	2	66.6	12.3
Grass straw	1,000,000	12	60.6	60.6
Wheat straw	2,100,000	25	60.0	126.0
Agricultural residues	1,018,842	12	50.0	50.9
Forest residues	2,940,000	35	66.0	194.1
Total	8,500,776			506.9

Source: Graf and Koehler, 2000.

Table 12
Ethanol Production Potential from Oregon's Biomass Resources, 1998, Assuming Forest Thinning at the Rate of 488,000 Acres Annually

Feedstock	BDT/Yr.	% of Total	Ethanol Yield (gal./BDT)	Ethanol Potential (mill. gpy)
Greenwaste	278,750	2	46.6	12.9
Mixed waste paper	652,536	4	54.0	35.2
Wood and lumber	326,688	2	45.6	14.9
Paper mill sludge	183,960	1	66.6	12.3
Grass straw	1,000,000	6	60.6	60.6
Wheat straw	2,100,000	13	60.0	126.0
Agricultural residues	1,018,842	7	50.0	50.9
Forest thinnings	10,248,000	65	66.0	676.5
Total	15,808,776			989.3

Source: Graf and Koehler, 2000.

Table 13
Ethanol Production Potential from Oregon's Biomass Resources, 1998, Assuming Forest Thinning at the Rate of 610,000 Acres Annually

Feedstock	BDT/Yr.	% of Total	Ethanol Yield (gal./BDT)	Ethanol Potential (mill. gpy)
Greenwaste	278,750	2	46.6	12.9
Mixed waste paper	652,536	4	54.0	35.2
Wood and lumber	326,688	2	45.6	14.9
Paper mill sludge	183,960	1	66.6	12.3
Grass straw	1,000,000	5	60.6	60.6
Wheat straw	2,100,000	11	60.0	126.0
Agricultural residues	1,018,842	6	50.0	50.9
Forest thinnings	12,809,999	70	66.0	845.7
Total	18,202,776			1,148.5

A comprehensive assessment of gasoline production costs in California provides an interesting baseline for gauging the economic potential of a non-subsidized ethanol industry (California Energy Commission 2003). As shown in Table 14, average crude oil costs plus refiner costs and profits approximated $0.91 for the period 1997 – 2003. By the end of the period (July 2003) the costs had risen to $1.16, with crude oil costs $0.70 per gallon. A little over a year later crude oil costs per gallon of gasoline were more than double the mid-July 2003 level ($1.47) and the price of crude oil plus refiner costs and profits was $1.93.

Ethanol prices, in contrast, were about $1.20/gallon in the fall of 2005, about the same level as the previous March (Figure 17). Even allowing for the fact that it takes about 1.5 gallons of ethanol to provide the same fuel value as gasoline, the price of ethanol was significantly lower than the price of gasoline in October 2005. Moreover, ethanol costs are projected to drop considerably going forward, whereas petroleum and thus gasoline costs are likely to rise.

Table 14
California Gasoline Cost Analysis
(Costs expressed as $US/gallon)

	Branded Gasoline			**Unbranded Gasoline**		
	July 2003	July 2002	1997-Present	July 2003	July 2002	1997-Present
Retail Prices	1.74	1.60	1.49	1.74	1.60	1.49
Federal Excise Tax	0.18	0.18	0.18	0.18	0.18	0.18
State Excise Tax	0.18	0.18	0.18	0.18	0.18	0.18
State and Local Sales Tax	0.13	0.12	0.11	0.13	0.12	0.11
Crude Oil Cost	**0.70**	**0.62**	**0.52**	0.70	0.62	0.52
Refiner Costs and Profits	**0.46**	**0.43**	**0.39**	0.32	0.28	0.34
Distribution Costs, Marketing Costs, and Profits	0.09	0.07	0.11	0.23	0.22	0.16

Source: California Energy Commission 2003.

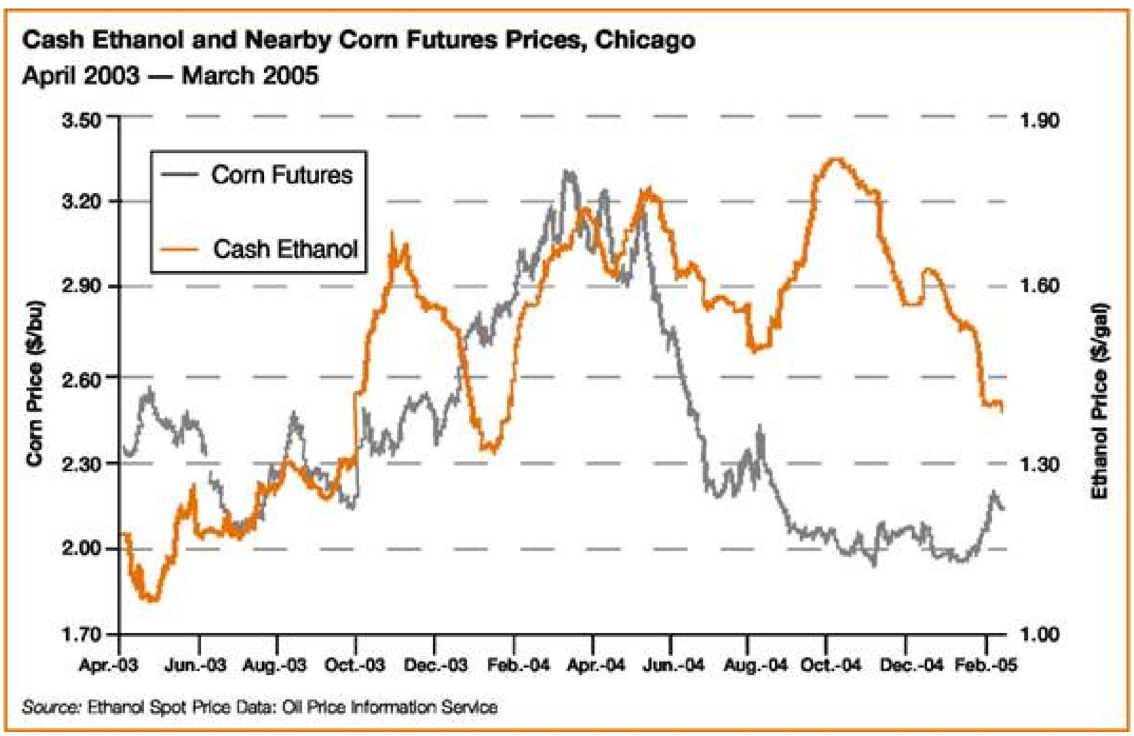


Figure 17 - Cash Ethanol and Corn Futures Prices, Chicago – April 2003-March 2005

Potential Benefits of Bio-energy Development

Darmstadter and Palmer (2005) pointed out that though burning of biomass results in some air pollution, this pales in comparison to pollution resulting from combustion of conventional fossil fuels. A substantial advantage of using biofuels is that biomass production results in the fixing of atmospheric carbon dioxide into organic carbon (USDOE 2005), with this carbon re- released as combustion occurs. Thus, a system of producing, harvesting and regenerating, and burning biomass to create energy is essentially a carbon-neutral system, with net carbon emissions limited to those created in biomass harvesting, regeneration, and transportation. In addition, emissions to air and water from biomass combustion are lower when combusting biomass than when burning or gasifying coal (Zerbe 2006). Moreover, energy generation from woody biomass provides an opportunity for constructive use of small diameter trees and other biomass generated in critically needed forest thinning programs and provides a way to minimize prescribed fires and wildfires. A 2004 Natural Resources Institute study report noted that fires, whether prescribed or wild, can impact human health, produce greenhouse gases, and can have detrimental impacts on forest ecosystems and Oregon's airsheds. Such impacts include massive quantities of visible smoke and particulates, significant quantities of nitrogen oxides and carbon monoxide, and hydrocarbon emissions that contribute to atmospheric ozone. Burning in biomass powered boilers rather than open burning could reportedly reduce NOx emissions by 64 percent and the release of airborne particles by 97 percent. Potential benefits of biomass energy development in Oregon were summarized as:

- Reduced wildfire risk and severity
- Reduced wildfire suppression costs
- Reduced wildfire-related property damage and losses
- Reduced greenhouse gas emissions
- Improved forest health (increased tree vigor, and fewer insect and disease problems)
- Improved water quality
- Improved air quality (less open burning)
- Increased jobs in economically depressed rural areas
- Increased energy independence; less reliance on fossil fuels
- Sustainable wildlife habitat

Public Policy Issues Related to Bio-Energy and Bio-Chemicals Development

While the advantages of bio-energy development are many, several issues deserve continued attention in the public policy arena. For instance:

- Lack of sufficient restraint in bio-energy development could result in one critically important resource – soil, being substituted for another critically important resource – energy.

  The estimated availability of one billion tons + of biomass annually (Perlack *et al.* 2005) is based on the assumption that basically every potentially productive acre in the U.S. will be brought into play for energy production, raising the possibility of diminished conservation reserve areas and an increase in the negative impacts of production agriculture. However, if biomass energy development were to be combined with a broad focus on energy conservation, dependence on fossil fuels could be much more dramatically reduced than if biofuels development alone were pursued, and that fossil fuel reliance reduction could be achieved using far fewer acres than if conservation prospects are ignored.

- Bio-energy development could create disincentives for energy conservation (Zerbe 2006).

- Biomass energy plants can create environmental problems of their own.

In Minnesota, ethanol production plants have met with opposition from some residents both because of emissions to air and because of high levels of water consumption. Current corn starch to ethanol production plants use 6 to 7 gallons of water per gallon of ethanol produced, stressing groundwater supplies in some localities. This suggests that work to develop closed-loop ethanol production processes is important for the future and that in any event questions regarding potential impacts of ethanol production on water supplies should be asked at the mill design stage and not after a facility is up and running.

- Public perception may inhibit bio-energy development within Oregon.

In a survey conducted by the Oregon Energy Trust (Itron 2004) "a few" respondents expressed a view that biomass energy is not a "green energy" source, leading report authors to suggest that such perceptions may limit acceptance of bio-energy projects in some areas of the state.

- Initiation of a carbon trading market, or efforts to link to developing carbon trading exchanges would provide another mechanism for encouraging biomass energy development (Itron 2004).

Public Policy Approaches that Have Proven Successful in Overcoming Barriers to Bio-Energy Development

A variety of legislative approaches are being used at the federal level and by state governments to promote ethanol development. A long-standing federal excise tax exemption on ethanol blended gasoline waives 5.1 cents per gallon of federal taxes for 10 percent ethanol blends. Available only to blenders of gasoline and ethanol, and not to ethanol producers, the credits are currently scheduled to end at the end of 2007. In addition to the blended gasoline credit, small producers of ethanol (i.e. those producing less than 30 million gallons annually) can deduct 10 cents per gallon for each of the first 15 million gallons produced annually; this program is also currently scheduled to end on December 31, 2007.

Last August President Bush signed the Energy Policy Act of 2005. Among the provisions of this legislation (Renewable Fuels Association 2005b,c) are establishment of a Renewable Fuels Standard (RFS) under which:

- The use of ethanol and biodiesel nationwide should double by 2012 from current levels to a target of 4.0 billion gallons in 2006 and to 7.5 billion gallons by 2012.

- A minimum of 250 million gallons a year of cellulosic-derived ethanol is included in the RFS beginning in 2013. In other provisions, the Secretary of Energy is directed to establish a program of production incentives to deliver the first billion gallons of annual cellulosic biofuels production.

- Flexibility is provided to refiners by creating a credit trading program that allows refiners to use renewable fuels where and when it is most efficient and cost-effective for them to do so. RFS credits have a lifespan of 12 months and every gallon of cellulose-derived ethanol is equal to 2.5 gallons of renewable fuel.

- Small refineries (facilities in which the average daily crude oil throughput does not exceed 75,000 barrels per day) are exempted from the RFS until January 1, 2011, although they are allowed to opt in to the program at any time.

In addition, the Energy Policy Act of 2005:

- Extends the income tax credit, excise tax credit, and payment provisions for agri-biodiesel, biodiesel, and renewable diesel through December 31, 2008.

- Increases the size limitation on the Small Ethanol Producer Credit to 60 million gallons.

Various states have taken steps to promote and encourage development of renewable energy and of ethanol in particular. Actions include state excise tax exemptions and state producer credits. In order to create local markets for ethanol, some states mandate use of ethanol blended fuels. States also indirectly encourage ethanol use through enactment of bans on use of methyl tertiary butyl ether (MTBE) as a gasoline oxygenate. Stimulated by instances of groundwater contamination, bans of MTBE use serve to create instant markets for ethanol which serve as an alternate means of achieving the minimum oxygen requirement for reformulated gasoline. Measures adopted by states to encourage development of ethanol production facilities and markets are summarized in Table 15.

Table 15
Summary of State Measures to Encourage Ethanol Production and Market Development

State	State Excise Tax Exemption	State Producer Credits	MTBE Ban in Effect	Special Information
Alaska	$.06 per gallon tax exemption	No producer credit	No	Tax exemption applies only in Anchorage and only during the winter months. No sunset.
Arizona	No tax exemption	No producer credit	Yes.	
California	No tax exemption	No producer credit	Yes	Despite a lack of other measures to encourage ethanol use or production, the ban on use of MTBE in fuel sold within California had the effect of creating the largest ethanol market in the U.S. – 580-715 million gal./year.
Colorado	No tax exemption	No producer credit	Yes	
Connecticut	$.01 per gallon tax exemption	No producer credit	Yes	No sunset
Hawaii	4% tax exemption	No producer credit	No	No sunset Other: Administrative rules signed 9/20/04 require that beginning 4/06, 85% of all gasoline sold in the state must contain 10% ethanol. Implements the ethanol requirement originally included in legislation signed in 1994.

State	**State Excise Tax Exemption**	**State Producer Credits**	**MTBE Ban in Effect**	**Special Information**
Idaho	Tax exemption is to equal the amount of ethanol blended in a gallon of gasoline – not to exceed 10%. Average exemption is $.023 per gallon.	No producer credit	No	No sunset
Illinois	2% sales tax exemption – average exemption is $.01 to $.015 per gallon. Extended in 2003 to include E85 and biodiesel.	No producer credit	Yes	A $15 million grant fund, the Renewable Fuels Development Program, was created in 2003 to support the construction of new ethanol/biodiesel plants and expansions; to qualify, a project must increase capacity by at least 30 million gallons per year (mgy). Sunsets in 2013; gradually reduces to zero after 12/31/13.
Indiana	No tax exemption	$.125 per gallon producer credit	Yes	Credit applies to facilities that increase production by at least 40 mgy. Total per facility not to exceed $5 million for all taxable years. Total program not to exceed $10 million.
Iowa	$.01 tax exemption	No producer credit	Yes	Sunset 2007; Income tax credit available to retailers who sell more than 60% ethanol-blended fuel at their station, including E85. Other: State fleet vehicles shall operate on 10% ethanol blends when commercially available.

State	**State Excise Tax Exemption**	**State Producer Credits**	**MTBE Ban in Effect**	**Special Information**
Kansas	No tax exemption	Average $.07 per gallon producer credit	No	Provides $.05 per gallon for producer in operation prior to July 1, 2001 during FY 2002-2004. Increased capacity of 5 mgy or more on-line on or after July 1, 2001 receives $.075 per gallon, limited to 15 mgy. Producers who begin prod. on or after July 1, 2001 are eligible for $.075 per gallon, limited to 15 mgy. Other: State's bulk fuel purchases for use in state motor fleet shall contain 10% ethanol, unless ethanol-blended fuel costs more than $.10 per gallon more than conventional fuel; same requirement for private fleet purchases.
Kentucky	No tax exemption	No producer credit	Yes	As of January 1, 2004 non-mandated encouragement to state agencies and others to use ethanol in place of MTBE.
Maine	Renewable fuels including ethanol and biodiesel produced in the state are exempt from state's motor fuel excise tax.	No producer credit	Yes – as of January 1, 2007	

State	State Excise Tax Exemption	State Producer Credits	MTBE Ban in Effect	Special Information
Maryland	No tax exemption	$.20 per gallon producer credit for ethanol produced from small grains (winter grain); $.05 per gallon producer credit for ethanol from other agricultural products.	No	Maximum total payment of $3 million/year for all ethanol produced. To reach maximum, would need at least 15 mgy of ethanol from small grains in a facility that began operating or expanded after 12/31/04. Sunsets 12/31/17.
Michigan	No tax exemption	No producer credit	Yes	
Minnesota	No tax exemption on 10% blend; $.058 tax exemption E85	$.20 per gallon producer credit; subject to reduction pending on state budget	Yes	Producer credit applies to the first 15 million gallons per plant per year. There is a $3 million annual cap per plant. Cap is 10 years from date of plant start-up. Other: statewide requirement to blend 10% ethanol in conventional gasoline sold in the state; legislation enacted in 2005 to increase blend requirement to 20% beginning in 2013 if waiver is received from US EPA.
Mississippi	No tax exemption	$.20 per gallon producer credit	No	Maximum payment of $6 million per producer of anhydrous ethanol and $37 million total per fiscal year. Provides formula for credit for production of "wet" alcohol. Sunset is June 30, 2015.

State	State Excise Tax Exemption	State Producer Credits	MTBE Ban in Effect	Special Information
Missouri .	No tax exemption	$.20 per gallon applies to the first 12.5 million gallons. $.05 per gallon to the next 12.5 million gallons produced.	Yes	Producer credit applies to the first 60 months of plant production
Montana	No tax exemption	$2 million per plant, per year producer incentive	No	To receive producer incentive, plant must use Montana produced grains: 20% in first year of production, 25% in 2nd year, 35% in 3rd year, and increasing by 10% per year until plant uses 65% Montana grains. Other: Provides for 10% ethanol mandate within 15 months of the state producing 40 mgy. Exempts 91 octane.
Nebraska	No tax exemption	No producer credit	Yes	$.18 producer incentive program expired in June, 2004.
New Hampshire	No tax exemption	No producer credit	Yes – as of January 1, 2007	
New Jersey	No tax exemption	No producer credit	Yes – as of January 1, 2009.	

State	State Excise Tax Exemption	State Producer Credits	MTBE Ban in Effect	Special Information
New York	No tax exemption	No producer credit	Yes	Under an Executive Order issued by governor Pataki in January 2006, state agencies and public authorities are required to purchase and utilize biofuels for use in boilers, heating/cooling plants, and in vehicle fleets. The Order mandates that by 2012, at least 5% of the heating fuel used in State buildings will be biodiesel, a bio-degradable fuel made from agricultural products. In addition, by 2007, at least 2% of fuels used in the State fleet must be biodiesel, with this rising to 10% in 2012.
North Dakota	No tax exemption	$.40 per gallon producer credit	No	2005 legislation establishes producer payments for 2005-07 biennium (and not beyond) for plants that were in operation by 7/1/95 (less than 15 mgy = $900,000 and greater than 15 mgy = $400,000). Also provides incentives for increased production by the lesser of 10 mgy or 50%. Other: Exempts E85 from all but $.01 per gallon of state's $0.21 per gallon fuel tax, up to 1.2 million gallons.
Ohio	No tax exemption	No producer credit	Yes	
Oklahoma	No tax exemption	$.20 per gallon producer credit	No	For production in place between 12/31/03-12/31/06. Maximum of $25 million per facility per year, with total maximum per facility of $125 mil. Credit of $.075 for new production after 1/1/11, for up to 10 mgy per facility for 3 years.

State	State Excise Tax Exemption	State Producer Credits	MTBE Ban in Effect	Special Information
Oregon	No tax exemption	No producer credit	No	Has ethanol production facility tax exemption in place that expires in 2008. For qualifying ethanol production facilities, 50% of the real market value of real and personal property is exempt from taxation. A qualified facility may claim exemption for five tax years. In addition, the Business Energy Tax Credit (BETC) program is an incentive for projects that produce energy using a renewable resource or that save energy or recycle waste. A tax credit covering 35% of eligible project costs is available to businesses. Research, design and development of new technology may qualify for a tax credit under BETC. Businesses may take the tax credit over five years. Biomass energy projects located in the State are eligible. They must provide a new source of energy or reclaim energy from waste. Tax credit applicants can sell energy or use it on-site. Applicants must own or be the contract buyer of the project. Businesses using alternative fuel vehicles and fueling stations dispensing alternate fuels are also eligible for BETC.
Pennsylvania	No tax exemption	$.05 per gallon producer credit	No	Up to 12.5 million gallons of renewable fuel per calendar year produced by a qualified renewable fuels producer. Money provided from state Alternative Fuel Incentive Fund. (SB 255, signed into law 11/29/04.

State	State Excise Tax Exemption	State Producer Credits	MTBE Ban in Effect	Special Information
Rhode Island	No tax exemption	No producer credit	Yes	
South Dakota	$.02 tax exemption	$.20 per gallon producer credit	Yes	416,667 gallons per month maximum allowable to ensure equal distribution among all producers.
Texas		$.20 per gallon producer credit for ethanol and biodiesel	No	Credit applies to first 18 mgy of production per plant for ten years. Imposes fee on ethanol and biodiesel producers of 3.2 cents for each gallon produced up to 18 million gallons per facility.
Washington	No tax exemption	No producer credit	Yes	
Wisconsin	No tax exemption	$.20 per gallon producer credit	Yes	$3 million per year, per plant (limited to first 15 million gallons/year). Measure calling for 10% ethanol requirement in all unleaded gasoline sold in Wisconsin after October 1, 2006 passed Wisconsin State Assembly in December 2005 and awaits action by State Senate and governor.
Wyoming	No tax exemption	$.40 per gallon producer credit	No	Program has a $4 million per year cap. Plants constructed after 7/1/03 eligible for 15 years. Plants in existence prior to 7/1/03 eligible until 6/30/09, unless they expand by at least 25%, in which case they are eligible for 15 years following the date of expansion.

Source: Based on summary provided by National Conference of State Legislatures, 2005/ Renewable Fuels Association, 2005 (http://www.ncsl.org/programs/energy/ethnic.htm). Information updated to January 2006 using a variety of sources including www.ethanolmarket.com and California Energy Commission. 2001.

Potential Advantages of a Forest Cluster Approach to Development of an Oregon Bio-Energy Industry

Oregon has significant potential for bio-energy development, with the greatest near-term opportunity in the area of biomass-derived electricity generation and perhaps biomass fueled hot water and steam district heating on various scales. Over the longer term, Oregon is in a strong position to exploit cellulosic ethanol markets assuming that technologies for converting cellulose to ethanol can be successfully commercialized.

Whether it is electricity, heat, or liquid fuels that are produced, Oregon's economy will benefit. The greatest potential benefit would appear to be from development of a liquid fuels industry that also has the capability of producing a range of industrial chemicals and advanced composite materials. The volume of forest biomass that is potentially available could support a large and highly profitable liquid fuels, chemicals, and composite products industry going forward.

At this writing it is not clear that the forest products industry will share the fruits of a biomass-to-energy industry. On the one hand, the value of wood wastes is likely to rise as new markets develop for this material. Moreover, should the industry participate fully in bio-energy development and achieve strategic linkages to energy, industrial chemicals, high tech, and perhaps transportation sectors, as suggested in a recent report from E.D. Hovee and Company (2005a), then the forest products industry will maximize the chances of major economic gains from the new paradigm. Under this scenario the industry will play a role in determining the allocation of various types of biomass fuels to product lines and industries so as to maximize economic returns. The development of an entirely new relationship with Oregon's citizens is also a possible outcome of a proactive approach to bio-energy development.

On the other hand, should the state's forest products industry sit on the sidelines as development proceeds, or should the industry seek to inhibit bio-energy development within Oregon in an attempt to limit competition for wood raw materials, then both economic outcome and public perception are likely to suffer. A major risk is that without the active participation of the state's wood products industry, decisions may be made that do not maximize potential returns or that lead to whole new industries that are exclusive of the current wood using sector.

The advantages of a forest sector approach to bio-energy development are many. On the other hand, the risks of not pursuing such an approach are high.

Literature Cited

American Forest and Paper Association. 2005. Biomass Study – Final Report. (December 6).

Bowyer, J. 2005. Opportunities for Biomass/ Biofuels from Oregon Wood. Oregon Forest Cluster Economic Strategy Workshop, Portland, October 17.

California Energy Commission. 2001. Costs and Benefits of a Biomass-to-Ethanol Production Industry in California. Commission Report P500-01-002. (http://www.energy.ca.gov/pier/renewable/biomass/ethanol/)

California Energy Commission. 2003. Causes for Gasoline and Diesel Price Increases in California. August 1.

California Energy Commission. 2004. Overview of Biomass to Ethanol. (http://www.energy.ca.gov/pier/renewable/biomass/ethanol/)

Czernik, S., R. French, K. Magrini, and R. Evans. 2004. Hydrogen Biomass: Process Research. National Renewable Energy Laboratory. (May 24-27). (http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/review04/hpd_p5_czernik.pdf)

Darmstadter, J. and K. Palmer. 2005. Renewable sources of electricity. Resources Issue 56: 24-27.

DiPardo, J. 2002. Outlook for biomass ethanol production and demand. US Department of Energy, Energy Information Administration. (http://www.eia.doe.gov/oiaf/analysispaper/biomass.html)

Drennen, T. and Erickson, J. 1998. Who will fuel China? Science, vol. 279 (March 6), p. 1483. (www.eia.doe.gov/emeu/cabs/china.html).

EIA. 1998. Forest products industry brief. U.S. Department of Energy, Energy Information Administration. (http://www.eia.doe.gov/emeu/mecs/iab98/forest/intensity.html).

EIA. 2000b. The year of peak production – when will conventional worldwide oil production peak? U.S. Department of Energy. (http://www.eia.doe.gov/pub/oil_gas/petroleum/presentations/2000/long_term_supply/sld001.htm)

EIA. 2002. Average heat content of selected biomass fuels. Energy Information Administration Renewable Energy Annual, 2002 and taken from U.S. Department of Energy, Annual Electric Generator Report – Non-utility 1999.

EIA. 2005a. Annual Energy Outlook, 2005. U.S. Department of Energy.

EIA. 2005b. U.S. Energy Supply and Demand: Base Case. EIA, Short-Term Energy Outlook – February. U. S. Department of Energy. (http://www.eia.doe.gov/emeu/steo/pub/steo.html)

EIA. 2006. Annual Energy Outlook, 2006. U.S. Department of Energy.

EIA. International Energy Outlook 2005. U.S. Department of Energy. (http://www.eia.doe.gov/oiaf/ieo/)

Ethanol Market. 2006. Legislative update. (http://www.ethanolmarket.com/legislative.html)

Graf, A. and T. Koehler. 2000. Oregon Cellulose-Ethanol Study. Prepared for the Oregon Office of Energy. June.

Greer, D. 2005. Creating cellulosic ethanol: spinning straw into fuel. BioCycle. May. (http://www.harvestcleanenergy.org/enews/enews_0505/enews_0505_Cellulosic_Ethanol.htm)

Haq, Z. 2002. Biomass for Electricity Generation. U.S. Department of Energy, Energy Information Administration. (http://www.eia.doe.gov/oiaf/analysispaper/biomass/index.html)

Harper, W. 1977. Petroleum. World Book Encyclopedia, p. 309.

Hovee, E. L. and Company. 2005. Baseline Forest Growth and Mortality Assessment. Prepared for the Oregon Forest Resources Institute. November.

Institute for Natural Resources. 2004. Report of the Forest Fuels and Hazard Mitigation Committee to the Oregon Department of Forestry, Oregon Fire Program Review. Oregon State University.

Itron. 2004. Oregon Energy Trust – Biomass Market Assessment, Final Report. Vancouver, Washington, December. (http://www.energytrust.org/RR/MarketAssessment/Full_Report.pdf).

Kerr, R. 1998. The next oil crisis looms large – and perhaps close. Science 281 (August 21), pp. 1128-1131.

Mayes, F. 2003. A view of the forest products industry from a wood energy perspective. U.S. Department of Energy, Energy Information Administration. (http://www.eia.doe.gov/cneaf/solar.renewables/at_a_glance/wood/woodenfa.htm)

Minnesota Department of Agriculture. 2003. Economic Impact of the Ethanol Industry in Minnesota. Agricultural Marketing Services Division, May. (http://www.mda.state.mn.us/ethanol/economicimpact.pdf).

National Conference of State Legislators. 2005. State Incentives for the Production and Use of Ethanol. (http://www.ncsl.org/programs/energy/ethnic.htm)

Northeast Regional Biomass Program. 2001. An Ethanol Production Guidebook for Northeastern States. May. (http://www.nrbp.org/pdfs/pub26.pdf)

Oregon Department of Energy. 2004. An Overview of Biomass Energy, (http://www.energy.state.or.us/renew/).

Oregon Department of Energy. 2004c. Estimating the Cost of Generating Electricity. Portland. (http://www.energy.state.or.us/renew/costs.htm).

Oregon Department of Energy. 2004d. Oregon's Biomass Energy Resources. Portland. (http://egov.oregon.gov/ENERGY/RENEW/Biomass/resource.shtml).

Oregon Department of Energy. 2004f. Oregon's Use of Biomass Energy. Portland. (http://egov.oregon.gov/ENERGY/RENEW/Biomass/use.shtml).

Perlack, R., L. Wright, A. Turhollow, R. Graham, B. Stokes, and D. Erbach. 2005. Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. U.S. Department of Energy, Oak Ridge National Laboratory/U.S. Department of Agriculture. (http://www.eere.energy.gov/biomass/pdfs/final_billionton_vision_report2.pdf)

Renewable Fuels Association. 2005a. Homegrown for the Homeland: Ethanol Industry Outlook 2005. (http://www.ethanolrfa.org/resource)

Renewable Fuels Association. 2005b. Renewable Fuels Standard. (http://www.ethanolrfa.org/resource/standard).

Renewable Fuels Association. 2005c. Renewable Tax Provisions: the Energy Policy Act of 2005 – H.R.6. Issue Brief.

Rummer, B.; Prestemon, J.; May, D.; Miles, P.; Vissage, J.; McRoberts, R.; Liknes, G.; Shepperd, W.D.; Ferguson, D.; Elliot, W.; Miller, S.; Reutebuch, S.; Barbour, J.; Fried, J.; Stokes, B.; Bilek, Ed.; Skog, K. 2003. A strategic assessment of forest biomass and fuel reduction treatments in Western States. USDA-Forest Service.

Sampson, N., M. Smith, and S. Gann. 2001. Western Forest Health and Biomass Energy Potential – a Report to the Oregon Office of Energy. Alexandria, Virginia: The Sampson Group, Inc. (April)

Searle, B. 2005. Building a bio-science economy – is it within our reach? Oregon Department of Agriculture.

Smith, S.J., M.A. Wise, G.M. Stokes, and J. Edmonds. 2004. Near-Term US Biomass Potential. Economics, Land-Use, and Research Opportunities. Battelle Memorial Institute, Joint Global Change Research Institute. PNWD-3285. January.

Tuscan, G., M. Downing, and L. Wright. 1994. Current status and future directions for the U.S. Department of Energy's short-rotation woody crop research. In: Stokes, B. and T. McDonald (eds). Proceedings: Mechanization in Short-Rotation, Intensive Culture (SRIC) Forestry. Mobile, Alabama, March 1-3. (http://www.woodycrops.org/mechconf/tuskan.html)

U.S. Department of Energy. 1999. Technology Roadmap for Plant and Crop-Based Renewable Resources – 2020. Office of Industrial Technologies, Renewable Vision. (http://www.oit.doe.gov/agriculture)

U.S. Department of Energy. 2005. Ethanol. Energy Efficiency and Renewable Energy, Biomass Program. (http://www.eere.energy.gov/biomass/ethanol.html)

U.S. Department of Energy. 2005. Energy Information Administration. (http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/rentrends04.html)

Walsh, M., R. Perlack, A. Turhollow, D. TorreUgarte, D. Becker, R. Graham, S. Slinsky, and D. Ray. 1999. Biomass Feedstock Availability in the United States: 1999 State Level Analysis. Oak Ridge, TN: Oak Ridge National Laboratory. (Updated 2000).

Walsh, M., D. TorreUgarte, H. Shapouri, and S. Slinsky. 2003. Bioenergy crop production in the United States – Potential quantities, land use changes, and economic impacts on the agricultural sector. Environmental and Resource Economics 24(4): 313-333.

Wang, M., C. Saricks, and D. Santini. 1999. Effects of Fuel Ethanol Use on Fuel-Cycle Energy and Greenhouse Gas Emissions. Argonne, IL: Argonne National Laboratory, Center for Transportation Research, Research Paper ANL/ESD-38, January.

Wood, J., G. Long, and D. Morehouse. 2004. Long-term world oil supplies. U.S. Department of Energy, Energy Information Administration.

Zerbe, J. 2006. Thermal energy, electricity, and transportation fuels from wood. Forest Products Journal 56(1): 6-14.

Biomass Energy and Biofuels Technology

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Abstract: The following review focuses on the production of fuel ethanol from forest residues via the "sugar platform" route. The "sugar platform" is generated through the controlled, bio-based, hydrolysis of the polysaccharides inherent in forest residues. This approach is analogous to that used in current corn-based starch-to-ethanol processes. The major differences between implemented starch-based and proposed forest residue-based processes are a consequence of the recalcitrance of the forest residue starting materials. The review also covers aspects of combined heat and power (CHP) production from woody feedstocks. CHP technologies are relatively "mature" compared to bio-based ethanol technologies; thus, calculations/forecasts based on CHP technologies are expected to have a significantly higher degree of certainty than those based on bio-based ethanol technologies.

Biomass Energy and Biofuels Technology

The conversion of forest materials to value-added products is obviously a complex issue. It is beyond the scope of this report to cover all possible products and the underpinnings of their many processing routes. Hence, we have chosen to focus on two products, power and fuel ethanol. These two products have existing markets, provided the forest feedstock-derived products are cost competitive, and their processes include the major operations that are expected to be encountered in the production of other products (such as commodity chemicals). The hydrolysis-fermentation (biochemical) approach to the production of ethanol, via a sugar platform, and the direct combustion approach to the production of power will be emphasized.

Forest Feedstock Composition

The major components of wood are cellulose, hemicellulose and lignin. In very general terms, woods are 40-50 percent cellulose, 20-35 percent hemicellulose, 15-35 percent lignin, < 1percent ash and usually 1-2 percent miscellaneous compounds (on a dry weight basis; University of Kentucky 1997). Hardwoods and softwoods, which differ in several respects, both contain, on average, approximately 42 percent cellulose (dry weight basis). The hemicellulose content of hardwoods generally ranges from 25-35 percent, while that of softwoods ranges from 25-30 percent. The two woods are significantly different with respect to the chemical nature of their hemicellulose components. The predominant hemicelluloses of hardwoods are partially acetylated acidic xylans. The predominant hemicelluloses of softwoods are galactoglucomannans (Puls and Schuseil 1993). Thus, the inherent ratio of six-carbon to five-carbon sugar units is typically higher for softwoods than for hardwoods. Softwoods contain 41 - 57 percent six-carbon sugar units and 8-12 percent five-carbon sugar units; hardwoods contain from 39 –50 percent six-carbon sugar units and 18 – 28 percent five-carbon sugar units (U. S. Department of Energy 2006). The principle structural sugar units of wood hemicelluloses are D-xylose, D-mannose, D-galactose, D-glucose, L-arabinose, 4-O-methylglucuronic acid, D-galacturonic acid glucuronic acid. Softwoods are generally higher in lignin (27-30%) than are hardwoods (20-25%) (McKendry 2002) and somewhat lower in ash content (softwoods, 0.1 – 0.4 %; hardwoods, 0.3 – 1.0 %) (U. S. Department of Energy 2006).

Feedstock Preconditioning

Essentially all value-added processing of forest biomass includes an initial size reduction operation. This pre-conditioning is necessary to obtain particle/chip sizes that may be handled efficiently. In general, feedstocks processed, via a sugar platform, to ethanol go through the following processes prior to delivery to the pretreatment operation: (1) harvested or collected; (2) debarked or peeled; (3) coarse chipped; (4) coarse screened (scalped); (5) dried and stored (optional); (6) fine-milled to process requirements; (7) delivered to main pretreatment processing unit (screw feeder, conveyor, etc.) (Himmel *et al.* 1985).

The initial size reduction is usually achieved with a chipper, resulting in particle sizes of 10-30 mm. Further size reduction is typically necessary to improve processing performance. This is most commonly achieved through milling or grinding, resulting in particles of 0.2 – 2.0 mm (Sun

& Cheng 2002). Rotary knife mills, hammer mills, and disc (attrition) mills are all potentially applicable to fine grinding operations. This operation, within the preconditioning sub-process, is likely to be the most costly. It has been suggested that the energy and operating costs of milling are prohibitive in processes requiring particle sizes of less than .2 mm (Datta 1981).

Particle size is expected to influence the mass and energy transfer properties of biomass, as well as its inherent reactivity. Thus, particle size optimization is an integral part of chemical, thermochemical, biochemical and microbiological processes. Mechanical operations such as chipping and coarse grinding/milling are expected to significantly increase surface area, as a result of decreased particle size; but they are not expected to have a significant impact on subcellular molecular architecture, including cellulose crystallinity/reactivity. In contrast, mechanical pulverization of lignocellulosics, for example using a vibratory ball mill (Millet *et al.* 1976), will greatly increase surface area and, potentially, markedly alter subcellular molecular architecture (Overend & Chornet 1987) – including increases in cellulose reactivity (Pew and Weyna 1962), presumably due to changes in cellulose crystallinity (Zhao *et al.* 2006).

Processing schemes for the conversion of forest biomass will by necessity include a pre-conditioning (size reduction) operation. Evaluation of such operations must consider energy input (cost), feed rates, feed properties (including size and moisture content) and the characteristics of the resulting particles (size, shape, handling, etc.). It is obviously important to have applicable estimates of power/energy/cost consumption as a function of conversion-ready particle size. Such relationships are expected to improve with incremental increases in milling efficiency. Prototype studies evaluating these relationships are available in the literature (Cadoche & Lopez 1989; Himmel *et al.* 1985; Millet *et al.* 1976), but information pertaining to state-of-the-art milling options applied to specific biomass feedstocks is not readily available in the public domain. It may be that such information can best be obtained from mill fabricators that are addressing specific feedstock/end product processes. This is a very mature technology, so only incremental increases in efficiency are expected.

Hydrolysis-Fermentation Process to Ethanol

There are ongoing worldwide efforts to develop economically viable processes for the production of bio-based liquid transportation fuels. The fuel that currently appears to have the most immediate relevance to the utilization of forest feedstocks is ethanol. There are several processes through which a biomass feedstock may be converted to ethanol (Towler *et al*. 2004). A particularly attractive processing route for ethanol production is the hydrolysis-fermentation (also called biochemical or sugar platform) route in which the feedstock's complex carbohydrates are hydrolyzed to simple sugars (the result being the sugar platform) and the resulting sugars are then converted to ethanol via microbial fermentation (Galbe & Zacchi 2002). There are many possible permutations for this processing route. The overall process may be considered in terms of the following sub-processes: (1) an initial pretreatment to render the cellulose component of the feedstock more susceptible to enzyme-catalyzed hydrolysis, (2) an enzyme-catalyzed hydrolysis operation to convert the complex carbohydrates of the feedstock to fermentable sugars, (3) a fermentation step to convert the sugars to ethanol, and (4) an ethanol recovery step. The following briefly discusses each of these sub-processes.

The pretreatment step, #1 above, is necessary due to the recalcitrance of native lignocellulosic materials (including forest residue feedstocks); they are highly resistant to enzyme-catalyzed hydrolysis (and hydrolysis is necessary to obtain the fermentable sugars that are inherent in the feedstock). Thus, enzyme-based processes currently under consideration for commercial application include a pretreatment operation. The pretreatment(s) may be physical and/or chemical in nature. The primary objective of all pretreatments is to the render the cellulose component of the feedstock readily susceptible to enzyme-catalyzed hydrolysis; but viable pretreatment processes must, by necessity, also maximize the recovery of the hemicellulose-derived sugars. Numerous studies have focused on the science and technology of the most promising pretreatment approaches (Wyman *et al.* 2005). Unfortunately, the majority of these studies dealt with herbaceous and/or hardwood, but not softwood, feedstocks. Those studies that did include a softwood feedstock have typically worked with debarked material. Hence, the results from the majority of published studies on lignocellulosic pretreatments are not easily extrapolated to softwood thinnings that contain a significant amount of non-wood residues.

The most studied pretreatment approach for application with softwood feedstocks is steam explosion, with or without the inclusion of an acid-catalyst (Galbe & Zacchi 2002). The acid is introduced prior to the steam treatment as either dilute sulfuric acid or sulfur dioxide. The most promising of the dilute acid pretreatments appear to be those designed to occur in two stages, a mild first stage to hydrolyze the readily available hemicllulose components and a second more severe stage for hydrolysis of recalcitrant hemicelluloses along with a fraction of the cellulose (Söderström *et al.* 1003). Such a two-stage dilute acid pretreatment has been successfully demonstrated with softwood whole tree chips (Nguyen *et al.* 2000). A feasibility study applying this type of pretreatment to softwood forest thinnings concluded that, under certain conditions, the process could be economically viable (Kadam *et al.* 2000). Other studies have demonstrated the usefulness of employing a continuous countercurrent screw extractor for such pretreatments (Kim *et al*. 2001). A recent study also demonstrated the applicability of this technology to bark-rich softwood feedstocks (Kim *et al.* 2005).

The other catalyst commonly used in conjunction with steam explosion for the pretreatment of softwoods is sulfur dioxide (Clark & Mackie 1987; Stenberg *et al.* 1998). This catalyst may also be used in either a one- or two-stage process. A recent economic evaluation of the two-stage technology indicated a 77% overall ethanol yield from softwood chips at a cost of approximately 52 cents per liter (Wingren *et al.* 2004). The technology has also been tested with softwood feedstocks containing bark (Boussaid *et al.* 2001). The presence of bark did not have a major impact on sugar recoveries, but did appear to impact subsequent sugar fermentations. In a study comparing SO_2-catalyzed and dilute H2SO4-catalyzed pretreatments Tengborg *et al.* (1998) concluded that the SO_2-catalyzed process was favored due to the better fermentability of the sugar stream resulting from the pretreatment. This conclusion is specific to the fermentation system applied in that study.

A second distinctive pretreatment approach for which softwoods have on several occasions served as model feedstocks are those based on lignin dissolution in aqueous/organic solvent mixtures. These methods are commonly referred to as organosolv pretreatments. Common organic solvents for these processes include ethanol, methanol, and ethylene glycol. The solvent receiving the most attention with respect to biomass-to-ethanol processes is ethanol. Optimum conditions for organosolv are feedstock dependent, but typical conditions include cooking temperatures of 180-195°C, cooking times of 30-90 minutes, ethanol concentrations from 35-

75 percent, and cooking liquor pH values from 2.0 to 3.8 (Arato *et al.* 2005). Softwood organosolv pretreatments are likely to employ sulfuric acid as a catalyst (Pan *et al.* 2005). Proponents of organosolve pretreatments are keen to point out the higher value of the lignin obtained from this process compared, for instance, to the highly condensed lignin that is recovered in acid-catalyzed hydrolysis-based pretreatments (Hasegawa *et al.* 2004).

The acid-catalyzed steam explosion pretreatments and the organosolve pretreatment each appear to have potential for near term (5-year) implementation in softwood to sugar platform processes. The steam explosion processes appear to have been studied and promoted primarily by public institutions. An organosolve pretreatment-based process, the branded name of which is Lignol Biorefinery Technology, is currently under development in the private sector by Lignol Innovations Corporation (Arato 2005). The most appropriate of these pretreatments for a particular application will likely depend on the composition of the feedstocks to be processed, feedstock volume, and the ability to market co-products resulting from the processes.

The second sub-process noted above, following the pretreatment, is the enzyme-catalyzed saccharification process (hydrolysis of cellulose to glucose). The objective is to generate a concentrated glucose solution as rapidly as possible while using a minimum amount of enzyme. Cellulase enzyme systems are very complex, consisting of multiple enzymes that act synergistically to degrade cellulose (Bayer *et al.* 1998). There continues to be a considerable effort to identify optimum enzyme cocktails that are stable under relatively harsh processing conditions and that can efficiently catalyze cellulose saccharification. The cost of the enzymes for cellulose saccharification has been considered a major barrier to the implementation of biobased biomass-to-ethanol processes. However, the efficiency of enzyme production continues to improve; recent estimates suggest that the retail cost of cellulase enzymes has dropped over 20-fold in the past five years. Saccharification studies continue to suggest that non-cellulase enzymes play an important role in the cellulose hydrolysis process (Berlin *et al.* 2005). The nature of the synergistic action observed with non-cellulase/cellulase enzyme mixtures is not well understood; a better understanding of this phenomena is likely to significantly impact overall saccharification strategies. When considering overall enzyme costs, it is common to think in terms of purchasing enzyme from a major retailer. However, this may not be the scenario for future biomass-to-ethanol processes. There is considerable research underway looking at methods for the production of cellulase enzymes on-site. It seems likely that future processes, albeit this may be limited to those facilities processing relatively large quantities of biomass, will have an enzyme production step as part of the overall process – thus further lowering enzyme costs.

The fermentation sub-process is designed to efficiently convert the wood-derived sugars to ethanol. Fermentation may occur in a separate operation from that of saccharification, referred to as separate hydrolysis and fermentation (SHF), or the saccharification and fermentation sub-processes may be combined in one operation, referred to as simultaneous saccharification and fermentation (SSF). SHF processes allow for each of the hydrolysis and fermentation steps to occur under optimum conditions. In SSF processes, reaction conditions are typically dictated by the metabolic requirements of the fermenting microorganism. An advantage of SSF processes is that the products of saccharification are continually removed from the reaction mixture be the fermenting microorganism, thus lowering the extent of enzyme product inhibition. Furthermore, combined saccharification and fermentation reduces the numbers of reactors required for the overall process. Regardless of whether the fermentation takes place in an SHF or SSF operation, the sugar stream resulting from the combined pretreatment and saccharification sub-processes will contain a variety of sugars along with an assortment of chemicals that are potentially inhibitory to fermenting microorganisms. Hence, considerable effort is currently being directed at improving the physiological capabilities of the fermenting microorganisms (Zaldivar *et al.* 2001) and or improving the growth characteristics of the sugar containing solutions (Palmqvist and Hahn-Hägerdal 2000).

Ethanol recovery, sub-process #4 above, is typically based on established distillation technology. Distillation-based processes are capable or near complete ethanol recovery; final ethanol concentrations approach that of the water-ethanol azeotrope (95% ethanol by weight) (Lynd 1996). Further water removal from the azeotropic mixture may be achieved using technologies such as molecular sieve driers or pervaporation. It is generally considered that the cost of and energy use by new distillation equipment are not significant in the production of bioethanol (Wyman 1999). However, this conclusion is thought to apply principally to larger scale biorefineries (Vane 2005). Several newer technologies for ethanol recovery are being developed for application in smaller scale ethanol production facilities (Vane 2005).

It is important to remember that commercially viable operations for the production of ethanol from forest residues will likely produce multiple products. This is the general concept of a forest residue biorefinery. The sub-processes outlined above only focus on the utilization of the carbohydrate component of the feedstock, but the non-carbohydrate components of the feedstock represent a considerable amount of biomass. One should expect that this material will be used in some capacity for economic gain; it is most generally assumed that it will be used for heat and power production. However, a better understanding of the chemical nature of the non-carbohydrate components, along with improvements in applicable separation technologies, will undoubtedly reveal constituents that have potential as value added products.

Biomass and Combined Heat and Power (CHP) Technologies

Combined heat and electrical power generation is a well established technology; one that provides significantly greater energy capture than electrical production alone. Dedicated electrical production facilities typically capture only about 1/3 of the energy in fuels, and even using the latest and most expensive technologies are hard pressed to surpass 45% efficiency. Conversely, the simultaneous generation of electricity and utilization of the heat in waste steam, provide efficiencies of 60-70%, and more.

In 1995 approximately 42 GW, or 6% of US total electricity, was generated in CHP plants (Kaarsberg and Elliott 2001). By 2003 the number had increased to 60 GW, with the Department of Energy (DOE) establishing a national goal of 92 GW by 2010 (Pescovitz 2003). Cogeneration of heat and power in Europe is much better established, with the Netherlands having achieved 40% cogeneration of total installed electrical capacity in 1996, with a goal of reaching 70% by 2010. The EU as a whole intends to reach 30% by 2010. (Roarty 1999)

The DOE's National Renewable Energy Laboratory (NREL) is a proponent of cogeneration of electricity and heat at or near the site of demand (NREL-1 2005). In CHP the resulting excess steam may be used for any of a number of heat requiring processes (e.g. facility heating, kiln drying) and, as Figure 1 illustrates, the maintenance of indoor air quality (IAQ). Conventional air-conditioning systems must lower the air temperature below its dew point to dehumidify the air. This chilled air must then be heated to bring it back to a comfortable level, consuming extra energy and increasing peak energy demands. The diversion of steam to the reheating of dehumidified air can lessen or eliminate this demand (NREL-2 2005).

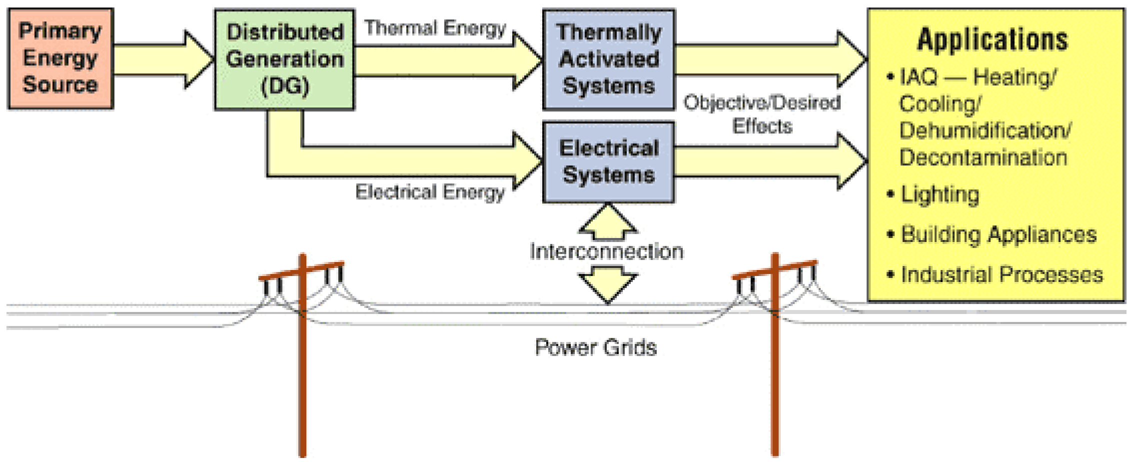


Figure 1 – Schematic of combined heat and power generation and potential uses[RGL1]**.**

Also note in Figure 1, a CHP facility can be run independent of the electrical grid, or where agreements with the utility are feasible, can sell excess power.

Power from Biomass

In 2002 there were about 9.7 GW of installed biomass electrical generation capacity in the United States, of which about 5.9 GW were fueled by forest and agricultural residues. The utilization of biomass for power or CHP is largely dictated by access to very low cost biomass supplies. In this scenario, both environmental advantages and economic factors make biomass a competitive fuel (DOE 2006). Under the economic conditions prevailing in 2000, the cost of transportation of biomass fuels beyond 20 miles was significant, and prohibitive for distances greater than 100 - 200 miles (Bain *et al.*2003).

In 2001 the Oregon Office of Energy reported 66 combustion facilities utilizing wood fiber solids. Energy produced by these plants ranged from 1 billion to about 2.5 trillion BTU/yr. Most of the plants produce steam which was utilized for drying or other processes. A handful are CHP plants (Table 1). Additionally, a half dozen paper mills recover energy from pulping liquor as processed steam or CHP (White 2001).

In the national perspective, the nearest term and lowest cost option for the use of biomass is cofiring with coal in existing boilers. Biomass can be used at up to 15% of the energy input. After modifying the feed and boiler system to accommodate biomass (approx. $200/KW) and tuning the combustion, conventional energy efficiency is retained (33-37%) and environmental benefits, specifically diminished SO2 and NOx emissions, are realized (Bain *et al.*2003).

Given the environmental benefits of substituting biomass for traditional fuels, and the rising cost of coal, oil and natural gas, biomass utilization will become increasingly feasible. Groups as diverse as Shell Oil and Greenpeace all forecast substantial increase in global electrical generation from biomass, with estimates ranging from 16400-40100 GWh by the year 2025 (Bens and Hüttl 2001).

Table 1 – CHP from wood fiber solids in Oregon (White 2001).

Facility Name, Equipment information	County	Fuel Type and Amount (bdt/yr*)	Energy Value (tBTU/yr*)	Electricity Prod-uction (GWh/yr)
Biomass One, L.P. Two Deltak spreader-stoker boilers, 8000 hr/yr, avg. 300,000 lb/hr	Jackson	Hogged fuel, urban wood waste, logging debris, railroad ties 150,952	2.57	125
Boise Cascade - Medford Operations	Jackson	Hogged fuel 81,181	1.38	13.1
Co-Gen II, LLC Wellons 4-cell boiler, 135,000 lb/hr	Douglas	Wood waste 154,393	2.62	65.0
Fort James – Wauna Mill Fluidized bed boiler, 8274 hr/yr, 107220 lb/hr, 600 psig	Clatsop	WWTP sludge, bark, hogged fuel 58,199	0.90	196.2
Prairie Wood Products Wellons boiler, 8400 hr/yr, 120,000 lb/hr, 425 psig	Grant	Hogged fuel 114,116	1.94	65.9
Roseburg Forest Products – Dillard 3 B&W hogfuel boilers, 8500 hr/yr, 600 psig	Douglas	Hogged fuel 166,792	2.84	109
SP Newsprint Company	Yamhill	Hogged fuel 265,110	4.51	184.7

*bone dry tons **trillion BTU

In a study of forest energetics, Bens and Hüttl estimated that over the 90 year life of a commercial pine forest that the total energy inputs per hectare are approximately 107 GJ. The corresponding energy yield from the forest products is 9500 GJ, of which a little over half – from thinning of young trees, sawmill waste and forest residues, can be utilized for energy production (Bens and Hüttl 2001). The timing of forest energy extraction is shown in Figure 2.

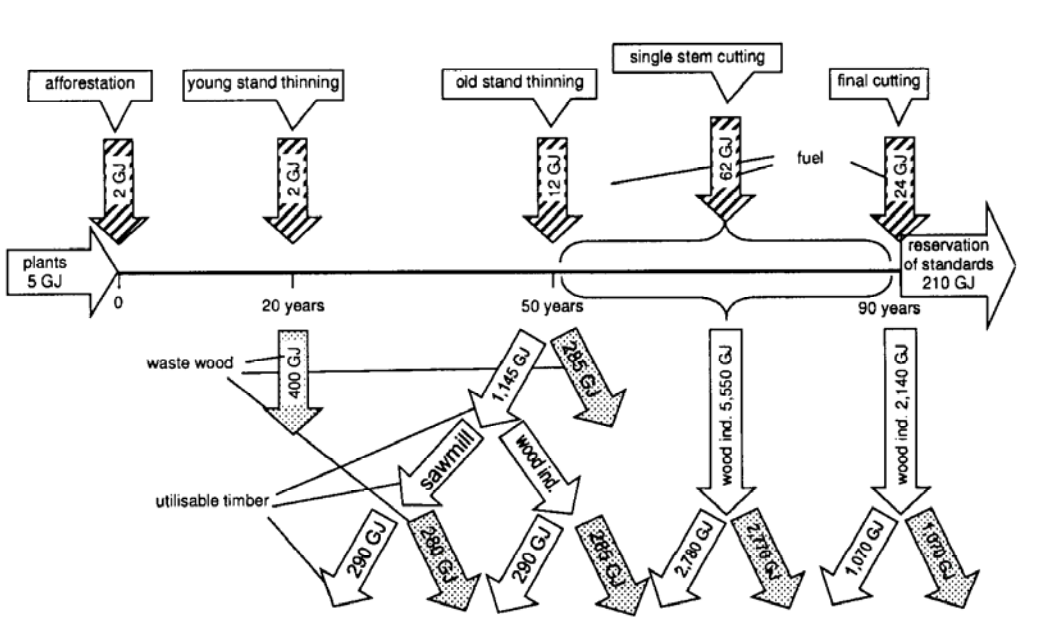


Figure 2 – Energy balance per hectare in a pine forest in sandy soil (Brandenburg, Germany)(Bens and Hüttl 2001).

Existing Technology

Biomass power systems fall into four primary classes: direct-fired, co-fired, gasification, and modular systems (DOE 2006). Currently most systems are direct fired combustion[RGL2]. While burning biomass in a furnace to produce hot gas has limited application, far more commonly the furnace is coupled with a boiler to generate steam from the heat of combustion (White 2001). Biomass is oxidized with excess air, the hot flue gases produce steam at a heat exchanger, and the steam can be used for a variety of processes as well as fed to a turbine or generator to produce electricity (Rankine cycle). Typically biomass plants use a single-pass steam turbine. (Bain *et al.*2003).

Plant sizes range from 10-80 MW (Bain *et al.*2003) with 20-50 MW range the norm (DOE 2006). This is small compared to coal-fired plants, typically in the 100-1500 MW range (DOE 2006).

Several different boiler technologies are employed in current facilities. Among them, traveling-gate stokers, and fluidized bed systems are most common (van den Broek *et al.*1995).

Pile burner – The biomass is dumped in piles in a furnace, burned with the help of combustion air coming from under and above the pile. Periodically the ash is dumped from the combustion chamber. Advantages of the pile burner include fuel flexibility and simple design. However, low efficiency and poor combustion control limit the utility of this design (van den Broek *et al.*1995).

Stoker fired boilers (grated) – Several different mechanisms of spreading the fuel evenly over a grate. All have improved efficiency and combustion control relative to pile burner, but often require more maintenance (e.g. traveling grate). A water-cooled vibrating grate permits high underfire air temperatures, which facilitate combustion of wet fuel (van den Broek *et al.*1995).

Suspension fired boilers – Fuel fired as small particles which combust as they are fed into boiler. While this boiler has the potential for high efficiency, woody biomass often requires extensive pretreatment to achieve sizes similar to pulverized coal (approx. 200 mesh) required for efficient operation (Table 2). The less efficient combustion with larger particle size fuel, also results in greater ash buildup[RGL3].

Table 2 – Particle size (mesh=sieve openings per inch) of two wood potential fuel sources (Freeman *et al.*).

Mesh Size	Lumber Mill Sawdust	Processed Furniture Waste Sawdust
	% passing through	
8	97.1	100.0
20	24.6	98.6
50	4.1	54.8
100	1.6	18.1
200	0.7	5.0

Fluidized bed – These systems rely on high velocity air from beneath the fuel bed to create a bubbling mass of combusting fuel. Advantages include fuel flexibility and excellent carbon burnout. However the high fan capacity required adds to the capital cost. Bubbling fluidized bed designs are often more economical than circulating fluidized beds in systems less than 20 MW. (van den Broek *et al.*1995)

Whatever the boiler design, efficient combustion is a balancing act of a number of factors. Design and operation of the plant should provide conditions that completely convert the carbon compounds to CO2 (as only about one-third of the chemical energy of hydrocarbons is released with incomplete oxidation to CO). At the same time the amount of air is limited to just that necessary to achieve complete combustion, so as to minimize heat loss up the stack.
Factors that work together to influence the completeness of combustion and minimize the formation of CO, are:

- The amount of air introduced below the furnace grate (underfire air);
- The amount of air introduced above the fuel (overfire air);
- The degree of turbulence used to promote mixing of the volatile gases and air;
- Particle size and the evenness with which fuel is distributed inside the burning chamber;
- The rate at which it is fed into the furnace (van den Broek *et al.*1995).

Table 3 provides a qualitative evaluation of a number of construction, operation and fuel-related criteria for commonly encountered boiler designs. Because the availability of a particular kind of fuel may fluctuate, design for multiple fuels is a distinct advantage for biomass energy plants (Bain *et al.*2003).

Table 3 – Evaluation of other operational criteria for the four common boiler categories (van den Broek *et al.* 1995).

Criterion	Pile boilers		Stoker boilers			Suspension boilers	Fluidized bed boilers			
	Underbed fuel feed	Overbed fuel feed	Stationary sloping grate	Traveling grate	Vibrating grate (w.c.)		BFB	CFB	MCFB	CYMIC
Construction related criteria										
design simplicity	+	++								
design volume compactness						+	+	+	+	++
Erection speed										+
Modest capital cost at small scales	+	+					+	-		
Operation related criteria										
combustion control	+	-	-							
Load response rate	- -	- -			+	+			+	
turn down ratio									+	+
steam data insensitive for fuel variation			-						+	
uninterrupted operation capability	-	-								
modest start up / shot down time									+	+
reliability	-	+								
operation convenience	-	+								
maintenance friendly				-	+					+
operating experience	++	++	++	++	+		0	0	-	-
Fuel related criteria										
fuel moisture design flexibility	++	++	+	+	++	- -	+	+	+	+
fuel size design flexibility	++	++	+	+	+	- -	++	+	+	+
fuel moisture switching flexibility	++	++	-	-		- -	0	0	+	0
fuel size switching flexibility	++	++	-	-		- -	+	0	+	0
fossil fuel (co)-firing capability					+	++				
fuel fouling resistance			-				-	-		
boiler tube erosion resistance								-		
explosion safety						-				

Fuel Considerations

Biomass does not have the same energy density as coal and petroleum fuels (Table 4). As noted above, particle size can be detrimental to combustion, as can high and variable moisture content of the biomass.

Table 4 - Energy value of select fuels (Freeman *et al.*).

	Biomass fuels				Fossil fuels		
	Urban wood1	Forest residues	Yellow straw	Mis-canthus	Peat	Coal	Natural gas
Heating value MJ/kg(wet,HHV)	16.6	10.7	14.4	17.2	14.3	26.9	41.8
Heating value MJ/kg(wet,LHV)	15.4	9.1	13.1	16.2	12.8	25.8	38.0

The moisture content of dry wood may be 20%, while 40-50% moisture is common in green or wet wood. High moisture fuels require substantial energy input to vaporize the water (2.26 MJ/kg.) prior to actual combustion. Wet fuel typically results in incomplete combustion, and difficulty in regulating the output of the boiler. Dry wood flame temperatures may be approximately 1350°C, while wet wood burns several hundred degrees cooler. Particularly above 40% moisture, significant decreases in boiler efficiency are seen. Some wood boilers use an air preheater to recover heat from the exhaust gases dry fuel immediately preceding and in the early stages of the combustion process (van den Broek *et al.*1995).

Future Efficiency

In 1995 van den Broek reported maximum steam temperature of approximately 540°C in conventional power production facilities (van den Broek *et al.*1995). Eight years later Bain indicated that newer technologies had made feasible steam temperatures as high as 750-980°C. (Bain *et al.*2003) This is of significance because the efficiency of electrical production through the Rankine steam cycle depends on the pressure and temperature of the steam.

Some of the modifications that increase efficiency of the Rankine cycle include: reheating of steam and feed water preheating with steam extracted from the turbine. The additional output of the system more than offsets the additional fuel consumption required for reheating. Reheating also results in a drier steam and less corrosion of the turbine fan blades. Depending on the pressure at which the steam is reheated, one stage of reheat in a steam turbine can increase the cycle thermal efficiency by almost 4 %.

While techniques exist to raise biomass electrical generation efficiency above 40%, current plant efficiencies are typically in the high 20 too low 30% range, as illustrated in Table 5[RGL4]. In 1995 van den Broek wrote that efficiencies in the range of 38 - 44 % are only obtainable with biomass combustion systems in larger scale plants (ranging from 100 MW up to 250 MW) (van den Broek *et al.*1995). Cogeneration dramatically increases the efficiency of net energy capture, as illustrated in a comparison of dedicated electricity and CHP biomass plants in table 6.

Table 5 – Examples of the investment and efficiency of biomass power plant of different design and scale (van den Broek *et al.* 1995).

Plant (country, start up year)	Boiler system	Capacity [MW]e	Efficiency (LHV)		Investment $(1992)/ kWe
			_Boiler	_e,net	
Delano I plant (USA, 1991)	Bubbling Fluidized Bed	27	86	29	
Burlington plant (USA, 1984)	Traveling Grate	50	83	30	1800
Händelöverket CHP boiler (S, 1994)	Circulating Fluidized Bed	46	89	32	1100[2]
Enköping CHP plant (S, 1995)	Vibrating Grate (Water Cooled)	28	96	33	1900
EPON co-fire plant (Nl, 1995)	Pulverised Coal Boiler	20	n/a[1]	37	800[3]
Whole Tree Energy concept (-, -)	Pile/Grate Boiler	100	90	38	1500
ELSAM cofiring scale-up project (DK,2005)	Circulating Fluidized Bed	250	n/a[1]	44	

[1]No data were available to determine this value. [2]Only investments in the newly installed CFB boiler are included. [3]Only additional investments to enable wood cofiring have been included.

Table 6 – Biomass Plant Performance (Bain *et al.* 2003).

	Efficiency %	Fuel Rate MBtu/hr*	Electricity MW	150 lb. Steam 1000 lb./hr
25 MW Electric – Direct Combustion	30	284	25.0	0
25 MW Electric – CHP	62	284	19.8	107
25 MW Steam	75	284	-2.5	214
75 MW Electric – Direct Combustion	30	853	75.0	0
75 MW Electric – CHP	62	853	62.2	321

*Assumes 17 MBTU/dry ton

Unfortunately, the capital cost associated with efficiency-enhancing equipment has been a barrier to introduction of these technologies into the small and mid-size plants typical of biomass (DOE 2006). However, in 2003 Bain indicated that several newer technologies, already seen in larger conventional fuel plants, were being adapted to smaller plants. Examples include multi-pressure, reheat and regenerative steam turbine cycles, and supercritical steam turbines. (Bain *et al.*2003)

Supercritical Steam

Conventional boilers have operating pressures around 19 mPa, resulting in a non-homogenous mixture of steam and water. The mixed steam and water from the evaporative section of the boiler is collected in a drum, where the liquid water is removed from the steam, prior to superheating the latter for introduction to the turbine. However, if the operating pressure of the evaporator can be raised above 22.1 mPa, the steam becomes supercritical (with homogenous properties, and therefore no need to separate the steam form water), allowing the use of once-

through boilers. For the same energy input, this increase in pressure (and temperature) results in a greater amount of energy delivered to the turbine for electricity production.
Advanced materials are required for the boiler (and other components in contact with the steam) to permit operation under supercritical conditions. Currently the use of steels with 12% chromium content permit operation up to 30 MPa and 600°C, with consequent efficiency around 45%. On the horizon is Austenite, a proven but expensive material sustaining temperatures up to 620°C and pressures of 31.5 MPa. Nickel-based alloys, e. g. Inconel, would permit 35 MPa and 700°C operation, yielding efficiencies up to 48% (Ingo 1999).

Selected Pacific Northwest Facility News and Profiles

NorskeCanada – Pulp and Paper Mill – Powell River B.C.
Biomass-fired bubbling fluidized bed power boiler burns wood waste from sawmills (hogfuel), dryland log sort debris, and some land-clearing debris and effluent sludges from the mill. Wood waste from sawmills has a higher thermal value and contains less rocks and log sort and land clearing debris. With shutdown of sawmills (since the commissioning of the boiler in 1998) the availability of hogfuel has diminished, and the company was forced to use a greater percentage of the other biomass sources. Furthermore, in winter the moisture content of hogfuel is elevated and requires diversion of heat for drying. To maintain the efficiency of the boiler it has been necessary to burn natural gas as a supplemental fuel. The company initiated a trial of tire derived fuel in 2003 as an alternative to wood waste. (B.C. Environmental Appeal Board 2002)

Confederated Tribes of Warm Springs
Through the Healthy Forests Restoration Forest Service authorized to spend $5 million annually between 2004 and 2008 on grants to help communities and small businesses use biomass. The Confederated Tribes of Warm Springs has received one such grant to expand generation at its sawmill to produce 15-20 MW of electricity. Potential fuel sources include the limb and other residue from thinning operations in the Metolius area, as well as residues from the sawmill (Durbin 2006; The Electricity Forum 2006).

Biomass One LP – White City, Oregon
Biomass one is a 25 MW wood waste fired cogeneration plant. It utilizes 355,000 tons of wood waste annually. Electricity generated is sold to Pacific Power; steam sold for drying lumber and veneer (Biomass One 2006).

Douglas County Forest Products
A 6 MW plant that also provides steam to run driers was slated to begin operation in Dec. 2005 (Biopower Work Group 2005).

Collins Company
A feasibility study for a 20 MW CHP facility at the Fremont Sawmill is in progress (Biopower Work Group 2005).

Literature Cited

Arato, C., Pye, E. K. & Gjennestad, G. 2005. The Lignol approach to biorefining of woody biomass to produce ethanol and chemicals. App. Biochem. Biotechnol. 121-124, 871-882.

Bain, RL, Amos, WP., Downing, M, Perlack, RL. 2003. Highlights of biopower technical assessment: state of the industry and the technology. National Renewable Energy laboratory: Golden, Colorado. (NREL/TP-510-33502).

Bayer, E. A., Chanzy, H., Lamed, R. & Shoham, Y. 1998. Cellulose, cellulases and cellulosomes. Curr. Opin. Structural. Biol. 8, 548-557.

Bens, O, Hüttl, RF. 2001. Energetic utilization of wood as biochemical energy carrier – a contribution to the utilization of waste energy and landuse. Int. J. Therm. Sci. 40:344-351.

Berlin, A., Gilkes, N., Kilburn, D., Bura, R., Markov, A., Skomarovsky, A., Okunev, O., Gusakov, A., Maximenko, V., Gregg, D., Sinitsyn, A. & Saddler, J. 2005. Enz. Micro. Technol. 37, 175-184.

Biomass One. 2006. www.biomassone.com Web site accessed 4/19/2006.

Biopower Work Group. 2005. Notes, November 10 2005.

Boussaid, A., Cai, Y., Robinson, J., Gregg, D. J., Nguyen, Q. & Saddler, J. N. 2001. Sugar recovery and fermentability of hemicellulose hydrolysates from steam-exploded softwoods containing bark. Biotechnol. Prog. 17, 887-892.

British Columbia Environmental Appeal Board. 2002. Appeal no. 2002-WAS-020(b), 023(a), 024(a).

Cadoche, L. & Lopéz, G. D. 1989. Assessment of size reduction as a preliminary step in the production of ethanol from lignocellulosic wastes. Biological Wastes 30, 153-157.

Clark, T. A. & Mackie, K. L. Steam explosion of the softwood Pinus radiata with sulphur dioxide addition. I Process optimization. J. Wood Chem. Technol. 7, 373-403.

Datta, R. 1981. Energy requirements for lignocellulosic pretreatment processes. Process Biochem. 16, 15-19 & 42.

Durbin, K. 2006. Slim margins. High Country News: Paonia, CO, 4/17/2006.

Freeman, MC, Chitester, DC, James, RA, Ekmann, JM, Walbert, GF. Results of pilot-scale biomass co-firing for P.C. combustors. Federal Energy Technology Center, US Department of Energy.

Galbe, M. & Zacchi, G. 2002. A review of the production of ethanol from softwood. Appl. Microbiol. Biotechnol. 59, 618-628.

Hasegawa, I., Tabata, K., Okuma, O., & Mae, K. 2004. New pretreatment methods combining a hot water treatment and water/acetone extraction for thermo-chemical conversion of biomass. Energy Fuels 18, 755-760 .

Himmel, M., Tucker, M., Baker, J., Rivard, C., Oh, K. & Grohmann, K. 1985. Comminution of Biomass: Hammer and Knife Mills. Biotechnol. Bioeng. Symp. No. 15, 39-58.

Ingo, P. 1999. Supercritical coal-fired power plants. Energy Issues no. 19. The World Bank.. http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/1999/10/07/000094946_99092312090218/Rendered/PDF/multi_page.pdf. Web site accessed 4/21/2006.

Kaarsberg, T, Elliott, RN. 2001. Combined heat and power: saving energy and the environment. Northeast-Midwest Institute, www.nemw.org/ERheatpower.htm. Web site accessed 4/2/2006.

Kadam, K. L., Wooley, R. J., Aden, A., Nguyen, Q. A., Yancey, M. A., & Ferraro, F. M. 2000. Softwood forest thinnings as a biomass source for ethanol production: a feasibility study for California. Biotechnol. Prog. 16, 947-957.

Kim, K. H., Tucker, M. & Nguyen, Q. 2005. Conversion of bark-rich biomass mixture into fermentable sugar by two-stage dilute acid-catalyzed hydrolysis. Bioresource Technol. 96, 1249-1255.

Kim, K. H., Tucker, M. P., Keller, F. A., Aden, A. & Nguyen, Q. A. 2001. Continuous countercurrent extraction of hemicellulose from pretreated wood residues. Appl. Biochem. Biotechnol. 91-93, 253-267.

Lynd, L. R. 1996. Overview and evaluation of fuel ethanol from cellulosic biomass: technology, economics, the environment, and policy. Annu. Rev. Energy Environ. 21, 403-465.

McKendry, P. 2002. Energy production from biomass (part 1): overview of biomass. Bioresource Technol. 83, 37-46.

Millett, M.A., Baker, A.J. & Satter, L.D. 1976. Physical and chemical pretreatments for enhancing cellulose saccharification. Biotechnol. & Bioeng. Symp. No. 6, 125-153.

Mosier, N., Wyman, C., Dale, B., Elander, R., Lee, Y. Y., Holtzapple, M. & Ladisch, M. 2005. Features of promising technologies for pretreatment of lignocellulosic biomass. Bioresource Technol. 96, 673-686.

National Renewable Energy Laboratory. 2005. Combined heat and power – waste heat recycling: onsite and national energy impact analysis. http://www.nrel.gov/dtet/heat_power.html. Web site accessed 4/20/2006.

National Renewable Energy Laboratory. 2005. Thermally driven air conditioning. http://www.nrel.gov/dtet/thermal_air_cond.html. Accessed 4/20/2006.

Nguyen, Q. A., Tucker, M. P., Keller, F. A. & Eddy, F. P. 2000. Two-stage dilute-acid pretreatment of softwoods. Appl. Biochem. Biotechnol. 84-86, 561-576.

Overend, R. P. & Chornet, E. 1987. Fractionation of lignocellulosics by steam-aqueous pretreatments. Phil. Trans. R. Soc. Lond. A 321, 523-536.

Palmqvist, E. and Hahn-Hägerdal, B. 2000. Fermentation of lignocellulosic hydrolysates. I: inhibition and detoxification. Bioresource Technol. 74, 17-24.

Pan, X., Arato, C., Gilkes, N., Gregg, D., Mabee, W., Pye, K., Xiao, Z., Zhang, X. & Saddler, J. 2005. Biotechnol. Bioeng. 90, 473-481.

Pescovitz, D. 2003. Lab notes: waste not, want not. College of Engineering, University of California, Berkeley. www.coe.berkeley.edu/labnotes/1203/kammen_print.html. Web site accessed 4/2/2006.

Pew, J. C. & Weyna, P. 1962. Fine grinding, enzyme digestion, and lignin-cellulose bond in wood. Tappi 45, 247-256.

Puls, J. & Schuseil, J. 1993. Chemistry of hemicelluloses: relationship between hemicellulose structure and enzymes required for hydrolysis in Hemicellulose and Hemicellulases. (Coughlan and Hazelwood, Edts.), Portland Press, London, 1-27.

Roarty, M. 1999. Cogeneration-combined heat and power (electricity) generation. Research note 21 1998-99. Science, Technology, Environment and Resources Group, 1999. www.aph.gov.au/Library/pubs/rn/1998-99/99rn21.htm. Web site accessed 4/2/2006.

Söderström, J., Pilcher, L., Galbe, M. & Zacchi, G. 2003. Two-step steam pretreatment of softwood by dilute H_2SO_4 impregnation for ethanol production. Biomass Bioenergy 24, 475-486.

Stenberg, K., Tengborg, C., Galbe, M. & Zacchi, G. 1998. Optimization of steam pretreatment of SO_2-impregnated mixed softwoods for ethanol production. J. Chem. Technol. Biotechnol. 71, 299-308.

Sun, Y. & Cheng, J. 2002. Hydrolysis of lignocellulosic materials for ethanol production: a review. Bioresource Technol. 83, 1-11.

Tengborg, C., Stenberg, K., Galbe, M., Zacchi, G., Larsson, S., Palmquist, E. & Hahn-Hagerdal, B. 1998. Comparison of SO_2 and H_2SO_4 impregnation of softwood prior to steam pretreatment on ethanol production. Appl. Biochem. Biotechnol. 70-72, 3-15.

The Electricity Forum. 2006. CEO of Bend, Ore.-area forest-products firm plans to build biomass power plant. http://www.electricityforum.com/ Web site accessed 2/15/2006.

Towler, G. P., Oroskar, A. R. & Smith, S. E. 2004. Development of a sustainable liquid fuels infrastructure based on biomass. Environmental Progress 23, 334-341.

U. S. Department of Energy Efficiency and Renewable Energy Biomass Program. 2006. Electrical power generation. http://www1.eere.energy.gov/biomass/electrical_power.html. Accessed 4/23/2006.

U. S. Department of Energy 2006. Understanding biomass as a source of sugars and energy. U. S. Department of Energy – Energy Efficiency and Renewable Energy Biomass Program, web site: http://eereweb.ee.doe.gov/biomass/understanding_biomass.html.

University of Kentucky 1997. An introduction to wood anatomy characteristics common to softwoods & hardwoods. Cooperative Extension Service FOR-59.

van den Broek, R., Faaij, A, van Wijk, A. 1995. Biomass combustion power generation technologies. Energy from biomass : an assessment of two promising systems for energy production. Background report 4.1. Department of Science, Technology and Society. Utrecht University, The Netherlands.

Vane, L.M. 2005. A review of pervaporation for product recovery from biomass fermentation processes. J. Chem. Technol. Biotechnol. 80, 603-629.

White, JG. 2001. Oregon Biomass Energy Book. Oregon Office of Energy.

Wingren, A., Galbe, M. & Zacchi, G. 2003. Technoeconomic evaluation of producing ethanol from softwood: comparison of SSF and SHF and identification of bottlenecks. Biotechnol. Prog. 19, 1109-1117.

Wingren, A., Söderström, J., Galbe, M. & Zacchi, G. 2004. Process considerations and economic evaluation of two-step steam pretreatment for production of fuel ethanol from softwood. Biotechnol. Prog. 20, 1421-1429.

Wyman, C. E. 1999. Biomass ethanol: technical progress, opportunities, and commercial challenges. Annu. Rev. Energy Environ. 24, 189-226.

Wyman, C. E.; Dale, B. E.; Elander, R. T.; Holtzapple, M.; Ladisch, M. R. & Lee, Y. Y. 2005. Coordinated development of leading biomass pretreatment technologies. Bioresource Technol. 96, 1959-1966.

Zaldivar, J., Nielsen, J. and Olsson, L. 2001. Fuel ethanol production from lignocellulose: a challenge for metabolic engineering and process integration. Appl. Microbiol Biotechnol. 56, 17-34.

Zhao, H., Kwak, J. H., Wang, Y., Franz, J. A., White, J. M. & Holladay, J. E. 2006. Effects of crystallinity on dilute acid hydrolysis of cellulose by cellulose ball-milling study. Energy Fuels 20, 807-811.

Market Conditions for Woody Biomass in Oregon

Marie Lennette & Roger Lord, Mason, Bruce & Girard, Inc.

Abstract: In 2002, 6.8 million bone dry tons of mill residuals were produced in Oregon. Sixty-four percent was subsequently used in the production of secondary products, 25% was used as fuel, and less than 1% was un-used. The market for logging waste biomass is limited due to high recovery and transportation costs. As a result, nearly all is left in-woods. Wood combustion boilers at 49 industrial sites use 1.6 million BDT of biomass fuel in 2004. Six pulping liquor combustion facilities consumed 2.7 million BDT in 2004. Ten combustion boilers and 2 pulping liquor facilities produce electrical power in addition to steam. These facilities used 1.6 million BDT of biomass fuel to produce 1.1 million MWh. Four of the facilities sell electricity to the grid. Market barriers to increasing use of biomass for energy include power price, power sales agreements, transportation costs, fuel availability, and utility interconnection issues. Potential markets are also discussed.

Market Conditions for Woody Biomass in Oregon

The purpose of this paper is to describe current market conditions and trends in Oregon for biomass fuels including hogged fuel and chips from mill wastes and woody biomass from logging operations. It also discusses some of the market barriers to woody biomass use that are mentioned in the literature.

Existing Market Conditions

Primary Mill Residuals

The market for woody mill residuals from the production of primary wood products in Oregon is a mature commodity market. Most residuals generated by the state's lumber and veneer mills are subsequently used in the production of fiber products such as pulp and paper or composite wood products such as particle board, or in lower value products such as mulch and bedding. Vertically-integrated companies transfer residues between solid wood facilities and their pulp mills and particleboard plants. Solid wood facilities without an internal use for the higher valued residues market them to pulp mills or other users, often through short or long term contracts. Residuals that do not have higher value use are generally used as fuel for energy production on-site at the primary facility.

In 2002, $222.6 million worth of mill residues were produced in Oregon. The majority of this was consumed within the state, with approximately 5% being sold out-of-state (USDA Forest Service 2005). The volume of residue produced by the mills is summarized in Table 1 for 2002 by residue type and byproduct. The majority of residues, 64%, were used in secondary fiber products - predominantly for pulp and paper production. Twenty-five percent was used as fuel. Less than 1% of the 6.8 million BDTs generated in 2002 in Oregon were un-used.

Table 1 – Volume of mill residues (BDT) produced in Oregon and end use in 2002.

Primary Mill residues	Total Residue Product	Secondary End Use			
		Fiber Byproducts	Fuel Byproducts	Misc. Byproducts	Un-used Mill Residues
Bark	1,443,828	499	1,188,002	249,744	5,583
Coarse wood	3,398,509	2,869,026	196,046	330,274	3,163
Fine wood	1,992,489	1,490,387	344,378	156,557	1,166
Total	6,834,826	4,359,912	1,728,427	736,575	9,912

Source: USDA Forest Service (2002)

Some studies have suggested that were the price high enough, some of the existing residue supplies currently used for paper production could be redirected to producing electricity or other energy products (e.g. McNeil Technologies 2003). However, it seems unlikely that prices for fuel chips would reach the price of residuals currently used for pulp production. Recent market price for conifer pulp chips average $62 per bone dry ton (BDT) versus $36 per BDT for energy biomass in competitive markets in California (International Woodfiber Report 2005; Fried *et al.* 2005). Prices for pulpwood chips have reached as high as $60 per green ton (approx. $120 per BDT) in the past (McNeil Technologies 2003). Moreover, wood processing facilities faced with a decision to sell fuel residues currently used for steam and energy production would evaluate the decision based on the cost of alternative replacement energy sources, such as natural gas, which are likely to be much more expensive than energy produced from residues.

Forest Residues

Forest residues from logging waste and pre-commercial thinning for fire hazard reduction present a much larger potential supply than mill residues (CH2MHILL 2005). The market for forest residues is extremely limited, however, due to high transportation costs for longer distances and the lack of reliable, long-term supply sources. Both of these issues are discussed further under the Market Barriers section of this paper and the companion paper, *Forest Biomass Supply.* In addition to logging residue having higher initial costs associated with transportation and processing, it has lower energy potential than mill residues due to higher water content.

Processing Capacity

The Northwest Power and Conservation Council (2005) maintains a current database of energy processing facilities. Data for the following sections on wood-based energy facilities was obtained from this source.

Wood fiber combustion facilities

There are wood fiber biomass combustion boilers at 49 industrial sites in Oregon. The boilers process steam for industrial processes, supply heat for dryers, and ten of these sites also produce electric power. The facilities consumed over 1.6 million BDT of biomass fuel in 2004 with an energy value of about 27 trillion British thermal units (tBtu).

Chemical recovery boilers

There are six pulping liquor combustion facilities in Oregon. The boilers at these facilities produce steam for industrial processes, drive turbines, and two of these sites also produce electricity. The facilities consumed roughly 2.7 million BDT of biomass fuel in 2004 with an energy value of about 35 tBtu.

Cogeneration facilities

There are 12 wood-based biomass cogeneration facilities in Oregon: ten wood fiber combustion boilers and two pulping liquor facilities. The facilities consumed roughly 1.6 million BDT of biomass fuel in 2004 and generated about 24 tBtu of energy. The electricity produced from this was about 1.1 million MWh. Four of these cogeneration sites currently produce energy to sell to the grid. These are listed in Table 2 along with their location and capacity.

Table 2 - Oregon Cogeneration Facilities Selling Power to Grid.

Facility Name	Location	Nameplate Capacity (MW)
Biomass One, L.P.	White City, OR	25.0
Fort James Company: Wauna Mill	Clatskanie, OR	36.0
Port of Morrow: Heppner Power Plant	Boardman, OR	10.0
Weyerhaeuser: Springfield Containerboard	Springfield, OR	51.2

Source: Northwest Power and Conservation Council (2005)

The six pulping liquor combustion facilities in Oregon are listed in Table 3. The 49 wood fiber biomass combustion boilers are listed in Table 4. The locations are shown in Figure 1. The ten wood fiber combustion boilers and two pulping liquor facilities that are also cogeneration sites are shown as well.

Table 3 – Oregon Combustion Facilities – Pulping Liquor

Mill Name	Mill Type	County	City	Fuel Consumption BDT/year	Energy of Fuel Consumed tBtu
Boise Cascade	Paper	Columbia	St. Helens	577,500	7.5
Fort James Wauna Mill	Paper	Columbia	Clatskanie	491,597	6.4
Georgia-Pacific West, Inc.	Paper	Lincoln	Toledo	470,721	6.1
Pope & Talbot, Inc.	Pulp	Linn	Halsey	400,428	5.2
Weyerhaeuser Co.	Paper	Lane	Springfield	469,148	6.1
Weyerhaeuser Co.	Paper	Linn	Albany	287,635	3.7

Source: Northwest Power and Conservation Council (2005) and MB&G mill database

Table 4 – Oregon Combustion Facilities – Wood Fiber Solids

Mill Name	Mill Type	County	City	Fuel Consumption BDT/year	Energy of Fuel Consumed tBtu
Biomass One, L.P.	Power Plant	Jackson	White City	111,895	1.9
Blue Heron Paper Co.	Paper	Clackamas	Oregon City	594	0.01
Blue Mountain Lumber Products	Sawmill	Umatilla	Pendleton	3,702	0.06
Boise Cascade	LVL	Jackson	White City	20,042	0.34
Boise Cascade	Plywood	Union	Elgin	83,055	1.41
Boise Cascade	Sawmill	Union	La Grande	24,400	0.41
Boise Cascade	Plywood	Jackson	Medford	101,768	1.73
Boise Cascade	Veneer	Yamhill	Willamina	8,639	0.15
CoGen Co.: Prairie Wood Products	Sawmill	Grant	Prairie City	96,695	1.64
CoGen II	Sawmill	Douglas	Riddle	82,752	1.41
Columbia Plywood	Plywood	Klamath	Klamath Falls	15,791	0.27
Elk River Enterprises	Sawmill	Lane	Swisshome	1,680	0.03
Fort James: Wauna Mill	Paper	Columbia	Clatskanie	65,097	1.03
Frank Lumber Co., Inc.	Sawmill	Linn	Mill City	9,130	0.16
Fremont Sawmill	Sawmill	Lake	Lakeview	7,655	0.13
Freres Lumber Co.	Sawmill	Linn	Lyons	33,881	0.58
Georgia-Pacific West, Inc.	Paper	Lincoln	Toledo	71,668	1.22
Glide Lumber Products Co.	Sawmill	Douglas	Glide	6,220	0.11
Grant Western Lumber	Sawmill	Grant	John Day	7,695	0.13
Hampton: Fort Hill	Sawmill	Polk	Grande Ronde	1,188	0.02
Hampton: Tillamook	Sawmill	Tillamook	Tillamook	29,398	0.5
Hull-Oakes Lumber Co.	Sawmill	Benton	Monroe	1,668	0.03
Interfor Pacific Inc.	Sawmill	Klamath	Gilchrist	79,180	1.35
Jeld-Wen Inc.:Thomas Lumber Co.	Sawmill	Klamath	Klamath Falls	19,431	0.33
Malheur Lumber Company	Sawmill	Grant	John Day	4,026	0.07
McKenzie Forest Products, LLC	Plywood	Lane	Springfield	21,150	0.36
Murphy Plywood Co.	Plywood	Douglas	Sutherlin	9,700	0.16
Oregon Industrial Lumber Products	Sawmill	Lane	Springfield	3,400	0.06
Pacific Wood Laminates	LVL	Curry	Brookings	26,132	0.44
Panel Products LLC	Veneer	Jackson	Rogue River	6,648	0.11
Port of Morrow	Power Plant	Morrow	Boardman	12,981	0.22
Rosboro Lumber Company	Plywood	Lane	Springfield	no data	no data
Roseburg Forest Products	Plywood	Coos	Coquille	34,576	0.59
Roseburg Forest Products	Plywood	Douglas	Riddle	87,966	1.5
Roseburg Forest Products	Plywood	Douglas	Roseburg	137,577	2.34
Rough & Ready Lumber Co.	Sawmill	Josephine	Cave Junction	3,250	0.06
SierraPine Ltd.	Particleboard	Lane	Springfield	5,749	0.1
South Coast Lumber Co	Chipmill	Curry	Brookings	4,680	0.08
SP Newsprint Corp.	Paper	Yamhill	Newberg	119,880	2.04
Stimson Lumber Co.	Sawmill	Washington	Forest Grove	63,826	1.09
Sun Studs LLC	Sawmill	Douglas	Roseburg	13,641	0.23
Superior Lumber Co.	Sawmill	Douglas	Glendale	27,777	0.47
Umpqua Lumber Co.	Sawmill	Douglas	Dillard	7,135	0.12
Wallowa Forest Products	Sawmill	Wallowa	Wallowa	7,143	0.12
Warm Springs Forest Products Ind.	Sawmill	Jefferson	Warm Springs	35,344	0.6
Weyerhaeuser Co.	Sawmill	Lane	Eugene	56,938	0.97
Weyerhaeuser Co.	Plywood	Linn	Sweet Home	11,579	0.2
Weyerhaeuser Co.	Plywood	Lane	Springfield	12,290	0.21
Weyerhaeuser Co.	Sawmill	Clatsop	Warrenton	18,935	0.32

Source: Northwest Power and Conservation Council (2005) and MB&G mill database

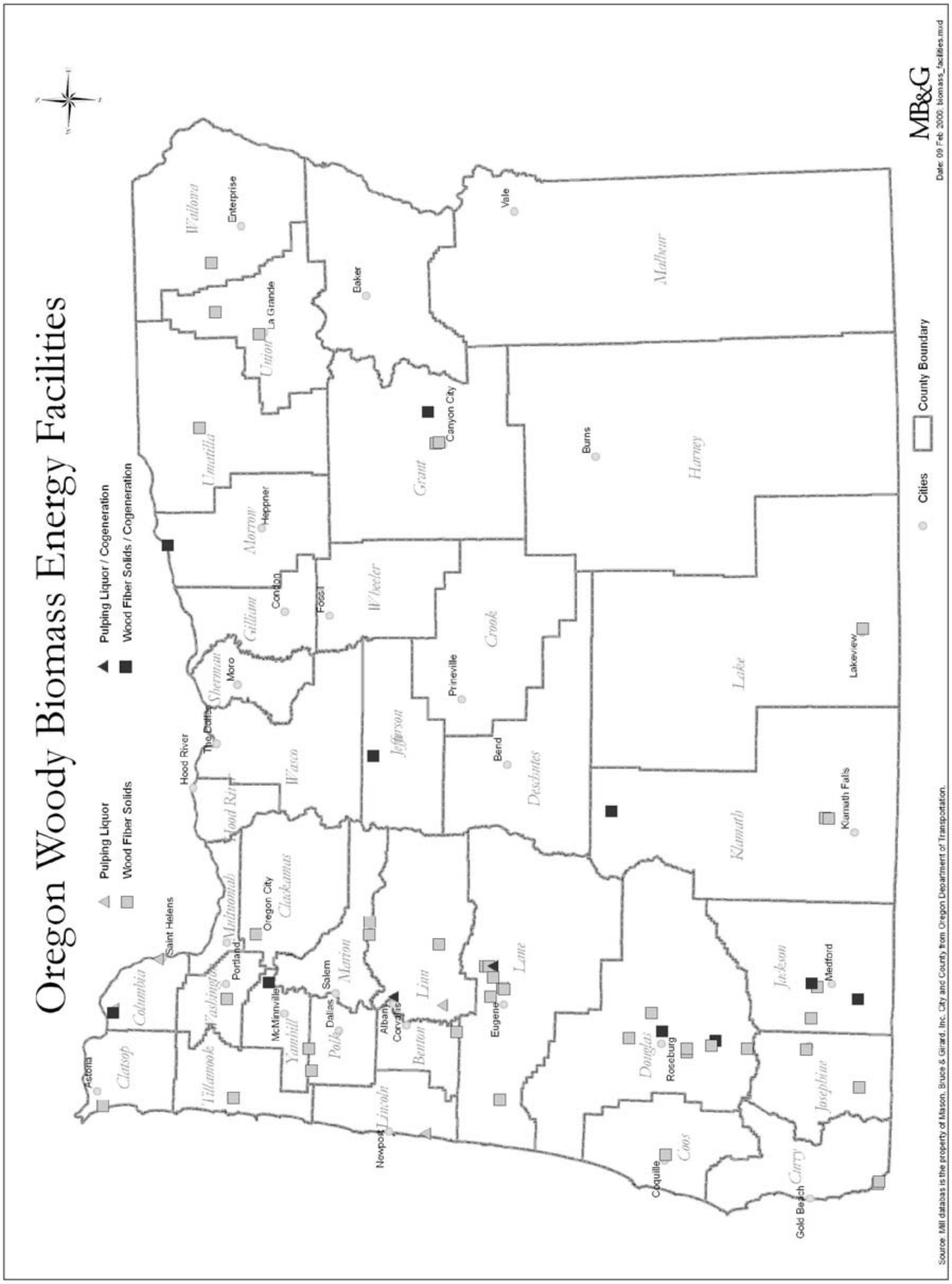


Figure 1 - Location of woody biomass energy facilities in Oregon.

Market Barriers

The current market barriers for woody biomass fuels are listed below in descending order of severity of impediment. This list is a compilation of the most commonly stated market barriers according to a number of recent studies focusing on the Oregon biomass energy market.

Power price

The current price of electricity in the Pacific Northwest is relatively inexpensive, thus limiting the competitiveness of biomass generated electricity. In their interview process, Itron (2004) found that the majority of the cogeneration facilities in Oregon reported being able to buy electricity cheaper than they could produce it to sell back to the grid. In addition, the wholesale price of electricity is not high enough to offset the costs of investing in new cogeneration plants.

Power sales agreement

The Itron study also found that negotiating a favorable long-term power purchase agreement with an energy purchaser is difficult for most biomass energy producers. The study states that the only Oregon plants currently operating profitably are those that negotiated long-term contracts in the 1980's and were able to lock in high energy prices.

Transportation costs

The transportation costs associated with hauling mill residue to a cogeneration site are expensive, and even more so for hauling logging waste from the forest. Delivered costs for mill residues such as veneer cores and chips were estimated at $3-$14/GT and $15-$27/GT, respectively, for a conversion site in Eastern Oregon (McNeil Technologies 2003). The estimate for forest biomass to the same site was $48-50/GT. Thus, even though the largest potential supply of biomass fuel is from forest thinning operations, this supply source is the most costly to collect.

Fuel availability

As mentioned above, the largest potential biomass fuel supply is forest residue. However, in addition to being the most expensive woody fuel source, there is no guarantee of a reliable long-term, constant supply. The federal agencies that would likely contribute the bulk of this supply through fuel reduction contracts cannot guarantee a reliable supply due to budget constraints or potential litigation (Almquist 2005).

Utility interconnection

In interviews with existing operators of biomass facilities who produced electricity primarily to sell on the grid, Itron (2004) found that utility interconnection did not represent a major difficulty. Many of those operating net-metered cogeneration systems, however, reported resistance from utilities in the form of extra fees and demand charges. Although utility interconnection is a one-time process, the potential frustration and expense involved are worth mentioning as possible market barriers.

Several developments could minimize the severity of these barriers. A continued rise in oil prices will likely drive the prices of other energy products up as well. A higher wholesale electricity price would help to offset forest residue transportation and new biomass facility investment costs as well as diminish the need for more favorable power sales agreements. In addition, a renewed focus on forest health and concerns regarding the risks to urban-wildland communities from wildfire will hopefully encourage new legislation to enforce the implementation of hazardous fuel reduction on federal lands. With fuel reduction stewardship contracts from federal land managers to guarantee a reliable feedstock supply for at least 10 to 15 years, investment in biomass facilities becomes much more achievable (Sampson *et al*. 2001).

Potential Markets for Woody Biomass

Both Itron (2004) and CH2MHILL (2005) report that the potential biomass energy market for mill residue is limited due to the majority of existing residue being used for higher-valued end products such as pulp, paper, and plywood or for producing energy used in industrial processes at the existing mills. Some surplus mill residues west of the Cascades may be available[1]; however, the magnitude of the surplus is uncertain. CH2MHILL goes on to say that this market is mature: an excess of fuel results in the market price dropping until additional boilers are added to take up the excess, and a shortage of fuel results in the price rising until other fuels, such as oil or natural gas, are substituted. Therefore, the only woody mill waste that should be considered for electric power production is that currently being disposed of in landfills.

Forest residues seem to present limited potential as well. One obstacle to forest residues being used for biomass energy is the high cost involved with collecting and processing forest residues. CH2MHILL (2005) estimates this cost to be at $0.09-0.13 per kWh (versus $0.03-0.07 per kWh for mill residues), which is too high to recover through selling electricity to the grid at current wholesale electricity prices of $0.03-0.06 per kWh. In addition to high fuel transportation costs, there is a need for long-term feedstock supply contracts with the Forest Service which isn't promising in the short- or mid-term in many areas of the state. The greatest potential for new logging residue-based biomass facilities is in eastern Oregon where:

- the facilities can be located easily within reasonable transportation distance of the fuel source,
- the fuel supply is drier and more economical to process, and
- forests are in greater need of thinning due to increased fire danger.

Most of the information reviewed for this report seems to suggest limited market potential in the near- to mid-term for the use of forest biomass in energy production. However, recent efforts in eastern Oregon may be an indication of more potential than previously assumed. Three new facilities in La Grande, Wallowa, and Warm Springs have been proposed or are already underway. The Confederated Tribes of the Warm Springs Reservation (CTWSR) is in the process of developing a 15.5 MW cogeneration facility in Warm Springs that will require 160,000 BDT/year of biomass fuel. Although much of the material will come from Tribal assets, approximately half of this need must come from off-reservation sources requiring roughly 8,000 acres of material per year (Resource Innovations 2005). To meet this need, the CTWSR have signed a Memorandum of Understanding (MOU) with the Forest Service and BLM to utilize biomass generated from fuel reduction treatments on public lands within 75 miles of the Reservation. The MOU specifies that the agencies use competitive stewardship contracts, traditional service and timber sale contracts, sole source agreements with the CTWSR, and other contracting means to fulfill their obligations (AFRC News 2006). How well this plays out will be a

[1] Personal communication with Dan Burns, D.R. Johnson Lumber, 3/14/2006.

good indication of how limiting the current market barriers actually are for the mid-term biomass-generated electricity market potential.

Several studies have looked at the potential market in Oregon for ethanol and biochemical production from woody biomass. In cellulosic-ethanol production, the cellulose and hemicellulose components are broken down and fermented into ethanol, which has been used as an additive to, or an alternative to, gasoline and diesel fuels. The remaining lignin from the wood can be burned for heat and energy to drive the process, or used to extract valuable biochemical compounds.

As of now, the technology is commercially unproven and corn-ethanol is less expensive to produce than cellulose-ethanol. Even though the feedstock for cellulose-ethanol is cheaper than corn and the potential ethanol yield higher, the cellulose is more costly to process (Graf and Koehler 2000). However, anticipated advancements in cellulose-ethanol processing as well as the projected rise in the price of ethanol will hopefully make cellulose-ethanol economically viable. The economics can also be improved by the coproduction of biochemicals from lignin as well as using pulp and paper mill sludge as a potential feedstock. Due to the year-round availability of sludge, an ethanol facility could benefit from this consistent feedstock source by being located within close proximity to a pulp and paper mill. However, due to the limited quantity of sludge produced, as well as its other competing uses such as soil amendment, boiler fuel, and animal bedding, it would serve only as a supplemental feedstock source to an existing ethanol facility.

Another study reported that a guaranteed feedstock supply is the most critical factor for assuring success of a cellulose-ethanol venture in Oregon (Sampson *et al.* 2001). This presents the same market barrier as described under the current market potential for electricity produced from forest residues.

Despite these current drawbacks, Oregon may do well to position itself for a possible near- to mid-term market development. Ethanol is currently viewed as the best alternative for methyl tertiary butyl ether (MTBE) as an oxygenate in reformulated gasoline. Unlike MTBE, ethanol is safe for the environment and is not a carcinogenic. In the future, as ethanol replaces MTBE as an oxygenate, additional production will be required. The continued development of cellulosic-ethanol technology could reduce production costs and also lead to higher ethanol demand (Graf and Koehler 2000). When the technology and the economics allow for competitive cellulosic-ethanol production, Oregon should be in a good position to take full advantage of the expanding market.

The Oregon Cellulose-Ethanol Study (Graf and Koehler 2000) recommended four policy strategies to expedite the cellulose-ethanol industry in Oregon:

- Legislation to enforce forest thinning practices to increase feedstock availability.
- Re-designation of a portion of fire containment funds for use in forest management efforts designed to prevent fires (such as mechanical thinning).
- Tax incentives for ethanol production to secure project financing and reduce long-term debt.

- Legislation emphasizing the use of renewable fuels to promote the reduction of greenhouse gases and maintain clean air standards.

With guarantees of long-term feedstock supplies, improvements in cellulosic-ethanol processing technology, a rise in ethanol prices, and beneficial legislation and/or economic incentives, significant opportunities exist in Oregon for an emerging cellulose-ethanol market.

Summary

The studies cited above tend to come to the same conclusions: very little near- or mid-term potential for the woody biomass fuels market in Oregon. Mill residues are currently being used mostly at the mills and there does not appear to be enough surpluses for a sustainable energy supply for new cogeneration facilities. Forest residues present other problems: costs of transporting logging residues do not offset the current wholesale value of the power produced, and lack of reliable, long-term supply sources through contracts with federal land managers. In addition, commonly cited market barriers to economic biomass energy development include:

- limited competitive power prices,
- lack of decent long-term power sales agreements,
- high fuel transportation costs,
- questionable reliable, long-term fuel availability, and
- difficulties with utility interconnection.

Despite this reserved market outlook, current woody biomass utilization efforts in Eastern Oregon may hint at there being more market potential than is currently reflected in the literature. The performance of these efforts should give a better indication of the mid-term woody biomass market potential in Oregon.

In addition to biomass-generated electricity, several studies consider the production of ethanol and biochemicals from wood biomass to have reasonable mid-term potential in Oregon. Despite the current conversion technology being commercially unproven, anticipated advancements in cellulose-ethanol processing as well as the projected rise in the price of ethanol will hopefully make cellulose-ethanol economically viable. In the meantime, legislation emphasizing the use of renewable fuels, enforcement of forest thinning practices, and increased tax incentives for ethanol production would position Oregon to take maximum advantage of emerging technologies and markets.

Literature Cited

AFRC News. 2006, February. MOU with tribes. Portland, OR: American Forest Resource Council.

Almquist, B. (2005). An Inventory and Analysis of Biomass Utilization Efforts in Southwestern Oregon. Eugene, Resource Innovations, University of Oregon.

CH2MHILL. 2005. Phase II Biopower market assessment: sizing and characterizing the market for Oregon Biopower projects. Prepared for EnergyTrust of Oregon, Inc.

Fried, J.S., G. Christiansen, D. Weyermann, R.J. Barbour, R. Fight, B. Hiserote, and G. Pinjuv. 2005. Modeling opportunities and feasibility of siting wood-fired electrical generating facilities to facilitate landscape-scale fuel treatment with FIA Biosum. P.195-204 *in* Systems analysis in forest resources: proceedings of the 2003 symposium, Bevers, M.K. and T.M. Barrett (tech. comps.). USDA For. Serv. Gen. Tech. Rep. PNW-GTR-656.

Graf, A., and T. Koehler. 2000. Oregon cellulose-ethanol study: an evaluation of the potential for ethanol production in Oregon using cellulose-based feedstocks. Prepared for Oregon Office of Energy. Available at: http://www.oregon.gov/ENERGY/RENEW/Biomass/study.shtml

International Woodfiber Report. 2005, August. Northwest fiber prices and markets continue stable; record sawmill chip supplies displace expensive pulp logs. San Francisco, CA: Miller Freeman, Inc.

Itron. 2004. Biomass market assessment: final report. Prepared for EnergyTrust of Oregon, Inc.

McNeil Technologies, Inc. 2003. Biomass resource assessment and utilization options for three counties in eastern Oregon. Prepared for Oregon Department of Energy. Available at: http://oregon.gov/ENERGY/RENEW/Biomass/assessment.shtml

Northwest Power and Conservation Council. 2005. Power plants in the Pacific Northwest database. Personal communication with Jeff King, October 2005.

Sampson, N., M. Smith, and S. Gann. 2001. Western Forest Health and Biomass Energy Potential: A Report to the Oregon Office of Energy. Alexandria, Virginia: The Sampson Group, Inc.

USDA Forest Service. 2005. Oregon's forest products industry (preliminary tables). Pacific Northwest Research Station. Available at: http://www.bber.umt.edu/forest/pdf/OR2003.pdf

USDA Forest Service. 2002. Forest Inventory and Analysis Program. Available at: http://ncrs2.fs.fed.us/4801/fiadb/temp2/j012121531.htm

Estimates of Forest Biomass Supply at National, Regional, State and Sub-State Scales

Roger Lord, Mason Bruce & Girard

Abstract: Research literature on woody biomass supply at national, regional, state, and sub-state scales are reviewed. Some studies look at all sources of woody biomass while others focus only on supply from forest health thinnings. Estimates of available woody biomass residues from primary wood processing plants range from 0.0 to 6.8 million bone dry tons annually. Higher estimates assume volume can be bought away from existing uses. Estimates of forest biomass from forest health thinnings in Oregon range from 0.8 – 12.7 million bone dry tons annually depending on assumptions of area needing treatment, volume removed per acre, proportion of volume that is net biomass versus commercial timber, and the number of years over which treatments are accomplished. Studies providing sub-state supply estimates for northeastern Oregon, the east Cascades, and southwestern Oregon are also reviewed. Supply from hybrid poplar plantations and western juniper supply sources are also considered.

Estimates of Forest Biomass Supply at National, Regional, State and Sub-State Scales

The purpose of this paper is to review existing studies of forest biomass supply from fuel reduction treatments, logging residue, and other forest and woodland resources in Oregon and surrounding states. A number of previous studies have addressed the question of biomass supply at different geographical scales. We have organized this literature review based on geographic coverage of the studies as:

- National
- Regional
- Statewide
- Sub-state

Some of the regional and national studies also provide state-level detail. In these cases, we provide information at the broader geographic scale in the appropriate sections and re-visit the studies for Oregon statewide data under *Statewide Supply Estimates.*

We also address other potential supply sources including biomass from hybrid poplar plantations and juniper woodlands.

National Supply Estimates

Two studies provide a national look at woody and non-woody biomass feedstock availability. Because our focus is Oregon, we cover these only briefly to provide a national context.

ORNL 1999 Analysis

The Oak Ridge National Laboratory (ORNL) provided a national estimate of biomass feedstock availability for 1999 in Walsh *et al.* (1999). Biomass feedstocks were classified into five general categories: forest residues, mill residues, agricultural residues, urban wood wastes, and dedicated energy crops. Forest residues were classified as logging residues, rough, rotten and salvable dead wood; excess saplings; and pole trees. The model used in the analysis estimated the total inventory by residue type, then revised this downward to reflect quantities that can be recovered due to constraints on equipment, road access, and impact of slope. Since nearly 98% of mill residues generated each year are already used as fuel or to produce fiber products, the study assumes volume can be bought away from current users if prices exceeding value for the current uses are paid. Availability by delivered cost is provided in broad ranges. Little detail on assumptions employed is provided, making it difficult to draw conclusions about the reasonableness of the results. Table 1 summarizes the national estimate of biomass supply from forest and primary mill residues.

Table 1 – Estimated annual cumulative forest and mill residue quantities by delivered price in the United States, from Walsh *et al.* (1999).

Feedstock	***< $30/BDT delivered***	***< $40/BDT delivered***	< $50/BDT delivered
		Million bone dry tons	
Forest Residues	24	35	45
Primary Mill Residues	2	41	90
Total	**26**	**765**	**135**

Walsh *et al.* (1991) also provide state-level estimates of supply. Discussion of findings in this report relative to Oregon is provided under *Statewide Supply Estimates.*

ORNL/USDA 2005 Analysis

A more recent national analysis by ONRL and the USDA examined the technical feasibility of a billion-ton annual supply of biomass feedstock (Perlack *et al.* 2005). It estimates that 245 million bone dry tons (BDT) could be sustainably produced annually from forestland sources and primary mill residues.

Table 2 – Summary of potential woody biomass supply from forest resources in the U.S. from Perlack *et al.* 2005)

Feedstock	***Existing Use***	***Un-exploited***	***Growth***	Total
		Million bone dry tons		
Logging Residues	32	0	15	47
Other Removal Residues	9	0	8	17
Fuel Treatments (timberland)	49	0	0	49
Fuel Treatments (other forestland)	11	0	0	11
Fuelwood	35	0	16	51
Primary Mill Residues	46	8	16	70
Total	**182**	**8**	**55**	**245**

Forest residues from thinning were estimated using the Fuel Treatment Evaluator model (Miles 2005) and based on treatments needed to reduce fire risk in over-dense stands. It is not clear why this volume was categorized as "existing use" since most of this volume represents potential, but currently unexploited, supply. Data on logging residues and other removals were based on the USDA Forest Inventory and Analysis program's timber product output database. Fuelwood volume includes annual consumption of wood extracted for residential, commercial and electric utility purposes. Growth in volume of several categories is based on projected expansion in demand for forest products and other economic trends.

Regional Supply Estimates

Three recent studies provide estimates of the physical supply of forest biomass across the western U.S. In each, the focus is on potential biomass supply from forest health treatments on forestlands where overstocked conditions pose high wildfire risk.

Oregon Office of Energy Report

A report for the Oregon Office of Energy by The Sampson Group examined forest health issues across 11 western states and assessed the potential for biomass energy production from a 10-year accelerated forest health treatment program (Sampson *et al.* 2001). Treatments in three forest types were considered – ponderosa pine, Douglas-fir and true firs. Areas where harvesting is not allowed, such as parks and Wilderness, were excluded from the analysis.

The study assumed average removal of 15 BDT per acre of the following biomass volume from across the regional forest inventory:

- 80% of inventory in 5 – 7" dbh class
- 70% of inventory in 7 – 9" dbh class
- 60% of inventory in 9 – 11" dbh class

In total, the study estimates a total biomass harvest of over 40 million tons annually during a 10-year period of restoration treatment work. The area to be treated totals 28.7 million acres and covers 42% of the three forest types in the intermountain region, 18% of the PNW and 34% of the PSW. [1]

In Oregon and Washington, the study estimates an annual supply of 7.4 million BDT for 10 years from treatment of 493,000 acres. However, due to data limitations, the study excluded the Douglas-fir type in Oregon and Washington. In this respect, it is a conservative estimate of biomass potential for these states. The Douglas-fir type represents about 1.7 million acres (11%) of the eastern Oregon timberland area (Campbell *et al.* 2004) and 3.0 million acres (46%) of eastern Washington (Bolsinger *et al.* 1997).

USDA Forest Service Strategic Assessment

A more detailed analysis of potential biomass supply was published by the USDA Forest Service in 2005 as, *A Strategic Assessment of Forest Biomass and Fuel Reduction Treatments in Western States* (USDA Forest Service 2005). This assessment characterizes, at regional scale, the forest biomass that can potentially be removed to implement the fuel reduction and ecosystem restoration objectives of the National Fire Plan for the Western United States. The assessment area covers forests on both public and private ownerships in the region and describes all standing tree volume including stems, limbs and tops.

The study identifies at least 28 million acres in 15 Western States that could benefit from some type of mechanical treatment to reduce hazardous fuel loading. About 60% of this area could be

[1] PNW: Oregon, Washington; INT: Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, New Mexico; PSW: California.

operationally accessible for treatments with a total biomass removal of 345 million bone dry tons. Two-thirds of the area needing treatment is on public lands.

The analysis combined regional forest conditions data from the Forest Inventory and Analysis (FIA) program and a coarse-scale fire regime assessment to delineate areas needing treatment. Of the 236 million forested acres in the 15 states,[2] about half (130 million acres) is classified as timberland – land capable of growing at least 20 cubic feet per acre per year and not reserved by law or administrative action from timber harvest.

Potential removals were quantified based on selective removal prescriptions using the Stand Density Index (SDI) criterion. SDI (Reineke 1933) is an established, science-based forest stocking guide widely used as a measure of forest stocking condition and adaptable to uneven-aged conditions. SDI-based partial removal prescriptions were developed for each combination of forest type and ecoregion. The prescriptions generally reduced stocking to 30% of maximum SDI by removing small to mid-sized trees. Larger trees were removed if the SDI surpluses occurred in those size classes. Removal volume was divided into merchantable volume and biomass volume. Merchantable volume included stem volume in trees at least 7-inches dbh up to a 4-inch minimum top diameter. The remaining volume, including small trees, limbs and tops constituted biomass volume.

Treatable areas were defined as timberland with stocking in excess of 30% of maximum SDI for that forest type and ecoregion. Analysis of inventory data based on this criterion established that treatment opportunities exist on three-quarters of the timberland area, or 97 million acres.

Area needing treatment for overstocking was further classified by Fire Regime Condition Class (FRCC). FRCC is a measure of how much a forest has departed from natural wildfire conditions (Schmidt *et al.* 2002). Table 3 summarizes the FRCC system and describes the type of management activities needed to treat each class.

[2] 15 western states include: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington and Wyoming.

Table 3 – Fire Regime Current Condition Class descriptions.

Condition Class	***Fire regime***	Example management options
Condition Class 1	Fire regimes are within an historical range and the risk of losing key ecosystem components is low. Vegetative attributes (species composition and structure) are intact and functioning within an historical range.	Where appropriate, these areas can be maintained within the historical fire regime by treatments such as fire use.
Condition Class 2	Fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one or more return intervals (either increased or decreased). This results in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetative attributes have been moderately altered from their historical range.	Where appropriate, these areas may need moderate levels of restoration treatments, such as fire use and hand or mechanical treatments, to be restored to the historical fire regime.
Condition Class 3	Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetative attributes have been significantly altered from their historical range.	Where appropriate, these areas may need high levels of restoration treatments, such as hand or mechanical treatments, before fire can be used to restore the historical fire regime.

Source: Schmidt et al. (2002), p. 8.

Treatment opportunities exist on 97 million acres overall and 67 million acres in FRCCs 2 and 3. More than 40% of this, 28 million acres, is in FRCC 3 and in most critical need of treatment. In Class 3 areas, fire regimes have been significantly altered and there is a high risk to serious ecosystem damage in a wildfire. Due to high fuel loadings, mechanical treatments are needed before the introduction of fire in these areas. Table 4 summarizes acres and removal volumes by state under various assumptions of conditions to be treated.

Table 4 – Treatment opportunity area and volume removed by state (USDA Forest Service 2005).

State	All Treatable Timberland		FRCC 2 & 3		FRCC 3	
	Million acres	Million BDT	Million acres	Million BDT	Million acres	Million BDT
Oregon	16.9	436.6	12.2	291.1	5.6	91.0
Washington	12.4	371.5	8.5	241.5	2.5	63.0
Idaho	12.1	242.9	8.0	177.6	3.3	80.4
California	13.4	368.1	11.8	317.9	5.5	125.1
Other western states	42.1	734.9	26.4	465.3	11.6	216.6
Total	**96.9**	**2,154.0**	**66.9**	**1,493.4**	**28.5**	**576.1**
60% of Total	**58.1**	**1,292.4**	**40.1**	**896.0**	**17.1**	**345.7**

The range of available material is large. At the upper end, volume available for removal on all timberland in need of treatment is more than 2.1 billion BDT. However, it is unlikely that the entire area could or should be treated. The study asserts, based on some general evidence, that about 60% of western timberlands are accessible and suitable for timber production operations. If this is the case, a more reasonable upper end for removal volume is 1.3 billion BDT.

A lower end estimate of available volume is based on treating only the high-risk FRCC 3 areas that require mechanical treatment before reintroduction of fire. Treatment of this portion of the forest would provide removal volume of 576 million BDT. If only 60% of this is treatable, there is still an estimated 346 million BDT of material that could be removed from FRCC 3 lands.

Not all of this is material that would be used in energy production, however. Although the vast majority (86%) of trees that would be removed is less than 10-inches dbh, most of the volume comes from trees larger than 14-inches. This volume would presumably have more value for conversion into conventional forest products such as lumber, plywood, or paper. The report estimates that about 29% of total volume would be in non-merchantable biomass material including small trees, limbs and tops. The range for production of biomass material is from 617 million BDT if all 97 million treatable acres are treated to 101 million BDT if 60% of the FRCC 3 area is treated.

Western Governors' Association Study

An analysis completed by the Biomass Task Force for the Western Governors' Association used the Fuel Treatment Evaluator (FTE) model (Miles 2005) to assess biomass supply from fuel thinnings in 12 western states[3] (WGA Biomass Task Force 2006). The model identified 23 million acres at high risk for fire and simulated thinning treatments. Treatments were designed to improve both Crowning (CI) and Torching Indices (TI). On one-half of the acreage, trees were removed proportionally from all diameter classes to meet CI and TI values. On the remainder, trees were removed from below – taking small trees first, and then progressively larger trees until CI and TI values were met. Treatments had to produce at least 300 ft^3 of merchantable wood (or about half a truckload) to help offset thinning costs.

[3] 12 western states included Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, South Dakota, Utah, Washington and Wyoming.

Of the 23 million acres identified, 10.6 million could be effectively treated, yielding 270 BDT of biomass. The study assumed 50% would be used for higher value products, leaving 137 million BDT for energy production. If treated at the rate of 500,000 acres annually, the supply of energy biomass would be 6.2 million BDT per year for 22 years.

Conclusions from Regional Studies

The three regional studies reviewed come to similar conclusions from different data sources and analytical approaches.

Sampson *et al.* (2001) provides a very high level estimate of regional biomass supply from a forest health treatment program across 11 Western U.S. states in which assumed proportions of trees in the 5 – 11 inch dbh classes are removed. This study estimates biomass availability at 400 million bone dry tons from 28.7 million acres.

USDA Forest Service (2005) provides a more thorough examination based on more detailed analysis of overstocked forest conditions and simulation of alternative fuel treatment prescriptions. The study also included removal of merchantable trees when needed to reduce fuel hazard and includes top and limb biomass in addition to stem volume. A range of estimated biomass is provided based on alternative areas of treatment.

WGA Biomass Task Force (2006) is the most recent analysis and uses a different model to assess supply from fuel reduction treatments. It examines a smaller landbase, 12 states versus 15 states in USDA Forest Service (2005) but reaches generally similar conclusions. One area where it departs from other studies is in the assumption that 50% of the volume is available for energy use. Other studies place this proportion between 25 and 20%.

Table 5 summarizes the results of the studies in terms of acres treated and volume removed.

Table 5 – Summary of results from three regional forest biomass studies.

Study	*Region Included*	*Trees Removed*	*Million Acres Treated*	*Removal Per Acre (BDT)*	*Total Volume (MBDT)*	*Biomass Volume (MBDT)*	Merch. Volume (MBDT)
Sampson *et al.* (2005)	11 Western States	Variable percentage of trees in 5-11" dbh classes	28.7	15.0	400	n/a	n/a
USDA Forest Service (2005)	15 Western States	All diameter classes from 2" dbh, but generally from small to medium sized trees	96.9 (All treatable)	22.3	2,154	617	1,537
			66.9 (FRCC2+3)	22.3	1,493	433	1,060
			28.5 (FRCC 3)	20.2	576	167	409
			17.1 (FRCC3*.6)	20.2	346	101	245
WGA Biomass Task Force (2006)	12 Western States	Thin from below on 50%; thin across all diameters on 50% of area	10.6 (treatable, providing >300 ft^2/ac of merch. wood)	25.5	270	135	135

MBDT = Million Bone Dry Tons

Some general conclusions that can be drawn from these three studies are:

- Significant opportunities exist to link forest health treatment with biomass energy production.

- The physical supply of otherwise non-merchantable woody biomass in overstocked western forests is in the range of 600 million BDT.

- Approximately 100 – 150 million BDT could be recovered by treating only the accessible portion of the forest most critically in need of mechanical fuel reduction treatments (FRCC 3).

- At least 28 million acres across the west is in need of mechanical fuel reduction to reduce fire hazards; two-thirds of this is on public lands.

These studies, however, are regional and landscape scale in nature. Biomass is a low value product relative to its transportation costs. In order to estimate biomass supply for any localized situation, more detailed analysis of supply within an economical transportation distance is needed.

Statewide Supply Estimates

A number of studies have estimated forest-based biomass supply potential for Oregon. These include national studies that provide state-level details (Walsh *et al.* 1999; USDA Forest Service 2005) as well as studies developed specifically for Oregon (Graf and Koehler 2000; CH2MHILL 2005).

ORNL 1999 Study

Walsh *et al.* (1999) estimated biomass feedstocks by state for a broad range of sources including forest residues, mill residues, agricultural residues, urban wood wastes, and dedicated energy crops. Forest and mill residue supplies, estimated for a range of delivered prices, are shown in Table 6.

Table 6 – Estimated annual cumulative forest and mill residue quantities by delivered price, in Oregon, from Walsh *et al.* (1999).

Feedstock	***< $30/BDT delivered***	***< $40/BDT delivered***	< $50/BDT delivered
	Thousand bone dry tons		
Forest Residues	1,299	1,928	2,516
Primary Mill Residues	10	1,738	6,834
Total	**1,309**	**3,666**	**9,345**

The estimate of forest residues is based on a model of total forest inventory, haul distances and operability constraints. Delivery costs are in 1995 dollars and include collection, harvesting, chipping, loading, hauling and unloading costs as well as a stumpage fee (return to the landowner) and a return for risk and profit. Since nearly all mill residue is already used to produce paper and other fiber products or energy, the mill residue supply is based on the assumption that it could be bought away from current uses if higher prices were paid for use in higher efficiency fuel systems.

Oregon Cellulose-Ethanol Study

This study by Graf and Koehler (2000) was commissioned by the Oregon Office of Energy to evaluate the potential of an Oregon cellulose-based ethanol industry. It contains an overview of a broad range of cellulose feedstock sources including forest-based biomass supply.

The study analyzed feedstocks from agricultural residues, forestry thinnings, municipal solid wastes (MSW) and other materials. Despite Oregon's abundance of forests, according to the study, agricultural residues are the leading source of readily available feedstock, comprising 49% of the total of 8.5 million BDT. Forest residues represent 35% of the total, followed by MSW at 15%. However, this supply from the forest is based on current levels of timber harvest and residues from manufacturing. The report notes that a forest management strategy to promote ecosystem sustainability would increase the quantity of feedstock for ethanol production.

The study estimates that if public policy were put into place to facilitate active management of areas with poor forest health at the rate of just 2% per year, the quantity of small diameter wood thinned could produce nearly 200 million gallons of ethanol. This would entail thinning of

140,000 acres annually generating 2.9 million BDT of feedstock. An estimated ethanol yield for forest thinnings is over 66 gallons per BDT.

The study concludes that wheat straw and forest residues provided the greatest potential based on quantity available, feedstock cost and ethanol production technology.

Energy Trust of Oregon Report

A recent report prepared for the Energy Trust of Oregon, which was designed to assess the near- and mid- term potential of five biomass market segments including forest biomass, provides another general view of the forest-based biomass supply in Oregon (CH2MHILL 2005).

The report estimates that 1.8 million dry tons of material is left in the forest after logging operations, using 2004 harvest levels. This equates to 18 trillion Btu/yr of potential fuel, which if converted to electrical power could produce 112 MW. In addition, the report estimates the amount of material potentially available by thinning overgrown forests is 2.5 million dry tons per year. This volume would amount to an additional 183 MW if converted to electric power. The combined fuel streams of harvest residues and biomass from thinnings would be sufficient to convert the Boardman, OR coal-fired facility to wood.

The study estimates fuel delivery and energy conversion costs assuming use of condensing turbine technology. The report concludes that forest-based biomass has a potentially promising outlook in the long term, but does not present near- or mid- term opportunities for Energy Trust because of economic, administrative and regulatory barriers.

USDA Forest Service Strategic Assessment

Oregon ranks first among the 15 western states for acres in need of fuel reduction treatment, and in acres in FRCC 2 & 3 and FRCC 3, according to a recent Forest Service study (USDA Forest Service 2005). The study estimates there are 16.9 million treatable acres of timberland in Oregon, including 12.2 million acres of FRCC 2 and 3, and 5.6 million acres in FRCC 3. Oregon represents about 17% of the timberland area needing treatment and 20% of the FRCC 3 area.

The estimated volume removed from fuels treatments in Oregon ranges from 91 million BDT from treatment of only FRCC 3 lands to 437 million BDT if all treatable acres are treated. Assuming 29% of this is non-merchantable as conventional forest products, from 16 to 127 million BDT could be available for energy production. Table 7 summarizes the biomass supply estimates from the Forest Service report for Oregon.

Table 7 – Estimates of biomass supply in Oregon (USDA Forest Service 2005)

Landbase treated	***Percent of area treated***	***Area treated***	***Total volume removed***	Biomass volume removed **(at 29% of total)**
		Million Acres	*Million BDT*	*Million BDT*
All treatable timberland	100%	16.9	436.6	126.6
	60%	10.1	262.0	76.0
FRCC 2 & 3	100%	12.2	291.1	84.4
	60%	7.3	174.7	50.7
FRCC 3 only	100%	5.6	91	26.4
	60%	3.4	54.6	15.8

Conclusions from Statewide Estimates

Estimates of biomass annually available from harvest residues in Oregon, based on existing commercial timber harvests range from 1.3 – 2.5 million BDT in the national study by Walsh *et al.* (1999). The 1.8 million BDT per year estimated by CH2MHILL (2005) falls near the mid-point of this range.

Estimates of residue from primary wood processing facilities are only partially addressed in these studies. Walsh *et al.* (1999) estimate that 0 – 6.8 million BDT of mill residues might be available depending on delivered price offered relative to its value for competing uses. CH2MHILL (2005) assumes that only the 0.62 million BDT per year that is currently landfilled would be economically available.

Potential biomass from forest health thinning is estimated at 2.9 million BDT by Graf and Koehler (2000) and 2.5 million BDT by CH2MHILL (2005). The former estimate is based on thinning 140,000 acres annually, or 2% of the 7 million acres of timberland estimated by the OR Department of Forestry to need treatment. This rate of thinning would theoretically treat all 7 million acres in 50 years. But this rate is probably not acceptable given the critical wildfire risk. Sampson *et al.* (2001), suggests a 10-year thinning program. At this accelerated rate, 700,000 acres of timberland would be treated annually. By extrapolation, this would yield 14.5 million BDT per year using Graf and Koehler's per acre yield estimate. Treatment of 350,000 acres per year over 20-years would yield 7.3 million BDT.

Under the National Fire Plan, five federal agencies mechanically treated an average of 175,250 acres in Oregon during FY2003-2005 and area treated rose each year. In FY2005, the agencies mechanically treated 226,750 acres (National Fire Plan, http://www.fireplan.gov. February 8, 2006).

USDA Forest Service (2005) estimates biomass availability from fuel thinning at 16 – 127 million BDT, but does not provide an annualized number. If treated over 10 years as suggested by The Sampson Group, supply would range from 1.6 – 12.7 million BDT.

None of the studies considers growth that will occur in the period before initial forest health treatment nor do they estimate the long-term sustainable level of biomass supply after the forests have been restored to more natural conditions.

Table 8 summaries the results of the statewide studies cited.

Table 8 – Summary of statewide reports on forest biomass supply in Oregon.

Study	***Harvest residues***	***Mill residues***	***Forest health thinnings***	Comments
		Million BDT / yr		
Walsh *et al.* (1999)	1.3 – 2.5	0.0 – 6.8		based on current harvest levels
CH2MHILL (2005)	1.8	0.06	2.5	assumptions for thinning not provided
Graf and Koehler (2000)			2.9	thin 140,000 ac/yr for 50 yrs
			7.3	Thin 350,000 ac/yr for 20 yrs
			14.5	Thin 700,000 ac/yr for 10 yrs
USDA Forest Serv (2005)			0.8 – 6.4	depending on landbase available for treatment, if treated in 20 yrs
			1.6 – 12.7	depending on landbase available for treatment, if treated in 10 yrs

Sub-State Supply Estimates

Three studies provide more detailed assessments of supply in sub-regions of the State. Two studies cover northeastern Oregon and one is in southwestern Oregon. Together, these studies provide some analysis of the major forested areas where wildfire risks are most critical.

Grant and Wallowa Counties

The study by Sampson *et al.* (2001) reviewed earlier provides an estimate of biomass supply in two eastern Oregon counties. The methodology used to provide these estimates is not described in detail, reflecting a lack of current data that was available at the time. Nor does the study address the economics of collecting and delivering the biomass for processing. Nevertheless, a review of the estimates illustrates the magnitude of the physical supply that may be present. Table 9 summarizes the study's estimate of biomass availability for Grant and Wallowa Counties.

Table 9 – Estimated ranges of biomass fuels currently available in Grant and Wallowa Counties, from Sampson *et al.* (2001)

County / Land Ownership	***Estimated Area***	Biomass Available	
		Low	**High**
Grant County	*acres*	*thousand BDT*	*thousand BDT*
Private non-industrial	69,883	700	1,000
National Forest	485,000	4,850	7,275
Total	**554,883**	**5,550**	**8,275**
Wallowa County			
Private non-industrial	130,000	1,300	1,950
Private industrial	150,000	1,500	2,250
National Forest	115,000	1,150	1,725
Total	**395,000**	**3,950**	**5,925**

If all biomass was accessible and harvested over a ten-year period, from 555 to 828 thousand BDT per year would be available in Grant County and 395 to 593 thousand BDT would be provided in Wallowa County. The study concludes that there appears to be an ample supply to sustain an energy facility in each county. By comparison, the Biomass One cogen plant in southwestern Oregon uses 112 thousand BDT annually (Oregon Dept. of Energy 2005). However, the majority (63%) of the supply in Grant and Wallowa counties is located on public lands. The problems of capturing this resource are political as well as economic.

Additionally, some of this volume may have higher value for other uses, since volume in trees as large as 11-inches dbh is included. The Sampson report does not divide its reported volumes into merchantable timber products and non-merchantable biomass. Other studies report biomass volume to be 25 – 29% of the total volume removed (McNeil Technologies 2003; Fried *et al.* 2005; USDA Forest Service 2005). The percentage for Sampson, however, may be higher because it limits removals to trees less than 12-inches dbh.

Baker, Wallowa and Union Counties

Biomass supply for three counties in Northeast Oregon was estimated for the Oregon Department of Energy in McNeil Technologies (2003). The goal of the study was to promote cost-effective, sustainable use of biomass energy in Baker, Wallowa and Union Counties. The assessment focused on use of both forest and agricultural biomass for electric power generation or conversion to ethanol fuel. Specific objectives were 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
- Provide an overview of biomass energy technologies, feedstock requirements, and the economic potential to convert biomass to electricity or ethanol.

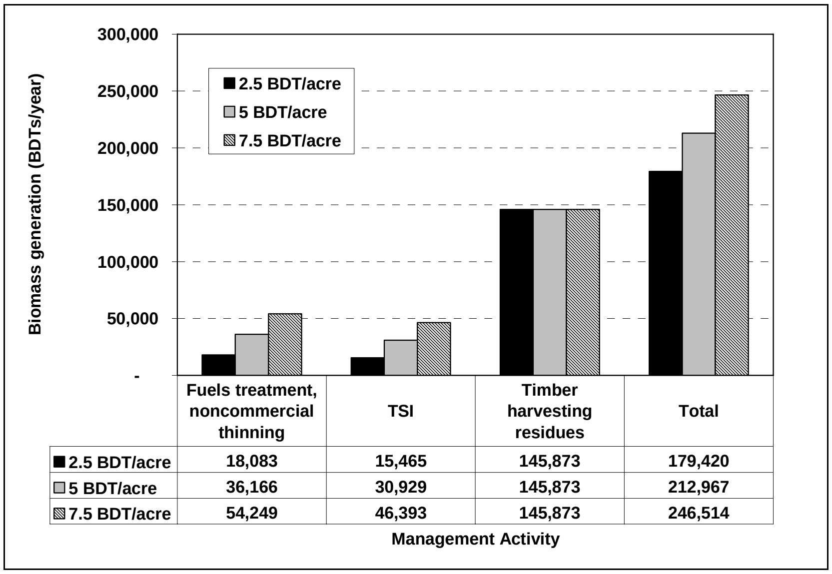
In some respects, the McNeil Technologies report offers a more comprehensive view of forest-based biomass supply than is available from other studies in Oregon. In addition to potential supply from fuel reduction treatments, the study also analyzed supply from non-commercial thinnings, timber stand improvement (TSI)[4], and logging residue from commercial timber harvests on federal, state, county, private and municipal land. In addition, it estimated wood products manufacturing residue as well as agricultural residue generation and availability in the three-county area. However, the report's emphasis is estimating biomass from current levels of management, so it does not include an estimate of biomass that would result from an accelerated forest fuel reduction treatment program. In that respect, it is conservative in its estimate of forest-based biomass supply.

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 and then evaluate the quantity of material that could be recovered considering technical and environmental (but not economic) constraints. Forest biomass generation estimates relied on historical timber harvest data and estimated overstocked acreage on public and private timberland. Area treated annually with pre-commercial and commercial timber harvests, timber stand improvement, and fuel reduction treatments was derived from a variety of data sources, and then multiplied by estimates of biomass produced per acre of treatment. This total was then reduced by the percentage of forestland with slope greater than 30% under the assumption that biomass from steep slopes was not recoverable.

The estimated forest biomass generation ranges from 231,500 to 318,000 BDT per year based on different yield assumptions.[5] Fifty-three percent of the total biomass generated comes from private land, 46% from federal land with small amounts from state, county and municipal lands.

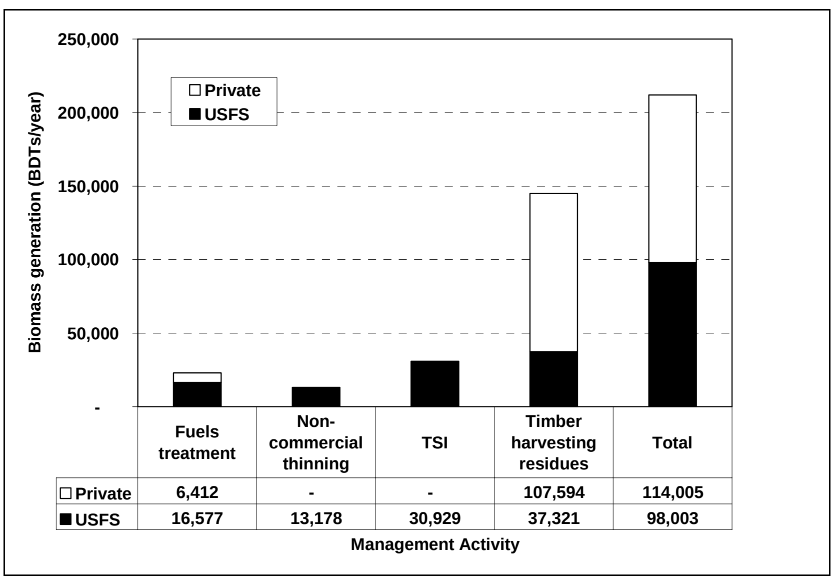
[4] TSI includes measures such as thinning, pruning, release cutting, prescribed fire, girdling, weeding, or poisoning of unwanted trees, aimed at improving growing conditions for the remaining trees.
[5] Volumes were expressed in the source report in green tons. For consistency, we have converted these to BDT assuming 50% wet-basis moisture content.

Availability of this biomass supply is subject to a number of factors including the need to leave some biomass on-site to reduce soil erosion and compaction, conserve soil nutrients and provide wildlife habitat. Also, technical barriers such as slope conditions preclude recovery of a portion of the generated biomass. The study assessed these constraints and estimated available forest biomass at 179,400 — 246,500 BDT/year. Figure 1 summarizes the study's estimate of available biomass by management activity under three alternative assumptions of yield per acre. Figure 2 depicts available biomass by ownership under the medium yield assumption (state, county and municipal ownerships are not shown but comprise less than 1% of the supply).



	Fuels treatment, noncommercial thinning	TSI	Timber harvesting residues	Total
2.5 BDT/acre	18,083	15,465	145,873	179,420
5 BDT/acre	36,166	30,929	145,873	212,967
7.5 BDT/acre	54,249	46,393	145,873	246,514

Figure 1 – Forest biomass availability by management activity under different yield scenarios in Baker, Union, and Wallowa Counties, from McNeil Technologies (2003).



	Fuels treatment	Non-commercial thinning	TSI	Timber harvesting residues	Total
Private	6,412	-	-	107,594	114,005
USFS	16,577	13,178	30,929	37,321	98,003

Figure 2 – Forest biomass availability by landowner and management activity in Baker, Union and Wallowa Counties, from McNeil Technologies (2003).

Biomass removals of 2.5 – 7.5 BDT per acre in McNeil Technologies (2003) are lower than those in other analyses. Sampson *et al.* (2001) assumed yield of 15 BDT per acre although some of this is merchantable size. USDA Forest Service (2005) estimated average removals of 20.2 – 22.3 BDT including 5.9 – 6.4 BDT of biomass volume based on its silvicultural modeling of fuel treatment needs. The yield at the high-end of the range used by McNeil Technologies is consistent with yields from the Starkey Fuels Reduction project on the Wallowa-Whitman National Forest, in which an average of 7.2 BDT were removed per acre (McNeil Technologies 2003).

Residue generation from the manufacture of wood products represents an additional source of woody biomass in the tri-county area. An estimated 357,500 BDT of residues are generated annually by mills in the three counties. This includes planer shavings, chips, plywood trim, sawdust, veneer cores, and hog fuel. However, all residues are currently utilized by secondary mills including a particleboard plant in La Grande and pulp mills outside the area. The study assumes that 154,500 BDT/year of these residues – the volume of wood chips and veneer cores that are currently shipped to secondary facilities outside the region – would be available for energy at the right price. However, the study notes that perhaps only 20% of the pulp chip volume, 31,000 BDT/year, could be diverted to energy production without disrupting chip market economics.

The study concludes that total estimated annual biomass generation is 631,000 BDT/year, of which 58%, or 368,000 BDT, could be available for use at a biomass energy facility. This volume is broken down as follows in Table 10:

Table 10 – Estimated woody biomass generation and availability for energy production in Baker, Union and Wallowa Counties, from McNeil Technologies (2003)

Source	***Generated***		Available	
	BDT/Year	***Percent***	***BDT/Year***	***Percent***
Forest biomass	273,810	43%	212,967	58%
Wood products residue	357,426	57%	155,126	42%
Total	**631,236**	**100%**	**368,093**	**100%**

The two reports covering northeastern Oregon provide sharply different estimates of biomass supply, but this is because of differences in assumptions as well as geography considered. The McNeil Technologies estimated supply of 213,000 BDTs annually from forest biomass in 3 counties is based on current levels of management – harvesting, thinning and fuel reduction treatments. The Sampson Group report's estimate of 950,000 – 1,421,000 BDTs from two counties is based on an accelerated thinning program to meet treatment needs from the forest health perspective. The results accentuate the potential increase in biomass availability that is contingent on treating overstocked, unhealthy forests in eastern Oregon.

East Cascades and Southwestern Oregon

Fried *et al.* (2005) linked FIA forest inventory data, simulations of alternative fuel reduction treatments using growth modeling, and estimates of harvest and haul costs with a geographic information system to develop a spatially-explicit assessment of biomass supply in portions of southwestern Oregon and northern California. The study was designed to identify biomass "hot spots" – locations where there was the best potential for accumulation of biomass, merchantable volume, net revenue, and acres treated – under the assumption of the construction of 4 biomass processing facilities capable of generating 50MW each.

The study focused on a 28 million acre area including the Klamath, Modoc Plateau, southern Cascades and eastern Cascades ecosections. The area was selected based on prevalence of acreage in Fire Regime Condition Class 3, which is most critically in need of fuel reduction treatments. Areas in designated wilderness, parks, preserves, inventoried roadless areas and the like were removed from analysis as were areas on steep slopes more than 2,000 feet from mapped roads. A net area of 10.4 million acres of forestland, including 8.2 million acres of federal lands and 2.2 million acres of private forests was included in the analysis of biomass supply potential.

Inventory plots representing this land base were modeled using the Forest Vegetation Simulator (FVS) growth model (Stage 1973) and its Fire and Fuels Extension (FFE) (Reinhardt and Crookston 2003). Nine fuel treatment prescriptions were designed for stand density and ladder fuels reduction treatments. The prescriptions generally thinned the stands to alternative residual stand densities and alternative maximum acceptable diameter for cut trees. The treatment prescriptions were simulated on 1,556 FIA sample plots to produce alternative estimates of merchantable and biomass removal volume.

Trees smaller than 3.5″ dbh remained on site, as did volume from trees 3.5 – 7.0″ dbh on steep slopes. Biomass volume brought to the landing included 3.5 – 7.0″ dbh trees on gentle slopes, limbs and tops of merchantable trees, and all harvested hardwoods. The FFE model was used to predict improvement in 2 measures of crown fire potential for each plot – torching index (TI) and crowning index (CI). TI is an estimate of the wind speed at which a fire could be expected to move from surface fuels into tree crowns. CI is the wind speed at which a crown fire could be expected to be sustained. Increases in TI and CI were assumed to reduce fire hazard. Treatments that did not generate a minimum of 20 mph improvement in either TI or CI with no reduction in the other were discarded as being ineffective in terms of fire risk reduction. The total area that could be effectively treated with the prescriptions was 5.4 million acres.

Logging costs for each simulation were predicted using STHARVEST (Fight *et al.* 2003). Haul costs were estimated using a haul cost model based on the forest plot locations, a road network layer, and assumptions regarding travel costs for various grades of road. Haul costs were generated to numerous alternative delivery locations, which were then analyzed for total volume available and cost of delivery. One site in each of the four ecosections was selected from among the sites with the best accumulation potential. Sites chosen were Bend, Klamath Falls, and Grants Pass in Oregon and Burney in northern California. Each forest plot was allocated to the market with lowest haul cost (Figure 3).

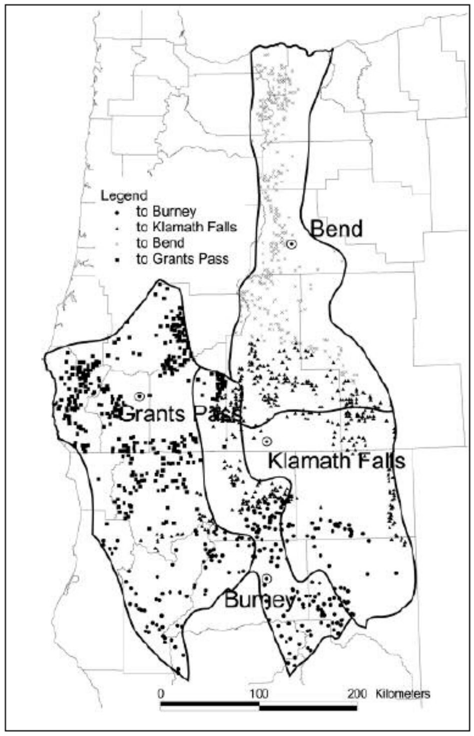


Figure 3 – The California-Oregon study area with ecosections, accessible plots, and the four potential processing sites considered in the analysis, from Fried *et al.* (2005).

Biomass volume was assumed to have a delivered value of $18 per green ton based on prices paid in competitive markets in northern California.

Four fuel treatment policy scenarios were modeled in which all treatable plots were treated with the prescription for each plot that:

Scenario 1 – maximizes net revenue
Scenario 2 – maximizes improvement in Torching Index
Scenario 3 – minimizes the merchantable material removed
Scenario 4 – maximizes improvement in Crowning Index[6]

In addition, three alternative scenarios (1A, 2A, and 3A) were developed to correspond with Scenarios 1–3 with the constraint that only plots that broke even or generated positive revenue were treated.

Although quite different in terms of the assumptions, the results for the scenarios were similar in terms of the total biomass yield (Table 11). Biomass yield ranged from 38 to 47 million BDT in total if all 5.4 million acres are treated (Scenarios 1, 2 and 3). If only sites returning positive net revenue are treated (Scenarios 1A, 2A and 3A), biomass volume drops by 40 to 50%. Area treated also drops by about half. Biomass volume available varies by processing site. The Grants Pass processing site generated the highest volume of biomass in each scenario.

[6] Scenario 4 is not fully developed in the paper so results will not be summarized here.

Table 11 – Volume of biomass delivered to hypothetical processing sites by fuel treatment policy scenario (Fried *et al.* 2005)

Processing Site	Biomass Delivered by Scenario (millions of green tons)					
	1	***2***	***3***	***1A***	***2A***	***3A***
Burney (CA)	24	30	21	11	12	12
Klamath Falls	14	15	12	7	7	7
Bend	12	11	9	8	8	8
Grants Pass	30	37	34	16	17	21
Total	**79**	**94**	**75**	**42**	**44**	**47**

The study also estimated the potential longevity of a 50MW biomass plant located at the processing sites (Table 12). A 50MW plant at Grants Pass, for example, could be supported for at least 50 years under Scenario 2 and probably longer since the study does not account for growth or the need for periodic re-treatment.

Table 12 – Years of feedstock for a 50MW biomass-based electrical generating plant consuming 1750 green tons per day of biomass in an 24/7 operation (Fried *et al.* 2005)

Processing Site	Years of Operation by Scenario					
	1	***2***	***3***	***1A***	***2A***	***3A***
Burney (CA)	38	47	33	18	19	19
Klamath Falls	22	24	18	11	11	10
Bend	18	18	14	12	12	12
Grants Pass	47	58	53	25	27	33

The study draws the following general conclusions from the analysis:

- There is sufficient biomass to supply four 50 MW power plants for decades under the most aggressive treatment scenarios.
- Supply under the most conservative scenarios is much more limited but could perhaps support several smaller or less heavily capitalized plants over a shorter time period.
- Most of the material removed – 75% – is merchantable logs that would bring higher prices for other uses than $18 per ton for biomass.
- Biomass volume represents 25% of the material removed and only 20% of that is from trees less than 7" dbh.
- Biomass volume recovered represents only 10% of the total value recovered.
- Biomass rarely pays it way out of the woods. Haul cost alone averaged $8.53 per green ton ($17.06/BDT), nearly half of the delivered market value. Harvest costs exceed the remaining $9 per green ton of value by a significant margin.
- Leaving the biomass-sized material in the woods reduces costs and would increase net revenue but make the risk reduction benefits of the treatment more dubious.
- Focusing efforts on areas where net revenue is positive reduces the acreage treated by 51%.

The authors also list a number of caveats that imply that the analysis in many ways is optimistic in regard to biomass supply:

- The analysis assumed that all non-reserved acres would be allocated to fuel reduction treatments. In reality, some landowners will choose other management options or will not consider any treatment.

- Much of the National Forest land in the study area may be in late successional reserves, riparian reserves, of other designated uses that are considered incompatible with the fuel reduction treatments considered.

- Some costs were not considered, including planning, administration, site clean-up, environmental assessments, or litigation.

- The road network information used in the study was coarse, at best, and may have resulted in an underestimate of haul distances.

- The price assumed for biomass was derived from the competitive northern California market, while the potential processing sites were specifically chosen to operate in separate supply areas with minimal competition between them. Hence, the market value of the biomass may be over-stated.

- Generation of large quantities of merchantable volume, if processing capacity does not expand proportionally, may drive down market prices and reduce potential revenue.

Other Sources of Woody Biomass Supply

Non-forest sources of biomass supply include mill residuals and urban wood waste. Mill residuals are addressed in a companion literature review, *Market Conditions for Woody Biomass in Oregon*. This section focuses on two additional sources – hybrid poplar plantations and western juniper.

Hybrid Poplar Plantations

Hybrid poplar (or willow) plantations are sometimes mentioned as a potential source of woody biomass for energy production (Perlack *et al.* 2005; Wimberly 2005). In Oregon and Washington, approximately 45,000 acres of poplar plantations have been established with major production areas along the lower Columbia River and in northeastern Oregon and southwest Washington (Chastagner and Hudak 1999). In Oregon alone, there are more than 34,000 acres of hybrid poplar plantations (Oregon Dept. of Energy, http://www.oregon.gov/ENERGY/RENEW/Biomass/resource.shtml #Poplar, January 26, 2006). Most of the production from these farms has historically been used for pulp chips. However, a shift toward higher value products is occurring. Potlatch has announced plans to shift production to sawlogs and is seeking a partner to develop a lumber business based on its 17,000 acre poplar plantation near Boardman, OR (Potlatch Corporation 2006). GreenWood Resources, the other large owner of poplar plantations in Oregon, is also focusing on sawlog products (GreenWood Resources, http://www.greenwoodresources.com/products/, February 6, 2006).

Poplar plantations are managed using short rotation intensive culture (SRIC) techniques to produce a harvestable crop in 6 to 15 years depending on the target product. Cultural techniques are more similar to agriculture than forestry with intensive weed control, multiple fertilizations and, on east-side of the Cascades, drip irrigation (Chastagner and Hudak 1999).

According to the U.S. Department of Energy, dedicated energy crops are not currently being produced in the U.S., but could be if they could be sold at a price that ensures the producer a profit at least as high as could be earned using the land for production of traditional crops (Walsh *et al.* 1999). This is not likely to be the case for existing hybrid poplar plantations in the PNW, at least in the foreseeable future. Higher values for lumber and wood chips are likely to preclude use of much of the volume produced in these plantations for energy production. However, harvesting residues from these operations represent a potential source of feedstock for energy production. For example, harvest residue including ground bark, tops and limbs, from Simpson Paper Company's hybrid eucalyptus plantation in northern California has been used as feedstock at the Wheelabrator Shasta Energy Company wood-fired power plant in Anderson, California (Appel Consultants Undated).

Residue yield ranges from 7 to 15 bone dry tons of fuel per acre (Oregon Dept. of Energy, http://www.oregon.gov/ENERGY/RENEW/Biomass/resource.shtml#Poplar, January 26, 2006). Assuming a rate of harvest of 3,400 acres per year in Oregon and Washington (11-year average rotation), this would produce 23,800 – 51,000 BDT of biomass that could be delivered annually to energy facilities, if located within an economical haul distance of the plantations. In general, this magnitude of material would be an incremental source of feedstock rather than a sole source for an energy facility.

Currently, most harvest residue is left in piles, burned on site, or spread back and disked into fields, although it has been used as hog fuel on occasion at the Boise Cascade Wallula paper mill and the Heppner biomass power plant. Its stringy bark and lower Btu value makes it a non-preferred hogfuel (Chuck Wierman, Pers. Comm., Boise Cascade LLC, February 6, 2006).

SRIC poplar plantations grown specifically for energy biomass production may at some point become economically viable. Trees would likely be grown at closer spacing to produce more biomass at lower cost than is possible for other commercial products. However, use of naturally grown wood biomass for energy production is more efficient for conservation of fossil fuels than biomass grown under SRIC (Zerbe 2006). In addition, poplar plantations would have to compete with other dedicated energy crops. An economic model developed by the USDOE and USDA indicates that switchgrass production is more attractive than hybrid poplar and willow production at energy-equivalent market prices (Walsh et al 1999).

Western Juniper

Western Juniper is an invasive species on rangeland throughout much of the western U.S. and has often been cited as a potential source of energy biomass. In eastern Oregon, the area classified as juniper forest has increased from 420,000 acres in 1936 to 3.6 million acres in 1999. This includes area with stocking of 5% or greater. In addition, there is an extensive area of juniper savannah, defined as land with juniper trees growing on it, but with less than 5% stocking. The total area of juniper forest and juniper savannah has expanded by a factor of four, reaching

6.8 million acres in 1999 (Azuma *et al.* 2005). Limited evidence suggests that juniper expansion began at the end of the Little Ice Age in 1850. However, its rapid increase in abundance since the late 1800's has been attributed to climatic shifts and anthropogenic factors including introduction of livestock grazing and fire exclusion (Azuma *et al.* 2005; Miller *et al.* 2005).

Overgrazing, fire suppression and climatic changes are thought to be responsible for the expansion of juniper in much of the west. The expansion of juniper has had a number of ecological effects. Juniper out competes other native vegetation for limited moisture, reducing rangeland productivity and modifying wildlife habitat (Azuma *et al.* 2005; Bedell *et al.* 1993). Juniper expansion is also thought to result in watershed degradation, reduction in water quality and quantity, changes in nutrient cycles and loss of biodiversity (Bedell *et al.* 1993).

The Pacific Northwest Research Station conducted an inventory of eastern Oregon's juniper resource in 1999. Of the 3.6 million acres of juniper forest, 1.5 million are on federal lands managed by the BLM. The agency's lands also include 1.2 million of the total 3.2 million acres of juniper savannah. Much of the remaining acreage is on private lands, including 1.6 million acres of forest and 1.9 million acres of savannah. Harney and Crook counties each have more than one million acres of juniper forest and savannah. Lake and Grant counties each hold about 840,000 acres. Wheeler and Jefferson counties are next, with over 500,000 acres each (Azuma *et al.* 2005).

Total biomass on juniper forests and savannahs is estimated to be 12.6 million BDT. This includes bole, branch and bark volume, but not foliage. About 94% of this, 11.8 million BDT, is on juniper forest lands. Fifty-six percent of biomass is on federal lands including 42% on BLM lands, and 14% of national forest. Private lands contain 41% of the juniper biomass. Crook, Lake, Harney, Grant and Klamath counties have the most biomass volume. Area and biomass volume by county are summarized in Table 13.

A major issue in utilizing juniper for biomass is low per acre volumes. Across all juniper forest, biomass averages 3.3 BDT per acre. Juniper savannah averages just 0.2 BDT per acre. However, stocking is quite variable. Over 1 million acres carry more than 4 BDT of biomass per acre (Table 14).

Without control, expansion of juniper will likely continue. Lands now classified as juniper savannah will continue to increase in tree density and will shift into the forest classification over time. If all juniper savannahs were to convert to forest, juniper would become the most common forest type in eastern Oregon (Azuma *et al.* 2005).

Control of juniper is an expensive undertaking. Chaining and dozing were the most common forms of control in the 1960's and 70's. Use of chainsaws increased in the 1980's and since the 1990's use of fire has significantly increased. The use of mechanical shears and whole tree chipping has been implemented since 2000 in Modoc and Lassen counties in northern California and Lake County, Oregon. These efforts have provided biofuel for power generation at the Honey Lake power plant in Wendell, CA (Miller *et al.* 2005). This experience suggests that further investigation into the use of juniper for energy production in Oregon is warranted.

Table 13 – Juniper area and biomass by county, 1999 (from Azuma *et al.* 2005).

County	Area (Thous. Acres)			Biomass Volume (Thous. BDT)		
	Forest	Savannah	Total	Forest	Savannah	Total
Baker	123	295	418	330	14	344
Crook	785	351	1,136	2,740	152	2,892
Deschutes	224	133	357	675	27	702
Gilliam	16	32	48	55	5	60
Grant	365	472	837	1,438	90	1,528
Harney	537	675	1,212	1,577	149	1,726
Jefferson	362	142	504	427	79	506
Klamath	265	13	278	1,466	27	1,493
Lake	352	495	847	1,672	157	1,829
Malheur	138	209	347	456	11	467
Morrow	4	0	4	-	-	-
Sherman	-	16	16	-	-	-
Wasco	48	234	282	41	67	108
Wheeler	340	169	509	934	10	944
Total	**3,559**	**3227**	**6,786**	**11,811**	**788**	**12,599**

Table 14 – Juniper forest area by biomass per acre and ownership, 1999 (from Azuma *et al.* 2005).

Biomass per acre (BDT)	Thousand Acres				
	BLM	National Forest	Other Public	Private	Total
0-1	455	90	-	564	1,109
1-2	307	31	-	270	608
2-4	306	52	64	344	766
4-6	227	47	32	128	434
6-8	112	52	-	78	242
8+	128	104	-	172	404
Total	**1,535**	**376**	**96**	**1,556**	**3,534**

Literature Cited

Appel Consultants. Undated. Lessons learned from existing biomass power plants. Prepared for National Renewable Energy Lab., Electric Power Research Institute, and Western Regional Biomass Energy Program. Available at: http://www.westbioenergy.org/lessons/index.htm.

Azuma, D.L., B.A. Hiserote, and P.A. Dunham. 2005. The western juniper resource of eastern Oregon. USDA For. Serv. Resour. Bull. PNW-RB-249.

Bedell, T.E., L.E. Eddleman, T. Deboodt, and C. Jacks. 1993. Western juniper: its impact and management in Oregon rangelands. Oregon State University Extension Service Corvallis, OR. Publication EC 1417.

Bolsinger, C.L., N. McKay, D. Gedney, C. Alerich. 1997. Washington's public and private forests. USDA For. Serv. Resour. Bull. PNW-RB-218.

Campbell, S., P. Dunham, and D. Azuma. 2004. Timber resource statistics for Oregon. USDA For. Serv. Resour. Bull. PNW-RB-242.

CH2M HILL. 2005. Phase II Biopower market assessment: sizing and characterizing the market for Oregon Biopower projects. Prepared for EnergyTrust of Oregon, Inc.

Chastagner, G.A. and J.M. Hudak. 1999. Crop profile for hybrid poplars in Washington & Oregon. Washington State University Cooperative Extension Service. Publication number MISC0355E.

Fight, R.D., X. Zhang, and B.R. Hartsough. 2003. User's guide for STHARVEST: software to estimate the cost of harvesting small timber. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-582.

Fried, J.S., G. Christiansen, D. Weyermann, R.J. Barbour, R. Fight, B. Hiserote, and G. Pinjuv. 2005. Modeling opportunities and feasibility of siting wood-fired electrical generating facilities to facilitate landscape-scale fuel treatment with FIA Biosum. P.195-204 *in* Systems analysis in forest resources: proceedings of the 2003 symposium, Bevers, M.K. and T.M. Barrett (tech. comps.). USDA For. Serv. Gen. Tech. Rep. PNW-GTR-656.

Graf, A., and T. Koehler. 2000. Oregon cellulose-ethanol study: an evaluation of the potential for ethanol production in Oregon using cellulose-based feedstocks. Prepared for Oregon Office of Energy. Available at: http://www.oregon.gov/ENERGY/RENEW/Biomass/study.shtml

McNeil Technologies, Inc. 2003. Biomass resource assessment and utilization options for three counties in eastern Oregon. Prepared for Oregon Department of Energy. Available at: http://oregon.gov/ENERGY/RENEW/Biomass/assessment.shtml

Miles, P.D. 2005. Fuel Treatment Evaluator web-application version 3.0. USDA Forest Service, North Central Research Station. Available at: http://www.ncrs2.fs.fed.us/4801/fiadb/FTE_Version3/Webclass1.asp.

Miller, R.F., J.D. Bates, T.J. Svejcar, F.B. Pierson, and L.E. Eddleman. 2005. Biology, ecology and management of western juniper. Oregon State University Agricultural Experiment Station, Corvallis, OR. Tech. Bull. 152.

Oregon Dept. of Energy. 2005. Oregon biomass energy facility directory: 2005. Salem, OR.

Perlack, R.D., L.T. Wright, A.F. Turhollow, R.L. Graham, B.J. Stokes, and D.C. Erbach. 2005. Biomass as feedstock for a bioenergy and Bioproducts industry: the technical feasibility of a billion ton annual supply. Oak Ridge National Lab., Oak Ridge, TN.

Potlatch Corporation. 2006. Potlatch Reports Higher First Quarter Results. Press release dated April 25, 2006.

Reineke, L.H. 1933. Perfecting a stand density index for even-aged forests. J. Agri. Res. 46:627-638.

Reinhardt, E., and N.L. Crookston. 2003. The Fire and Fuels Extension to the Forest Vegetation Simulator. USDA For. Serv. Gen. Tech. Rep. RMRS-GTR-116.

Sampson, N., M. Smith, and N. Gann. 2001. Western forest health and biomass energy potential: A report to the Oregon Office of Energy. Oregon Office of Energy. Available at: http://oregon.gov/ENERGY/RENEW/Biomass/forest.shtml

Schmidt, K.M., J. Menakis, C. Hardy, W. Hann, and D. Bunnell. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. USDA For. Serv. Gen. Tech. Rep. RMRS-GTR-87.

Stage, A.R. 1973. Prognosis Model for stand development. USDA For. Serv. Res. Pap. INT-137.

USDA Forest Service. 2005. A strategic assessment of forest biomass and fuel reduction treatments in Western States. USDA For. Serv. Gen. Tech. Rep. RMRS-GTR-149.

Walsh, M.E., R.L. Perlack, A.T. Turhollow, D. de la Torre Ugarte, D.A. Becker, R.L. Graham, S.E. Slinsky, and D.E. Ray. 1999. Biomass feedstock availability in the United States: 1999 state level analysis. Oak Ridge National Lab., Oak Ridge, TN. (Updated January, 2000). Available at: http://bioenergy.ornl.gov/resourcedata/index.html.

WGA Biomass Task Force. 2006. Biomass Task Force Report. Report prepared for the Western Governor's Association. January, 2006. Available at: http://www.westgov.org/wga/initiatives/cdeac/index.htm.

Wimberly, J. 2005. Pursuing realistic opportunities in home-grown energy. Biocycle 46(6):53-57.

Zerbe, J.I. 2006. Thermal energy, electricity, and transportation fuels from wood. For. Prod. J. 56(1):7-14.

Biomass Harvesting and Transportation: A Literature Review on Costs of Conventional and Innovative Technology

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***Abstract:** Residue from forest fuels reduction operations can be used as a feedstock for biomass energy facilities. At present, energy generated entirely from forest biomass is cost prohibitive and must be supplemented at bio-energy facilities with other sources of woody biomass, either mill residues or urban wood wastes (Bilek et al 2005). Biomass energy has the potential to become more cost competitive with other forms of energy if the delivery of forest biomass woody material was a more dependable and affordable option for facility managers. A well-established consensus for harvesting costs of the feedstock is not obtainable from literature since studies range over biomass production categories, equipment technologies, harvesting objective, and site conditions. However, one key driver to harvesting costs is stem size. Smaller stems create handling inefficiencies in all components of the process: felling, extraction, loading, and transportation. Challenges remain in the area of matching optimal harvest systems and processes with specific forest conditions to develop an economically feasible method for harvesting forest biomass.*

Biomass Harvesting and Transportation: A Literature Review on Costs of Conventional and Innovative Technology

Introduction

Fire preclusion policies in the 1900's significantly influenced forest structure throughout the western United States, contributing to increases in stand density and fuel loads versus historical levels (Covington *et al.* 1997, Fule *et al.* 2002). Reduction of biomass from these forests resulting from restoration silvicultural projects could be used to generate a form of renewable energy (Bain and Overend 2002) and strengthen rural communities throughout central and eastern Oregon. Several resources have been identified as raw material for energy production, including forest biomass. From a forest management standpoint, removal of biomass may be essential to return fire-adapted ecosystems to historic fire regimes (Hollenstein *et al.* 2001). Ecologically, fuels reduction projects that remove biomass material can have multiple positive benefits to ecosystem habitat (LeVan-Green and Livingston 2001).

At present, energy generated entirely from forest biomass is cost prohibitive and must be supplemented at bio-energy facilities with other sources of woody biomass, either mill residues or urban wood wastes (Bilek *et al* 2005). Biomass energy has the potential to become more cost competitive with other forms of energy if the delivery of woody material was a more dependable and affordable option for facility managers. Decreased harvesting costs and greater efficiency in extracting this material for transportation and conversion at bio-energy facilities could increase utilization of forest material as biofuels, help reduce the overall costs of restoration treatments, and encourage a more aggressive landscape approach to fuels reduction silviculture.

Categories of Forest Biomass

Biomass is extracted from forest settings in one of three categories:

1) by-products of commercial timber harvests,
2) an integration of small stem removals and by-products from log extraction, or
3) specific biomass harvesting where no other product is generated, often resulting from diameter limit treatments or forest residue collection.

Currently, most forest fuels reduction occurs as a commercial logging operation that generates biomass as a by-product of producing higher valued logs. For this review, operations that remove a significant portion of dead wood, standing or down, as part of a fuels reduction project are lumped into the by-products category. Another level of fuels reduction projects specifically targets the removal of small diameter stems in high fire hazard stands characterized by increased stocking levels. For these projects, justification for harvesting small diameter stems often comes from the utilization of larger material with a higher product value (Bilek *et al* 2005) to offset the elevated costs of extracting smaller stems. More recently, concern over timber extraction on public lands has limited fuels reduction efforts to extracting stems with little commercial value. In response to this sentiment, fuels reduction silvicultural prescriptions often detail an upper diameter limit for stem removal and remove stems best utilized as fuel for bio-energy facilities.

Typically, forest harvesting costs are broken into three components that may include felling, extraction, and comminution[1]. Not all cost components are recorded or delineated for each biomass category. For example, operations that generate by-product biomass often associate felling and extraction costs with the sawlog portion removal. Studies that have researched integrated harvesting projects have generally not broken down the specific costs for felling or extraction by product (sawlog and biomass). Additionally, felling costs for small stems, when integrated with a commercial harvest, may also not be detailed specifically. Costs for forest residue collection do not generally include any costs for felling or comminution. This lack of reference makes direct cost comparisons difficult among biomass categories. In order to do so, costs would need to be assumed for any missing component.

Within each category of biomass, harvesting costs vary with the range of equipment technology chosen for extraction. As the percentage of biomass to total removals increases, factors such as piece size, distance to landings, and removal volumes per acre can have significant effects on the cost per bone dry ton (BDT) to extract forest biomass to the landing.

Harvest Cost Standardization

This paper summarizes recent and past literature that detailed forest biomass harvesting and transportation costs. It explores the conventional use of forest equipment domestically and also looks at innovative approaches internationally, to discover technologies and methodologies that could aid in the development of a biomass harvesting initiative for Oregon's potential bio-energy resource. Costs are reported separately for harvesting – inclusive of all activities from felling to loading a truck – and transportation.

Since this review focused on the production costs of utilizing forest biomass for energy production, reviewed literature was primarily limited to those studies in which harvesting costs per unit volume were reported. Studies reporting treatment costs per acre would have required additional breakdown of reported figures. This could lead to misinterpretation of the original data given the range of products, stand conditions, and specific objectives of each study.

For sake of comparison, all costs are reported per BDT using the following factors for conversion:

0.5 BDT = 1 green ton (metric, 2000 lbs)
1.4 BDT = 1 CCF[2] (cunit, 100 cubic feet)
1 BDT = 1 cubic meter
0.45 BDT = 1 metric tonne

Some recalculating of reported figures was required; however, this provides the most direct cost comparisons of different harvesting methods. Additionally, all costs are reported in 2005 dollars (Table 1). In general, this review focuses on studies where total harvesting costs, including felling, extraction, comminution and loading, are reported. Missing component costs are noted for studies reviewed that report only portions of total harvesting costs. For example, since

[1] Comminution is the process of converting forest materials into consumable products (Pottie and Guimier 1985). More generally, it is a mechanical treatment process which cuts large pieces of material into smaller pieces. Used here as an inclusive phrase for chipping, hogging, tub-grinding, and shredding.

[2] From: http://www.forestry.state.al.us/publication/pdfs/WoodSyngasBook/Appendix%20C_%20Biomass%20Energy%20Glossary.pdf

comminution may occur at a bio-energy facility, projects that hauled biomass-sized material in roundwood form may not have associated comminution costs reported. Additionally, forest residue collection following a commercial harvest, may not report felling and/or comminution costs.

Equipment Configurations and Associated Biomass Harvesting Costs

Harvesting costs vary significantly by the technology employed for extraction. For this review, harvesting methods were lumped into three technology groups: 1) basic harvesting technology, 2) conventional logging equipment, and 3) modified or purpose-built machinery for handling small stems and forest residue. Each technology group has a specific role in biomass harvesting projects and an associated range of harvesting costs to achieve a specific objective. Costs and operating details pertinent to each study are reviewed for each harvest technology group below. Additionally, some discussion exists regarding the environmental effectiveness of each, as they pertain to soil and residual stem impacts.

Basic harvesting technology

Most biomass harvesting projects that employ basic harvesting technology integrate small sawlog production with the extraction of small stems. These operations generally involve manual felling of stems and utilize an array of extraction methods including manual labor, animal traction, all-terrain vehicles (ATVs), small skid-steer tracked machines, and monocable line systems in steeper terrain. These methods are most common in areas where social acceptability of stem removal is of concern, such as the wildland-urban interface (WUI), or where soil management concerns are increased.

Owning and operating costs are typically lower for basic harvesting methods compared to other technologies. This is beneficial to overall project economics when removals have little market value. Additionally, basic forms of harvesting can offer a lower cost method of removing forest biomass when production efficiencies are of low priority. For example, in steep terrain where ground-based machinery is not operable, skyline yarding systems can be used for extracting biomass in fuels reduction projects. These systems are costly to operate due to the equipment, layout skill, and labor required. Monocable yarding systems, a specialized yarding technique that utilizes an endless line, can offer a lower cost method to extract products with low market value while reducing fuel loads and protecting sites from detrimental soil impacts.

Literature Reviewed

Halbrook (2005) completed case studies in the WUI in northern Idaho. Three basic harvesting technologies were evaluated: 1) an ATV with skidding arch, 2) an Iron Horse skidder, and 3) an all-season vehicle (ASV) winching operation (Figure 1). Felling was completed manually for each extraction operation. Approximately 200 trees per acre (494 per hectare) were harvested and slope averaged 10% across all units. Large end diameter for removed stems roughly averaged 9.9" (25.1 cm) across all units. Although no biomass was utilized (slash was piled and burned), these case studies offer estimates of harvesting smaller diameter material in a fuels reduction setting.

A. B. C.


Figure 1. Basic harvesting technology equipment used in Halbrook (2004): A.) ATV with skidding arch, B.) Iron Horse skidding machine, C.) ASV with extraction winch. ***Photos courtesy of Jeff Halbrook.***

For the ATV operation (Figure 1-A), no tree less than 5" (12.7 cm) DBH was harvested. Total harvesting costs, including manual felling, were $27.86 /BDT[4]. Labor costs accounted for 84% of operating costs. Extraction efficiency declined when any uphill skidding occurred and limbs not trimmed smoothly acted as anchors. Machine power and maneuverability must be balanced for ATV skidding; more power allows for larger pieces to be extracted but increased size of the machine limits maneuverability in the stand. Concerns over deck management was observed since extracted pieces had to be stacked manually at the landing.

Using an Iron Horse (Figure 1-B), harvesting costs to the roadside were $35.71 /BDT; labor accounted for 81%. This machine was observed to be highly maneuverable in forest conditions and needed no access trail. Although multiple stem skidding is possible, log size can limit the ability of the Iron Horse to skid more than one stem. As with the ATV, deck management can be a concern when manual stacking is required.

The ASV winching operation (Figure 1-C) was a unique system that used a winch to extract products downhill (16 ft logs) to the roadside; self-loading trucks were used to load and haul sawlogs. The winch line capacity of the system was 130 feet. Total harvesting costs were reported at $25.00 /BDT; labor accounted for 57% of operating costs. For this operation the installed winch lacked sufficient power for multiple log skids, increasing overall harvesting costs.

Monocable line systems have been used in Japan and the developing world since the 1970s. This method is labor intensive and is generally most applicable where labor is abundant and affordable; a minimum of 4 – 5 woods employees manually attach each piece to the continually moving line. Moncable systems are also applicable in steep terrain fuels reduction projects since the system is not terrain limited. Monocable systems are best suited to extract small pieces (40 – 120 lbs or 18 – 54 kg) from the forest; in general, pieces should be less than 10 ft in length. Besse *et al.* (1994) conducted a precommercial thinning in western Oregon employing a monocable system. Maximum slope for the unit was 55% and 560 trees per acre (1400 trees per hectare) with stump diameters less than 6" (15.2 cm) were removed and bucked into pieces averaging 45 pounds (20.4 kg). Production averaged 25 green tons per day and cost $34.26 /BDT[5]. For biomass production, feeding small pieces into a chipper, on-site or off-site, may present some handling inefficiencies. Gathering and attaching tree tops and limbs typically extracted in fuels reduction projects could also add inefficiencies into the system.

[4] Costs reported in this study do not include comminution and loading costs.
[5] Cost is for extraction only and does not include felling or comminution/loading.

Besse et al. (1994) also report on a pine thinning on extremely steep slopes (> 55 %) using the monocable system in the Tahoe National Forest. For this operation, stems were delimbed and bucked to a 2" (5.1 cm) top for a firewood market; limbs and tops were yarded for chip production as a means to reduce fuel loadings. From volume removed and total project costs, it can be inferred that total harvesting costs for this operation were $97.70 /BDT[6].

Young *et al.* (1982) compared several approaches to removing western juniper from rangeland habitat. The wood harvesting option involved both manual felling and manual stacking of firewood, resulting in a total harvesting cost of $150.00 /BDT. Since this was marketed for a firewood market, no comminution costs were included. Overall, labor costs accounted for 80% of total extraction costs. Piling of slash accounted for slightly more costs than did felling, limbing, and bucking combined, $58.50 /BDT and $49.50 /BDT, respectively. Increased costs, correlated with tree height and high labor for slash piling, are the direct result of the amount of limbs on juniper stems. In this study, slash was not utilized for biomass and costs associated with piling are better attributed to management rather than production, reducing harvesting costs to the roadside to $91.50 /BDT.

Environmental Effectiveness

In general, environmental impacts are minimized when basic harvesting technology is used to extract biomass. The equipment used in these methods is typically small and has a lighter impact on soil resources. Much of this documentation is anecdotal; few studies have been published that document the relationship of site impacts to equipment size. Two factors can have negative impacts on soil and should be monitored when using small equipment: 1) an increased number of trips are needed to extract material, and 2) narrow tires, typical of farm tractors, can cause more rutting, especially when operating on soft soil conditions (Updegraff and Blinn 2003).

In general, smaller operations tend to protect residual trees since high production is not a concern (Halbrook 1995). Use of specifically designed small forwarding equipment, like a skidding arch or mini logging trailer, decreases impacts to residual trees and extraction trail surfaces, and can also extend operating seasons (Lanford *et al.* 1991).

Production Limitations & Opportunities

Basic harvesting technology has a role in fuels reduction and biomass harvesting projects; however, the use of smaller equipment presents certain challenges to producing low cost biomass to an energy facility. First, smaller piece sizes are extracted during operations using basic harvesting technology, requiring more training and skill for operators (Updegraff and Blinn 2003). Smaller piece sizes can also create inefficiencies in loading and have significant effects on transportation costs, increasing the total delivered price of biomass. Careful planning is necessary to match stand conditions to the chosen system in order to minimize biomass extraction costs. Stem size, removal piece size, and extraction distance are three key factors to monitor when employing basic harvesting technology. Maintenance and down time will increase if machines are overloaded on a regular basis.

One advantage of small equipment is the versatility afforded to the contractor. Small skid-steer machines, ATVs, and small excavators can be utilized for several functions during harvesting operations (felling and extraction) since changing attachments is relatively efficient (Updegraff

[6] Cost is for yarding material only and does not include felling or comminution/loading.

and Blinn 2003). For mechanical felling and extraction operations however, a small system employing two base machines will be more efficient than using one machine (Wilhoit and Rummer 1999). Additionally, these machines could be used by a contractor for other business outside of harvesting.

Opportunities for the use of small equipment are primarily limited to special circumstances where production efficiencies are not of highest priority. The largest obstacle for use of basic harvesting technology is the high labor cost component. In general, extraction distance (skidding, forwarding, or yarding) is very limited when using small, basic technology. Increased skidding distances, and associated increased costs, resulted from using limited landing choices to satisfy visual objectives in a fuels reduction project in the WUI in Idaho (Halbrook and Han 2005). Layout of biomass harvesting operations areas where social acceptability is of concern, can have an impact on overall harvesting costs.

Conventional logging operations

Use of conventional harvesting technology has been studied in various fuels reduction and small diameter harvesting projects throughout the United States. These systems include feller-bunchers, single-grip harvesters, forwarders, skidders, and small skyline systems. Research has shown that as the diameter of a tree decreases, harvesting costs increase (Bolding and Lanford 2005, Brown and Kellogg 1996, Rummer and Klepac 1996, Barbour *et al.* 1995). Forest fuels reduction operations have a high component of small-diameter stems in removals. One study showed that harvesting profitability with typical forest equipment can become negative when size of removal trees average less than 8" (20.3 cm) DBH (Kluender *et al.* 1998). One influence on high harvesting costs is that conventional logging equipment was optimally designed to handle larger material and is not suited to efficiently function in small diameter stems. Tree size limitations are not the only criteria for selection conventional harvesting equipment for use in small diameter harvesting operations. Factors such as capital costs, product considerations, harvest unit volume, slope limits, and soil impacts must be considered when choosing a harvesting operation to perform a fuels reduction or biomass harvesting operation (Hartsough *et al.* 1995).

In commercial logging operations in which biomass extraction is a portion of overall removals, revenue generated from sawlogs is used to cover expenses of extracting and hauling biomass. Harvesting costs for the biomass are shared, and thus reduced, when extraction occurs simultaneously with higher valued products, such as a small sawlogs (Richardson *et al.* 2002). Limiting removals to small stems using conventional equipment should result in higher extraction costs per unit volume of biomass than exhibited in integrated harvests.

Literature Reviewed

Brown and Kellogg (1996) reported a harvesting cost of $82.91 /BDT using a single-grip harvester and a small skyline yarder on flat terrain in eastern Oregon. For this operation, sawlogs and pulpwood, both standing and down, were extracted in roundwood form with diameter at breast height (DBH) averaging 9.0 inches (22.9 cm). Biomass was not specifically utilized in this project and costs were reported for integrated products. Felling costs were $17.36 /BDT while yarding costs were $44.18 /BDT. Brown and Kellogg speculate that extracting logs with a forwarder or rubber-tired skidder could have significantly lowered the overall harvesting costs.

Drews *et al*. (2001) completed a comprehensive study of a fuels risk reduction operation in the Blue Mountains of eastern Oregon. A single-grip harvester was coupled with either a forwarder or a skyline yarding system to extract fuels from a mixed conifer stand. Slopes averaged 12 % or less on all units and were similar between harvesting systems. Harvested stems averaged 7" (18 cm) DBH[7]. Costs were not separated by product but included felling, extraction, comminution, and loading. Units where the forwarder was used for extraction averaged $56.71 /BDT and skyline yarding units averaged of $132.13 /BDT.

Rummer and Klepac (2002) compared a manual felling and piling operation, coupled with a forwarder for extraction, to a typical mechanized CTL operation to harvest small-diameter lodgepole pine (*Pinus contorta*). No trees greater than 9" (22.9 cm) DBH were removed and average stem diameter of removed material was 4.1" (10.4 cm). Costs including manual felling were significantly lower at $58.48 /BDT[8] than the completely mechanized system, $88.90 /BDT. However, a direct comparison of these costs should be cautioned since the manual operation employed a fully depreciated forwarder and the CTL system employed new equipment. A new forwarder in the manual system would have increased harvesting costs to $80.35 /BDT.

Han *et al*. (2004) constructed a case study model of manual and mechanical ground-based integrated harvesting systems producing sawlogs and biomass fuel from small-diameter natural stands in southwestern Idaho. The modeled condition assumed 1) slope was less than 15 % throughout the harvest unit, 2) a maximum skidding distance of 800 ft., and 3) 150 trees per acre were harvested via single-stem selection. Mechanical harvests (felling and skidding) resulted in lower harvesting costs per BDT than did manual felling/mechanical skidding operations. Analysis was broken into two inch diameter classes, with results being presented for the 8 inch (20.3 cm) class. The mechanical felling (feller-buncher) and skidding operation exhibited the lowest cost at $30.71 /BDT, the CTL operation cost $34.85 /BDT, and methods that employed manual felling averaged $49.21 /BDT. These costs represent a weighted average for both sawlog and biomass fuel production. Breakdown of the costs by component indicates that extraction was the main difference for increasing costs for the manual treatments. It reasons that because stems were not bunched, extraction efficiency declined and increased removal costs. Generating only biomass fuel would have increased costs per unit volume because of even further decreases in handling efficiency.

Hartsough *et al.* (1997) researched three configurations of forested equipment to thin a naturally-regenerated mixed conifer stand in California's Sierra Nevada region. These operations did not have a specific fuels reduction objective but did produce a mix of small sawlogs and fuel chips. The configurations used in the study were a whole tree operation (feller-buncher, grapple skidder, and a drum chipper), a CTL system (single-grip harvester, forwarder, loader, and chipper) and a hybrid system (feller-buncher, single-grip harvester, skidders, loader and chipper). Biomass removals averaged 8" DBH (20.3 cm) and costs were segregated from sawlog production costs. Biomass production for the three equipment configurations cost $24.27, $30.62, and $63.67 /BDT, respectively. The majority of the cost difference can be explained by increased felling costs from using the single-grip harvester in the CTL operation. Since biomass production was a portion of total removals, the CTL and hybrid systems were used to investigate specialization efficiencies, felling only merchantable stems with the harvester. As with most

[7] 80% of woody material removed was dead, skewing product mix to chips over logs.
[8] Products were processed for post and rail markets and do not include comminution costs.

studies of this nature, the costs of handling sawlog tops, both in the woods and at the deck, were hard to separate from sawlog production costs. In this study, those costs were attributed to sawlog production and probably slightly decreased the reported costs to produce fuel chips.

Bolding and Lanford (2005) collected harvest cost information for non-merchantable stems in a mixed pine and hardwood stand in Alabama. Non-merchantable stems were defined as being less than 4" (10.2 cm) and consisted entirely of hardwood stems. A CTL harvesting system integrated merchantable log harvests with the removal of forest fuel. The non-merchantable material was extracted to the landing separately with the forwarder, chipped on-site, and utilized as hogfuel. Harvests costs were estimated for the non-merchantable portion of the removals to be $51.40 /BDT, compared to $17.04 /BDT for merchantable stems.

Lynch (2001) reported harvesting costs from a Ponderosa pine (*Pinus ponderosa*) forest restoration project conducted in southwestern Colorado. Although no stems less than 5" (12.7 cm) DBH were harvested and no specific biomass utilization was targeted, costs for smaller diameter products were documented independently of other products. In general, trees with a diameter less than 8" (20.3 cm) either went to an oriented strand board (OSB) or an experimental pulpwood market. Felling occurred by manual and mechanical (single-grip harvester) means, logs were skidded with a conventional rubber-tired skidder and a loader was employed to load trucks. Stump to truck costs for OSB production ranged between $33.47 - $44.70 /BDT over five units. Pulpwood was produced in only two units and cost $37.20 /BDT and $48.00 /BDT[9], respectively. It is worth mentioning, that to determine the cost reported above, transportation costs (44% of total) were subtracted from published OSB cost numbers.

Watson *et al.* (1986) investigated using different operational procedures with similar equipment in a natural pine stand in the US south. Using conventional equipment (feller-buncher, skidder, and chipper), energywood and pulpwood production using a one-pass system was compared to a two pass system. Energywood volume consisted of all pines less than 6" (15.2 cm) DBH and hardwoods less than 12" (30.5 cm) DBH. Costs for producing energywood to the roadside were estimated from time study data collected during operations to be $36.18 /BDT for the one-pass system and $47.56 /BDT for the two-pass system. However, the one-pass procedure generally delivered energywood with higher moisture content. This could affect energy conversion efficiency at the facility.

Halbrook and Han (2005) conducted a fuels reduction harvest in the wildland-urban interface (WUI) in Montana using conventional equipment on gentle terrain (10% slope). Removed stems averaged 10.5" (26.7 cm) DBH and fuelwood accounted for 21% of the total utilization. Fuelwood removal volume was calculated to have been 4.6 BDT /acre although there was no specific intent to harvest stems for biomass utilization only. Overall harvesting costs were $35.02 /BDT and included felling, skidding, comminution and loading. However, costs for felling, skidding, and processing the fuelwood were not segregated from those of sawlog or pulpwood production.

Huyler (1989) surveyed loggers producing fuelwood chips in the northeastern United States. The results showed that most biomass production was part of an integrated, single-entry harvest; sawlogs and pulp-grade chips were often produced simultaneously. The typical equipment configuration used by northeastern loggers for fuelwood comminution consisted of 1-2 feller-

[9] Costs reported do not include comminution costs.

bunchers, 1-2 grapple or cable skidders, a chipper, a dozer, and chain saws. Harvesting costs to the roadside ranged between $25.20 - $44.10 /BDT. Although these operations were not conducting fuels reduction harvests, most production was from selection cuttings.

Interpreting modeled results reported in Han *et al*. (2004) yields a harvesting cost of $78.24 /BDT for mechanical felling, skidding, and comminution of biomass fuel from fuels reduction operations on the Boise National Forest. These costs are estimated from harvesting stems between 1 and 4 inches (2.5 – 10 cm) DBH on 19 thinning sales on the Emmett Ranger District while producing no other products.

Environmental Effectiveness

Much research has shown the potential soil impacts of conventional logging equipment (Froelich et al. 1980, Tepp 2002, among others). In general, CTL systems, employing a harvester and a forwarder, tend to result in less soil compaction and rutting than tracked machines and rubber-tired skidders (Lanford and Stokes 1995). In a CTL system, a harvester progresses through a stand falling trees and delimbing and bucking stems to length at the stump. This creates a mat of slash on which both the harvester and forwarder travel, minimizing each machine's impact to the soil. However, for extraction of biomass, slash should be piled for efficiency gains. In doing so, the advantage of working on slash with CTL equipment is lost since the limbs and tops of stems are extracted from the stand.

Rubber-tired and tracked machines (feller-bunchers or skidders) also have their role in forest harvesting and with proper operation can limit impacts to the soil resource. Certain soils are more susceptible to compaction and rutting above certain moisture limits. Because of their efficient operating speeds, rubber-tired machinery allows for timely harvesting when working against a soil moisture timeframe; however, operations must stop immediately when that threshold is crossed because excessive soil compaction and rutting can occur. Tracked machinery distributes a load more evenly than rubber-tired machinery but has the potential for greater impacts when operated incorrectly during turning; travel in one consistent direction results in fewer impacts.

Both rubber-tired and tracked equipment have the potential to damage residual stems by damaging bark and lower branches. For both types of equipment, in general, soil compaction and damage to residual trees can be expected to increase with whole-tree harvesting since residues are not left to protect the soil (Richardson *et al.* 2002).

Production Limitations & Opportunities

Matching equipment design to specific harvest stem specific characteristics is necessary to reduce the overall cost of biomass production. Schneider (1987) found that using a small chipper as part of a small scale operation produced less biomass utilization than a large-scale comminution operation. The small-scale chipper could not handle some of the larger stems. This could have implications in stands where there exists a portion of larger, down and/or dead material that needs to be extracted as part of the fuels reduction silvicultural objective. Forest management decisions must balance the operating costs of a small-scale chipper with reduced utilization. Additionally, Schneider observed a difference in biomass utilization between hot logging (in which functions occur successively) and cold logging (in which functions are independent) techniques. The difference was attributed to the pressure on the landing crew to produce chips rapidly to ensure high productivity for the chipper. Cold logging allows the biomass to dry following felling, before being extracted. For an energy conversion facility, fuel with less moisture content would be more economical from which to convert energy (L. Potts, personal communication, Warm Springs Forest Product Industries).

Rubber-tired machinery has high productivity and relatively low associated costs. Rubber-tired drive-to-tree feller-bunchers can accumulate multiple stems before releasing them, but lose economic viability when stem size drops below 6" (15.2 cm) (Seki *et al.* 1982). Tracked feller-bunchers are also adept at removing multiple stems and have a relatively small footprint on the soil. However, tracked machines are more expensive and slower than rubber-tired machines. Costs of harvesting small trees with conventional equipment vary widely; however, average costs generally decrease as piece size increases and as the removed volume per acre increases (Hartsough and Stokes 1990).

Single-grip harvesters, used in CTL systems, were designed to improve utilization from small stems, upgrading pulpwood into solid wood products. Single-grip harvesting machines are efficient and have low impacts to the residual stand, in terms of both soil and stem quality. Harvesting small stems for biomass does not capitalize on the optimal bucking advantage offered by single-grip harvesters and operating costs for these machines are high. Therefore, harvesting small stems for strictly biomass production with a single-grip harvester is costly.

For steeper terrain, often skyline yarding systems are the only option for minimizing soil impacts. These systems require the highest operating costs relative to other conventional-type harvesting systems due to the expense of equipment, lines, and additional labor needed. Skyline systems require skill in layout and harvest design more than other ground-based harvesting methods. For these reasons, skyline yarding is most economical when extracting larger diameter (< 10" DBH or 25.4 cm) material. Pre-bunching of stems helps extraction efficiencies and costs when operating skyline yarding systems in thinnings (Brown and Kellogg 1996).

Modified or Purpose-built equipment

In general, Europe, and the Scandinavian countries in particular, have utilized forest biomass on a larger scale than the United States (Richardson *et al.* 2002). This has led to innovative harvesting technology to reduce production costs of the biomass fuel either by ad hoc modifications of existing equipment by machine owners or by engineering entirely new machines. This section explores the use of a range of equipment, from farm tractor base machines as harvesters, to slash-bundlers, to chipper-forwarders, modified or built with the direct intent of extracting small diameter stems or collecting forest residue.

Modified Equipment

One approach in Europe is to use farm tractors as base machines and attach harvester heads and forwarder trailers (Figure 2-A). These machines have much lower purchase costs and can be operated inexpensively compared to conventional logging equipment. Farm tractor equipment can be very versatile, both for multiple in-woods task and farm purposes, giving the owner options for generating business besides biomass production (Updegraff and Blinn 2000). Harvesting equipment with a farm tractor base is included in this category since it was modified specifically to handle small diameter stems.

Hartley (2002) investigated using farm tractor base equipment in fuels reduction harvesting operations in Idaho and Oregon. Two equipment configurations were utilized to extract small diameter stems; both systems employed manual felling means. In one case study where average diameter of removed stems was 12" (30.5 cm), harvesting costs totaled $43.43 /BDT[10]. The second system removed stems with an average diameter of 5.9" (15.0 cm) and resulted in $92.29 /BDT harvesting costs. Some of the difference in costs between systems was the effect of extracting smaller stems.

A. B. C.

Figure 2. Modified and purpose-built equipment harvesting equipment. A.) Farm tractor base, equipment with a forwarding trailer, B.) Neuson 1002 HV, small scale tracked harvester, C.) Modified tracked fell-buncher for skyline yarding. ***Photos courtesy of Han-Sup Han.***

Johansson (1996) evaluated tractors as base equipment for small tree harvesting in Sweden. Three custom built machines and two harvesting methodologies were compared for productivity and costs. In each stand, average diameter of harvested trees was less than 5.7" (14.4 cm). Only the felling process was observed and thus, only those costs are reported. For the stand in which average removal diameter was the smallest at 3.9" (9.9 cm), costs ranged from $46.32 /BDT[11] to $62.96 /BDT. As expected, costs were observed to be the lowest ($13.41 /BDT) in the unit with the largest average diameter of removed stems.

Similar to the idea of using a farm tractor base, smaller versions of tracked feller-bunchers have been engineered and have lower operating costs than traditional harvesters. Ewing (2001) investigated the use of a small harvester in a small diameter thinning operation. The average DBH of stems was 6.3" (16.0 cm) and 34% of the original volume was removed. Felling costs were observed to be $14.47 /BDT. Additionally, Rummer and Klepac (2002) researched a small harvester (similar to Figure 2-B) in a lodgepole pine (*Pinus contorta*) thinning operation. In this study, average stem DBH was 3.9" (9.9 cm) and felling costs were calculated at $36.60 /BDT. Although different machines were used in different conditions, the effect of stem diameter on felling costs is evident from these two studies. It should also be noted that the Rummer and Klepac study had the specific goal of maximizing utilization from each stem harvested, thus increasing time and costs for each felled stem.

Typical forest equipment can be modified or utilized differently to effectively extract stems by skyline yarding. Largo *et al.* (2004) conducted a study of non-guyline yarders in a commercial thinning. A tracked feller-buncher (Figure 2-C) and an excavator were modified with a two-drum winch and a small tower and used to yard small amounts of logs from sensitive areas.

[10] Costs in this study do not include comminution and loading.

[11] Converted from Swedish Kronor to US Dollars using 1996 exchange rate of 1 SEK = 0.1453 USD, then inflated to 2005 US Dollars. Costs do not include extraction or comminution for biomass.

Both operations had relatively short extraction distances (less than 328 ft or 100 m) and experienced some stability difficulties during inhaul. Production rates and cost differences were driven mostly by average piece size. Extraction costs were $9.27 /BDT for the excavator-based system and $22.42 /BDT for the tracked feller-buncher. In both of these studies, logs were only extracted from sensitive areas and placed in the unit for ground skidding to advance the logs to the landing; yarding stems to the landing would have increased costs. Stem size was large for both operations and aided in lowering costs per unit volume.

Innovative Technology

In the Nordic countries, most biomass is transported in chip form to the facility; comminution most frequently occurs in the stand or at the landing following final harvest (Richardson *et al.* 2002). Typically, this material has been stored on site for up to 6 months to decrease moisture content before comminution. Three general comminution methods are utilized:

1) at roadside employing a forwarder, chipper and trucks,
2) in the stand employing a terrain-chipper, and trucks to haul interchangeable containers (system may also use a chip-forwarder), or
3) at roadside or in stand employing a chipper-truck that chips and hauls.

Each system has different cost structures and performs differently in varying stand conditions. For gentle terrain with short transport distances to an energy facility, a chipper-truck works well; roadside comminution is best in steeper terrain. Comminution in the stand is effective when forwarding distances are short (< 1600 ft or 500 m) but can be extended (up to 6500 ft or 2 km) when using a chip-forwarder to shuttle chips to the roadside (Frisk 2001).

Bundling of slash has proven to be effective in collecting forest residues following final harvests of stands (Andersson and Norden 1998, Beach *et al.* 1982) but requires purchase of a specific machine or modification of existing equipment. This process uses a machine to collect, bundle and tie forest slash into composite residue logs (CRLs), creating both extraction and transportation advantages by increasing the density of forest slash. Cuchet *et al*. (2004) showed that CRL productivity and costs were correlated with the amount of residue on the surface, piece size, and layout (scattered or piled). Richardson *et al.* (2004) noted that overall cost of forwarding CRLs to the roadside were approximately half of that for loose residue.

Although this technology is not common in the United States, Rummer *et al.* (2004) observed a Timberjack 1490 Slashbundler (Figure 3) trial and noted that residue arrangement, scattered versus piled, significantly affected the ability of the machine to effectively collect potential biomass. Murphy *et al.* (2003) estimated CRL costs for different stand types in the Pacific Northwest. Using biomass equations, estimates of resultant residues following a conventional thinning operation were modeled and used in conjunction with CRL productivity rates from Scandinavia. Total extraction costs to roadside for ponderosa pine were estimated to be $53.56 /BDT.

A.  **B.** 

Figure 3. CRL equipment: A.) Timberrajck 1490 Slashbundler, and B.) Forwarder extracting CRLs. *Photos courtesy of Glen Murphy*

Stokes and Sirois (1986) completed a case study of a prototype chipper-forwarder machine producing fuelwood following a conventional timber harvest in Georgia. In this system, a small chipper was mounted on a tracked carrier and stems were chipped into an onboard bin for transport to the roadside. Costs, not including felling, ranged $24.57 - $40.94 /BDT, depending on whether the equipment was costed with some depreciation or as a new machine. Limits to production for this type of machine include hauling distance and terrain. Since comminution is idle during forwarding, haul distance should be minimized to reduce extraction cost for this type of machine (Hakkila 1979, Lillandt 1976).

Suadicani (2003) completed a cost and productivity analysis on several alternative systems for harvesting fuel chips in a 50-year old Norway spruce plantation in Denmark. Over the three units, removal stem diameter averaged 5.9" (15.3 cm). For each operation investigated, a chip-harvester followed the felling method, manual or mechanized, to chip stems and reload them into a chip-forwarder for transport to the roadside. Harvesting costs to the roadside per unit volume were extrapolated from data provided in the study and assume similar moisture contents across the units of 38% since this is the operating norm in Denmark. The manual felling treatment (MOMA) and the felling-bunching treatment (FEBU) exhibited similar costs, around $11.55 /BDT. The similarity is primarily due to the non-separation of stand data in these two units, specifically the volume harvested (used here for extrapolation of total costs/ha to costs/unit volume). By function, felling costs were higher for mechanized felling, but the bunching of stems contributed to a lower comminution cost. In the third treatment, a harvester was used to fell trees in a herringbone pattern for extraction and resulted in $23.27 /BDT total harvesting costs. Both felling and comminution component costs were significantly higher for the harvester method.

Environmental Effectiveness

Impacts to the residual stand and soil resource following operations using purpose-built equipment are similar to those for conventional logging-type equipment since most base machines are similar among the groups; for example, a CRL machine and a chipper-forwarder have a forwarder base. However, the advantage of using a slash mat to reduce compaction is not an option when that slash is being collected and utilized for biomass.

Farm tractor base machinery carries less weight than the conventional forest equipment. However, narrow tires, typical of farm tractors, can cause more rutting, especially when operating on soft soil conditions (Updegraff and Blinn 2003) and should be monitored closely during biomass harvesting operations.

One distinct advantage does exist for CRL production in reducing soil impact. The number of passes required to extract the same amount of biomass is greatly reduced versus the number necessary for a typical rubber-tired skidder (Rummer *et al.* 2004). A similar advantage is also afforded by a chipper-forwarder, since only one machine, and one pass, are necessary for collection, chipping, and extraction.

Production Limitations & Opportunities

Modified equipment is advantageous for biomass harvesting projects since the equipment is readily available and adaptable for forest contractors. Farm tractor base equipment with harvesting and extraction attachments capitalizes on an ability to be more efficient with smaller stems; however, production will be reduced. Small non-guyline yarders could be useful in short distance skyline yarding since operating costs are much lower than for traditional skyline systems. However, limited research has been completed with modified yarders and most biomass harvesting cost information is anecdotal. Yarding distances limit the applicability of this equipment since guylines are not rigged.

Purpose-built equipment has a role in harvesting biomass to fuel energy conversion facilities. Equipment specifically designed to fell and extract small diameter stems can reduce overall harvesting costs per unit volume by eliminating inefficiencies in the delivery system compared to conventional harvesting equipment.

The collection of forest slash presents efficiency and handling issues for conventional equipment that are addressed with specialized CRL equipment. Residue collection using CRLs has proven to be an efficient means to extract forest residues following final harvests (Hakkila 2004). Residue collection is more efficient when piles of slash exist versus scattered slash and short, large diameter pieces present handling problems for a CRL machine (Rummer *et al.* 2004). Additionally, since operating costs of these specialized machines are high, there needs to be a sufficient volume distributed per acre to improve project economics. However, purchase prices and operating costs for innovative equipment (CRLs, chip-harvester, etc.) are high due to the need to import machinery (Updegraff and Blinn 2003). Maintenance and replacement parts for these machines are not readily available compared to conventional equipment. CRLs and other innovative, purpose-built equipment can be risky investments for contractor when no established market exists for products (Richardson *et al.* 2002)

Transportation efficiencies are increased when biomass leaves the landing in chip form versus loose slash. Comminution in the stand requires flat and even ground and its range is 1200-1600 ft. (300-400 m) from the landing. The use of these systems is diminishing in Scandinavia and Finland (Hakkila 2004) and most comminution is completed at the landing (Richardson *et al.* 2002). In-woods chipping (actually occurring at the landing) and production of hogfuel for energy for pulp mills has been a part of forest harvesting in the United States for many years. Coupling this knowledge with the lowest cost felling and extracting method, dependent on site specifics such as objective and stem diameter, will result in the overall lowest cost for extracting biomass.

Transportation

Once biomass is extracted from the forest, either in roundwood form or chips, it must be transported to a facility for final conversion. Depending on the distance between the forest landing and the energy facility, transportation can add a significant cost. Richardson *et al.* (2002) notes that for an average distance of 37 miles (60 km) in the Nordic countries, transportation accounts for over half of the delivered costs of forest residues. In one case, costs for transporting material four hours were equated to the forest management costs to grow a 17 year-old pine (Richardson *et al.* 2002).

In general, transportation costs vary widely depending on form (chips, roundwood, loose residues, CRLs) and market values for fuel, insurance, and other uncontrollable costs. For these reasons, comparison of transportation costs across years and locations is extremely difficult. At present, it is primarily practical for biomass (as defined as stems, limbs and residue) to be transported from the forest to a comminution facility in one of two forms: chips or CRLs.

Transportation rates of chips, both clean chips for paper mills and fuel chips, are well understood in the United States, particularly in the south where in-woods chipping operations are common. Bolding and Lanford (2005) reported hauling costs for fuel chips of $0.242 /BDT-mile stems with a maximum payload of 11 BDT per load. In the Willamette Valley of Oregon, a typical 45 mile haul, transporting 15 BDT at 50% moisture content, can cost $2.95 /mile - $3.54 /mile, depending on fuel surcharges, here 0% and 20%, respectively (T. Cook, Georgia Pacific Corp., personal communication, 1/11/2006). Additionally, as moisture content of biomass decreases, transportation costs increase due to water loss.

Han *et al.* (2004) used an assumption of $0.369 /BDT per mile for hauling biomass in southwestern Idaho. These rates were calculated including woods road travel where the Oregon rates (reported above) were hauling rate averages for mill residues and did not include woods travel. The modeled rate for the Idaho study was a total of 53.5 miles and included 8.5 miles of woods travel (gravel or dirt) and 45 miles on pavement.

Small stems, limbs, and residues have low bulk densities when transported in roundwood-like form have low bulk densities, increasing costs (Hakkila 2004). This is the primary reason for the development of CRL technology; slash is compacted into bundles, increasing bulk density and allowing better integration among extraction and transportation methods (Richardson *et al.* 2002). However, Rummer *et al.* (2004) experienced very low haul weights when compared to conventional roundwood transportation. The largest payload achieved during trials in the Pacific Northwest only slightly rose above half the legal limit. A possibility for CRL transportation due to their shape and size is that they can readily be hauled by rail (Richardson *et al.* 2004).

Murphy *et al.* (2003) used $0.107 /ton-mile[12] and assumed 20.3 tons /load for analysis of CRL transportation with a self-loading log truck. Rummer *et al.* (2004) included $0.10 - $0.20 /ton-mile for hauling CRLs during a demonstration project in the Pacific Northwest. No specific cost information or road detail is included for either case. Although transportation was not researched in detail, some observations from Rummer *et al.* are worth noting. Several transport options were used throughout the project and several concerns surfaced: 1) material fell from the bundles while in transport, 2) low payloads, and 3) support problems with conventional log trailer bunks.

Richardson *et al.* 2002 indicates that shrinkage of residue occurs at an approximate rate of 25% when moisture content decreases from 50-55% to 30-40%. This shrinkage would allow more residues to be transported from a volume perspective; however this difference would not

[12] Costs were calculated from the assumptions in Murphy *et al.* 2003.

necessarily make-up for the loss in weight. Although dryer fuel is more efficient at the energy facility for conversion, it decreases transport efficiencies by reducing transportation payloads.

Non-traditional forms of transport may aid increasing the economic viability of biomass transportation. One, example is to use roll-off bin containers to haul either chipped material or loose residue. Both of these methods were observed during a case study in Montana (Rawlings *et al.* 2004). Roll-off bins are not cost competitive with traditional chip van transportation rates but could provide access to additional forest stands in need of fuels reduction work. Roll-off bin containers are hauled on standard trucks that give additional access to steep, windy roads than chip vans. More research is needed on the applicability of roll-off bin containers and other alternative transportation methods for biomass.

Due to its relatively low energy density, the economical transport distance for wood fuel is a fraction of that for oil; typically, wood fuel must be gathered from a radius of 62 miles (100 km) or less (Richardson *et al.* 2002). Transporting chips increases the bulk density of a load over CRL transport. One option for hauling CRLs to an integrated solid wood products and energy facility is to mix loads of CRLs and conventional roundwood products (Richardson et al. 2002). Eriksson and Björheden (1989) noted that the key to increasing forest fuel utilization essentially requires minimizing transport costs. Especially in areas where biomass markets are scattered, lengthy transportation distances and costs require significant costs.

Summary Points & Recommendations

Under present scenarios, harvesting small diameter stems and forest residues for biomass energy conversion are uneconomical when using a traditional definition of economics. In the Pacific Northwest, biofuel could be worth $25 - $40 per BDT delivered to a facility depending on the local market conditions (T. Cook, Georgia Pacific Corp., personal communication, 1/16/06). From the literature reviewed above, no complete harvesting system, including felling, extraction, and transportation costs, would result in positive net values for a landowner. However, when fire suppression and other fuels reduction management alternatives are considered as part of the economic framework, biomass harvesting can be viewed as a means to subsidize restoration silviculture. The goal of fuels reduction treatments is to increase the fire resiliency of a stand and this value must enter into the economic evaluation.

Biomass harvesting has been occurring in Nordic countries since the 1950's, and have become a much larger part of energy sourcing in the past 20 years. Initially, attempts were made to harvest small stems from young thinnings for biomass. As labor costs increased, mechanization, through multiple stem handling, allowed biomass harvesting to compete; eventually, whole-tree chips brought change to the production system. However, in the 1990's, biomass harvesting from small stems in thinnings was decreased for two main reasons: 1) silvicultural changes, and 2) competitiveness of forest residue for energy conversion. More recently, the majority of biomass production in Sweden and Finland occurs as residue collection following final harvests (Richardson *et al.* 2002). In Denmark, biomass chips are produced primarily from early thinnings but two factors aid economic validity: 1) high energy tax on fossil fuels, and 2) lack of a pulpwood market (Hakkila 2004). This history of biomass production holds valuable lessons for attempts in Oregon.

Based on the literature reviewed in this paper, several key points emerged regarding the economics of biomass harvesting for use in energy conversion facilities:

General Statements

- Costs for harvesting forest biomass are high relative to other forest products. A well-established consensus is not obtainable from the literature since studies range over biomass production categories, equipment technologies, harvesting objective, and site conditions.
- Taxation of fossil fuels and subsidies for renewable energy play a key role in allowing biomass to be competitive in the energy market in Scandinavia and Finland.
- One key driver to harvesting costs is stem size. Smaller stems create handling inefficiencies in all components of the process: felling, extraction, loading, and transportation. Decreasing stem size increases extraction costs across biomass production category and the range of equipment technology.
- Whole-tree harvesting of stems as part of an integrated operation, yields "free" felling and extraction costs for biomass production since component costs are attributable to the conventional products (ex. sawlogs). Additionally, revenue generated from the sale of commercial products can help subsidize a portion of overall costs for biomass removal in restoration treatments.
- In restoration treatments where removals are limited to a maximum diameter below commercial merchantability, harvesting methodologies must be combined from different technology groups to produce the lowest total harvesting cost, ie. hand felling and piling of slash for removal with a forwarder.
- For the wildland-urban interface and other socially sensitive areas, research should continue for reducing costs of basic harvesting technology. Layout is critical in these situations to minimize extraction distances and harvesting costs. At a landscape level, the use of ATVs, ASVs, and other small equipment for extracting biomass is unrealistic due to the maximum allowable extraction distances for this technology.
- Removal stem size has been traditionally small in European countries, especially for thinning, compared to the Pacific Northwest. Harvesting technology developed because of this and in result of a dedicated market for biofuels. Until energy wood is a viable market, modification and non-traditional combinations of conventional equipment should be evaluated.

Harvesting Costs

- For biomass removal only treatments of small stems, DBH < 9" (22.9 cm), single-grip harvesters should not be used because of high operating costs. Manual felling, use of small-scale equipment, or mechanical feller-bunchers are more cost effective.
- For small-scale feller-bunchers, shears may be more efficient than circular saw heads due to lower operating costs.
- A significant gap exists between costs of biomass generated in thinnings and that generated following a final harvest. This gap is most attributable to the felling and bunching of small stems; other cost components have similar costs.
- Felling methods should concentrate stems and residues to increase efficiency of collection. All extraction methods, regardless of technology group, will increase efficiency when formulating loads from piled slash.
- Tract size has an impact on harvesting costs when equipment with high operating costs is employed. Both size and technology contribute to higher operating costs; therefore,

purpose-built machines, like CRLs, need large areas and large volumes to be cost effective.
- The choice of where comminution occurs is a major factor on overall costs since both the extraction and transportation costs are significantly impacted by this decision.
- In Nordic countries, most comminution occurs at the landing after drying for a time period of 6 months or more.

Transportation
- Density of material is the major cost controlling factor for transportation costs. Comminution before transport is most effective, but bundling of slash offers advantages over transporting loose residues.
- There is an efficiency tradeoff between green ton and dry ton. This relationship is most driven by moisture content. Traditional transportation rates are based on increasing weight per unit volume to maximize payload, which in this case, equates to higher moisture content. However, energy facilities prefer dryer material for more efficient conversions. Current thought about transportation methodologies and rates does not address the "enterprise cost" of biomass, ie. the cost from standing stem to energy, the final product.
- The actual product being hauled is energy and not tons of biomass. Research should begin to investigate ways to maximize energy per load and find ways to base transportation costs on this concept.

Domestically and internationally, there are wide-ranging options for harvesting standing forest biomass and down woody fuel. However, challenges remain in the area of matching optimal harvest systems and processes with specific forest conditions to develop an economically feasible method for harvesting forest biomass. Transportation methods and network design can also have significant effects on biofuel costs. Challenges also remain in determining the applicability of subsidies for biomass production in the United States, similar to those in the Nordic countries. Though much research is needed in many areas, extraction of forest biomass for energy production presents a potentially attractive alternative for contributing to Oregon's energy needs, addressing forest fuel loadings, and enhancing economies of rural communities.

Literature Cited

Andersson, G. and B. Norden. 1998. Composite residue logs: A new concept in bio-energy fuel. Skogsforsk News 1998; 2:1.

Bain, R. and R. Overend. 2002. Biomass for heat and power. Forest Products Journal 52(2):12-19.

Beach, J., Perupral, J., Stuart, W., and M. Kamat. 1982. The design and analysis of an infeed system for forest residue baler. IN: Transactions of the ASAE Winter Meetings; Paper No. 82-1584; Chicago, IL; December 14-17, 1982.

Besse, L., Bergstrom, G., and D. Studier. 1994. Monocable zigzag yarding system. USDA Forest Service, Technology & Development Program. Timber Tech Tips, June 1994.

Bolding, M. and B. Landford. 2005. Wildfire fuel harvesting and resultant biomass utilization using a cut-to-length/small chipper system. Forest Products Journal 55(12):181-188.

Brown, C. and L. Kellogg. 1996. Harvesting economics and wood fiber utilization in a fuels reduction project: A case study in eastern Oregon. Forest Products Journal 46(9):45-52.

Covington, W., P. Fule, M. Moore, S. Hart, T. Kolb, J. Mast, S. Sackett, and R. Wagner. 1997. Restoring ecosystem health in ponderosa pine forests of the Southwest. Journal of Forestry 95(4):23-29.

Cuchet, E., Roux, P., and R. Spinelli. 2004. Performance of a logging residue bundler in the temperate forests of France. Biomass and Bio-energy 27(1):31-39.

Drews, E., B. Hartsough, J. Doyal, and L. Kellogg, 2001. Cut-to-length harvesting for reducing fuels loadings in the Blue Mountains of Oregon. International Journal of Forest Engineering 12(1):81–91.

Eriksson, L. and R. Bjorheden. 1989. Optimal storing, transports and processing for a forest fuel supplier. European Journal of Operational Research 43: 26-33.

Ewing, R.H. 2001. Four evaluations of compact tracked harvesters and forwarders in commercial thinning. Forest Engineering Research Institute of Canada (FERIC), Pointe Claire, Quebec, Canada. Advantage 2(37), 8 p.

Frisk, K. 2001. Production of fuel chips in thinning stands in Denmark. IN: Biomass Conference; Quebec, Canada.

Fule, P., W. Covington, H. Smith, J. Springera, T. Heinlein, K. Huisinga, and M. Moore. 2002. Comparing ecological restoration alternatives: Grand Canyon, Arizona. Forest Ecology and Management 170:19-41.

Hakkila, P. 2004. Developing technology for large-scale production of forest chips: Wood Energy Technology Programme 1999-2003. Final Report. National Technology Agency Tekes; Helsinki, Finland.

Hakkila, P., M. Leikola, and M. Salakarf. 1979. Production, harvesting and utilization of small-sized trees. The Finnish National Fund for Research and Development. Helsinki, Finland. p. 62-74.

Halbrook, Jeff & Han, Han-Sup. 2005. Costs and constraints of fuel reduction treatments in a recreational area. IN: Soil, Water & Timber Management: Forest Engineering Solutions in Response to Forest Regulation; COFE Annual Meeting; Fortuna, CA; July 11-14, 2005.

Han, H., H. Lee, and L. Johnson. 2004. Economic feasibility of an integrated harvesting system for small-diameter trees in southwest Idaho. Forest Products Journal 54(2): 21-27.

Hartley, D. 2002. Production and cost of tractor-based harvesting operations in thinning operations. From presented material at the Small Diameter Timber: Resource Management, Manufacturing, and Markets. Washington State University Cooperative Extension; Spokane, WA. February 25-27, 2002.

Hartsough, B., Drews, E., McNeel, J., Durston, T., and B. Stokes. 1997. Comparison of mechanized systems for thinning Ponderosa pine and mixed conifer stands. Forest Products Journal 47(11/12):59-68.

Hartsough, B. and B. Stokes. 1990. Comparison and feasibility of North American methods for harvesting small trees and residues for energy. IN: Proceedings of the IEA, Task VI, Activity 3 Workshop, "Harvesting Small Trees and Forest Residues"; Auburn, AL; May 28,1990. p. 31-40.

Hartsough, B., Stokes, B., McNeel, J. and W. Watson. 1995. Harvesting systems for western stand health improvements cuttings. IN: Proceedings of the 1995 ASAE Annual Meeting; Chicago, IL; June 18-23, 1995.

Hollenstein, K., R. Graham, and W. Shepperd. 2001. Biomass flow in Western forests: Simulating the effects of fuel reduction and presettlement restoration treatments. Journal of Forestry 99(10):12-19.

Huyler, N. 1989. Fuel supply structure of wood-fired power plants in the Northeast: Logger's prospective. USDA Forest Service. Northeast Forest Experiment Station, Research Paper NE-624. 20 pgs.

Johansson, J. 1996. Case studies on farm tractors as base machines for single-grip thinning harvester heads. Forestry 63(3):229-244.

Kluender, R., Lortz, D., W. McCoy, B. Stokes, and J. Klepac. 1998. Removal intensity and tree size effects on harvesting cost and profitability. Forest Products Journal 48(1):54-59.

Lanford, B., and B. Stokes. 1995. Comparison of two thinning systems. Part 1. stand and site impacts. Forest Products Journal 45(5):74-79.

Lanford, B., Wilhoit, J., and D. Curtin. 1991. Forwarder system development for non-industrial private forest (NIPF) applications. ASAE Paper 91-7509. St. Joseph, MI: American Society of Agricultural Engineers. 19 pgs.

Largo, S., Han, H., and L. Johnson. 2004. Productivity and Cost Evaluation for Non-guyline Yarders in Northern Idaho. IN: COFE Annual Meeting Proceedings; Hot Springs, AR April 27-30, 2004.

Larson, D., D. Neary, P. Daugherty, and C. Edminster. 2000. Harvesting costs for potential bio-energy fuels in a fire risk reduction programme. New Zealand Journal of Forest Science 30(1/2):114-129.

LeVan-Green, S. and J. Livingston. 2001. Exploring the uses for small-diameter trees. Forest Products Journal 51(9):10-21.

Lillandt M. 1976. Whole-tree harvesting by chipping methods (including transport in the forest) in Northern Europe. FAO/ECE/ILO Symposium on the Harvesting of a Larger Part of the Forest Biomass. Vol. 2. Hyvinkaa, Finland. p. 205-215.

Lynch, D. 2001. Financial results of ponderosa pine forest restoration in Southwestern Colorado. Conference Proceedings RMRS-P-22. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 141-148.

Pottie, M. and D. Guimier. 1985. Preparation of forest biomass for optimal conversion. Special Report SR-32. Forest Research Institute of Canada (FERIC), Pointe-Claire, Quebec, Canada. 112 pgs.

Rawlings, C., Rummer, B., Seeley, C., Thomas, C., Morrison, D., Han, H., Atkins, D., Graham, D., and K. Windell. 2004. A Study of how to decrease the cost of collecting, processing, and transporting slash. Montana Community Development Corporation, Missoula, Montana, 21 p.

Richardson, J., Björheden, R., Hakkila, P., Lowe, A., and C. Smith (*eds*). 2002. Bio-energy from sustainable forestry: Guiding principles and practice. Kluwer Academic Publishers, The Netherlands.

Rummer, R. and J. Klepac. 2002. Mechanized or hand operations: which is less expensive for small timber? IN: Proc. Small Diameter Timber: Resource Management, Manufacturing, and Markets. Washington State University Cooperative Extension; Spokane, WA. p. 183-189.

Rummer, R., Len, D., and O. O'Brien. 2004. Forest Residues Bundling Report: New Technology for Residue Removal. http://www.fs.fed.us/fmsc/sdu/biomass/bundling/documents/bundler_report_final.pdf

Schneider, M. 1987. Fuel chip harvesting: small-scale experience in New Brunswick. Forest Products Journal 37(2):39-42.

Seki, A., Sirois, D., Kamen, T. 1982. Harvesting and utilization. In: Hydropyrolysis of biomass to produce liquid hydrocarbon fuels: report on energy tree farm workshop. Hilo, HI: [Publisher Unknown]: 71-78.

Stokes, B. and D. Sirois. 1986. Evaluation of chipper-forwarder biomass harvesting concept. IN: Proc. 1985 Southern Forest Biomass Workshop. Gainesville, FL; June 11-14, 1985. p 23-26.

Suadicani, K. 2005. Production of fuel chips in a 50-year old Norway spruce stand. Biomass and Bio-energy 25(1):35-43.

Tepp, J. 2002. Assessing visual soil disturbance on eight commercially thinned sites in northeastern Washington. USDA Forest Service, Pacific Northwest Research Station, PNW-RN-535. 15 pgs.

Watson, W., Stokes, B., and I. Savelle. 1986. Comparisons of two methods of harvesting biomass for energy. Forest Products Journal 36(4):63-68.

Wilhoit, J. and B. Rummer. 1999. Application of small-scale systems: Evaluation of alternatives. IN: Proc. 1999 ASAE/CSAE-SCGR Annual International Meeting; Toronto, Ontario, Canada; July 18-21, 1999. ASAE Paper No. 99-5056. 18 p.

Updegraff, K. and C. Blinn. 2000. Applications of small scale forest harvesting equipment in the United States and Canada. University of Minnesota, College of Natural Resources, St. Paul, Minnesota. Staff Paper Series No. 143. 51 pgs.

Table 1. Costs per bone dry ton (BDT) broken out by component.

		FELLING			EXTRACTION				LANDING		
Technology & Reference	**Biomass Category**	**Manual Fell**	**Mech Fell**	**CTL Fell**	**Skid**	**Frwd**	**Yard**	**Woods Chipper**	**Comminution**	**Process & Load**	**TOTAL Harvesting Costs**
Basic Technology Methods											
Halbrook 2005											
ATV	1	♦			♦				Not Included		27.86
Iron Horse	1	♦			♦				Not Included		35.71
ASV	1	♦			♦				Not Included		25.00
Besse *et al.* 1994											
Stem removal only	2						34.26				
Limbs and tops yarded	2						97.70				
Conventional Equipment											
Brown and Kellogg 1996	1			17.36			44.18		Not Included	19.78	82.91
Rummer and Klepac 2002											
Manual fell/Forward	2	♦				♦			Not Included		80.35
CTL operation	2			♦		♦			Not Included		88.90
Han *et al.* 2004											
Manual Tree-length	1	19.27			29.21				3.62	2.48	54.58
Manual Whole-tree	1	9.87			29.21				2.85	2.84	44.77
Mech Whole-tree	1		8.75		13.77				2.85	5.33	30.71
CTL	1			17.47		10.64			3.62	3.08	34.85
Hartsough *et al.* 1997											
Convention Whole-tree	2		10.33		7.90				6.03		24.27
CTL	2			31.74		25.10			6.83		63.67
Hybrid	2		11.83		12.44				6.34		30.62
Bolding and Lanford 2005	2			17.04		20.14			3.46		51.40
Watson et al. 1986											
One pass system	2		15.11		10.20				10.87		36.18
Two pass system	2		14.01		16.58				16.97		47.56
Halbrook and Han 2005			4.54		7.10				22.30		35.02

Table 1 Continued.

		FELLING			EXTRACTION			LANDING			TOTAL
Technology & Reference	**Biomass Category**	**Manual Fell**	**Mech Fell**	**CTL Fell**	**Skid**	**Frwd**	**Yard**	**Woods Chipper**	**Comminution**	**Process & Load**	**Harvesting Costs**
Modified/Purpose-built											
Hartley 2002											
Oregon site	1		3.11			24.82			Not Included		43.43
Idaho site	1		17.06			75.23			Not Included		92.29
Johansson 1996	3		54.74								
Ewing 2001	--		14.47								
Rummer and Klepac 2002	--		36.60								
Largo *et al.* 2004											
Excavator	--						9.27				
Tracked feller-buncher	--						22.42				
Murphy *et al.* 2004											
CRL machine	3			♦		♦			Not Included		53.56
Stokes and Sirois 1986	3							40.94			
Suadicani 2003											
Manual felling	3							11.55			
Feller-buncher	3							11.55			
Harvester-herringbone	3							23.27			

Environmental Impacts of Forest Biomass Harvesting and Use for Energy Production

Roger Lord, Mason Bruce & Girard

Abstract: Science on the environmental issues surrounding use of forest biomass for energy production indicates environmental benefits arise from reducing the risk of catastrophic wildfire and restoring overcrowded forests to more natural conditions, and from replacing non-renewable energy with renewable energy. Benefits include air quality improvement, reduction in greenhouse gases, soil and water conservation, and protection and restoration of wildlife habitat and biodiversity. Some benefits accrue from both forest restoration and fossil fuel replacement. For example, air quality is impacted by reduced wildfire emissions and reduced emissions from energy production when biomass replaces fossil fuel. Other impacts are characterized in terms of short-term versus long-term risk. Estimated environmental benefits of biomass energy are 11.4¢/kWh. The value of avoided forest overgrowth is estimated as 20.2¢/kWh. The estimated net benefit of fuel reduction treatments is $606 - $1,402+ per acre. These results suggest that the environmental benefits of forest biomass use for energy are in excess of the market value of electricity produced.

Environmental Impacts of Forest Biomass Harvesting and Use for Energy Production

The purpose of this paper is to highlight some of the more important positive and negative environmental impacts of forest biomass harvesting and woody biomass use for energy found in the scientific and policy literature. A recent report for the Western Governor's Association (WGA Biomass Task Force 2006) provides a useful framework for understanding the social and environmental benefits associated with energy production from biomass. The framework is illustrated in Figure 1.

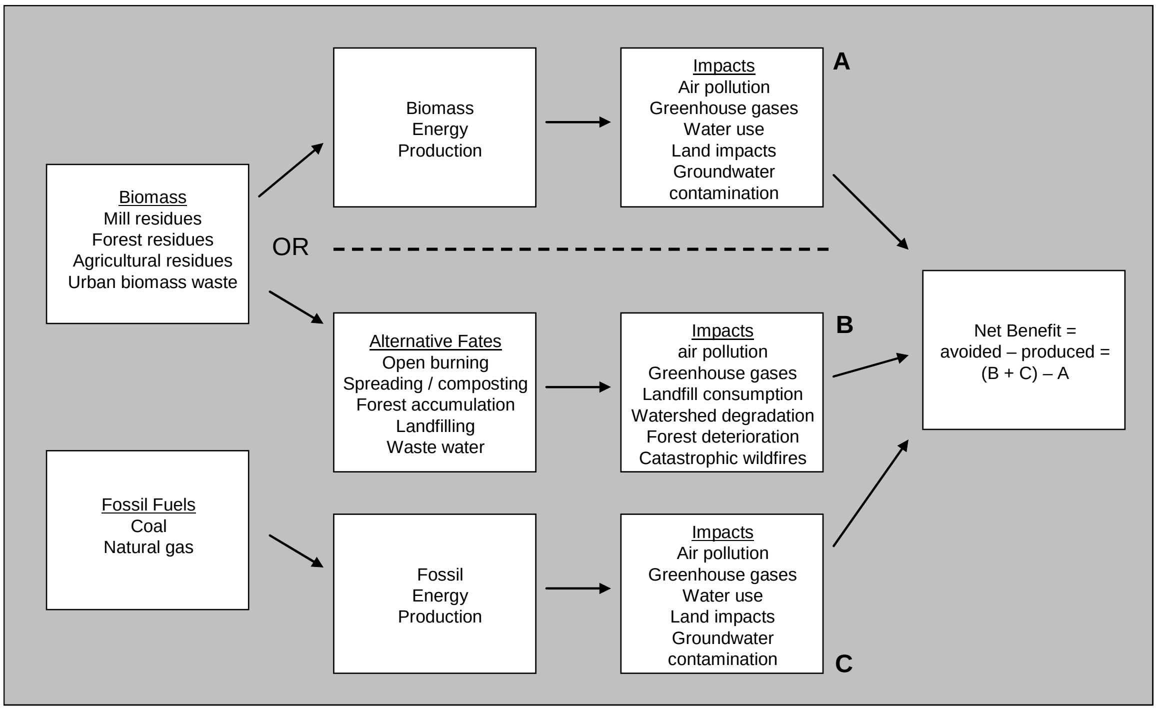

Figure 1 – Biomass benefits framework (source: WGA Biomass Task Force 2006).

In this framework, energy production from biomass is assumed to offset production of a like amount of energy from fossil fuel sources. Use of biomass fuels also avoids alternative disposal of these materials. The negative environment impacts of biomass energy production (box A, Figure 1) must be weighed against the avoidance of both the negative impacts associated with the alternative disposition of the biomass residues (box B) and the avoided impacts that would be caused by production of an equivalent amount of energy from fossil fuels (box C) (WGA Biomass Task Force 2006). Notably, in the Northwest, the same framework holds true for replacement of hydroelectric power for biomass power. Biomass energy's impacts must be weighed against impacts (e.g. to fish) from sustaining or adding to hydroelectric capacity.

One of the oft-cited benefits of forest biomass use for energy production is the opportunity to improve the fire resilience of forests that are currently overcrowded and at risk of catastrophic wildfire. Therefore, an evaluation of the risks and potential negative consequences of forest biomass harvesting must be weighed against the alternative consequences of large, destructive wildfires that are far more catastrophic than historical fire regimes. An excellent review of the environmental impacts of wildfire is found in the OFRI report on fire in Oregon's forests (Fitzgerald 2002a).

In addition to reducing the wildfire threat, there are many other environmental benefits, and some environmental costs, to forest biomass use for energy production. These pertain to the forest ecosystems from which the fuels are sourced as well as the larger issues surrounding continued reliance on fossil fuels for our ever-increasing world energy needs.

Improved Air Quality

Open burning of forest biomass – whether in wildfires, prescribed fires, or slash burning – produces large amounts of visible smoke, particulates, and significant quantities of nitrogen oxides, carbon monoxide and hydrocarbons that contribute to the formation of atmospheric ozone. Forest fires also emit substantial quantities of carbon dioxide (CO_2) as well as methane, and other trace gases (Morris 1999; McNeil Technologies 2003). Quantification of emissions is difficult because of extreme variability in fuels, burning practices and environmental conditions (Morris 1999).

The use of forest biomass for energy production results in lower particulate matter emissions (PM) than either prescribed burning or wildfire. Recovery of biomass from harvest residues also reduces emissions from slash burning. PM emissions from open burning depend on the amount of fuel and type of fire, generally ranging from 25 to 40 pounds per ton of fuel burned. Estimates of fuel burned per acre range from 11.0 tons for a prescribed fire in a low-density stand to 79.5 tons during a high intensity wildfire in a high-density stand (Sampson *et al.* 2001). Resulting emissions therefore could range from 275 to over 3,000 lbs. per acre burned.

Estimates of emissions from biomass power plants by the EPA include 0.22 – 0.3 lbs. per MMBtu of fuel input. This equates to 3.7 – 5.1 lbs. per ton of fuel, or 9 to 20% of the emissions from open burning.[1] Emittent pollution levels for ethanol plants are expected to be similar or less than biomass power facilities (McNeil Technologies 2003).

Use of biomass fuels also produces lower emissions than coal-fired plants, so to the extent that biomass replaces coal use, air quality will benefit. Biomass is lower in sulfur and fuel nitrogen than most U.S. coal and typically would produce less emission of these pollutants. Net emissions of CO_2 from a biomass plant are also less than a fossil fuel plant (McNeil Technologies 2003).

Lower Greenhouse Gas Emissions

Forests are a key contributor to stabilizing levels of atmospheric CO_2, a major greenhouse gas thought to contribute to global warming. Growing trees absorb and store CO_2 for years both in the wood of the tree as it continues to grow or as products made from the wood, such as structural lumber, furniture and paper (Sampson *et al.* 2001). Manufacture of houses from wood also serves indirectly to keep carbon dioxide out of the atmosphere because production of wood-based building products consumes much less fossil fuel than production of alternative building materials such as steel, aluminum and concrete (Oliver 2002).

[1] Energy content of wood = 17 MMBTUs per ton (Sampson *et al.* 2001)

Inland West forests are not contributing as much to the global sequestration of carbon dioxide as they can because:

- They are unhealthy and not absorbing as much CO_2 as if they were thriving;
- They are burning, and in the process releasing stored CO_2 into the atmosphere;
- They are not used much for the manufacture of housing and therefore, not preventing fossil fuels from being converted to carbon (Oliver 2002).

Wildfires release CO_2 and other greenhouse gases stored in trees and this rapid release contributes to climate change. In Canada it is estimated that carbon emissions from forest fires ranged from 2 to 75% of CO_2 emissions from all Canadian sources (McNeil Technologies 2003). In wildfires on the Boise National Forest in 1994, it was estimated that more than 2.5 million tons of carbon were emitted as fire consumed 199,400 acres of largely overstocked forest. In addition to the loss of this stored carbon, the effects of the high-intensity fires on soil properties caused a long term loss of productive capacity. The burned area will therefore provide only diminished capacity to re-absorb carbon through new forest growth in the future (Sampson *et al.* 2001).

Treating overstocked, unhealthy forests in advance of uncontrolled wildfire offers the opportunity to capture the stored carbon for long-term or short-term storage in products, or more controlled release during energy production. The treated forest is left in a healthy condition and is able to continue to sequester carbon through continued growth.

In comparison with open burning, biomass energy production can also reduce atmospheric greenhouse gas levels by shifting the proportion of emissions away from methane and towards CO_2. While open burning converts most of the biomass to CO_2, it emits a sufficient amount of methane and hydrocarbons that the net greenhouse gas effect is doubled or tripled compared with controlled combustion of a biomass boiler (WGA Biomass Task Force 2006).

An additional benefit of forest biomass conversion to energy is reduction of greenhouse gas emissions from energy production. Biomass energy production systems have the potential to significantly reduce net greenhouse gas emissions because they recapture emissions of carbon dioxide (USDOE and USDA 2000). The CO_2 emissions from the nation's current fuel mix, which is primarily coal and other fossil fuels, is more than 600 metric tons per GWh. Additional biomass power could bring the net emission level down (Sampson *et al.* 2001).

Greenhouse gas emissions from transportation fuels can also be reduced by use of biofuels made from wood. USDA and USDOE studies show that compared to gasoline, greenhouse gas emissions can be reduced on a gallon-for-gallon basis by 85 – 140% with use of cellulosic ethanol (USDOE and USDA 2000).

Soil and Water Conservation Trade-offs

In many ways, the choice between actively managing overstocked forests by making fuel reduction treatments and passive management, "letting nature take its course," is a trade-off between short-term and long-term risks. An example of this is in soil and water conservation. Here, the short-term risk of potential soil damage and water quality impacts from active management (fuels treatments, biomass removal) must be weighed against the long-term risk of even greater damage to soils and water quality by catastrophic wildfire.

One of the most significant impacts of high-intensity wildfires is long-term damage to soils. Severe fire can cause damage that can take decades or longer to recover, causing long-term ecological damage On the Boise National Forest fires of 1992 and 1994, for example, damaged topsoil literally slid off the slope (Sampson *et al.* 2001). Super-heated soil can become hydrophobic – unable to absorb water – causing long term loss of productivity as well as increasing the potential for severe erosion and siltation of streams and rivers (Fitzgerald 2002b).

Even less intense wildfires can eliminate organic matter within the upper mineral soil and affect soil structure causing a reduction in water infiltration and increasing erosion potential. When soils in this condition are exposed to even moderate thunderstorms, overland flow can result, causing flash flooding and significant sediment transport (Fitzgerald 2002b).

These effects have impacts on downstream municipal water systems as increased sediment causes treatment problems. Most municipal water systems in Oregon are supplied by surface water from forested watersheds, including the Bull Run watershed on Mount Hood National Forest, which supplies the City of Portland (Fitzgerald 2002b).

Other effects are less direct. Loss of vegetation following a wildfire leads to more water retained in the soil profile since plants are not actively drawing moisture. Soils are less able to absorb melting snow pack and precipitation during the following winter and spring. Peak flows can be higher and occur earlier in the spring because of lack of shade. Wildfires also disrupt soil nutrient balances and availability, causing long term loss of productivity. Loss of riparian vegetation may lead to increased stream temperatures causing concern for fish populations, including salmonid species (Fitzgerald 2002b).

A related effect is the impact of wildfires on water partitioning – the distribution of water that soaks into the subsoil to feed subsurface groundwater supplies, the amount that runs off the surface to affect streamflow and the amount that evaporates into the atmosphere to affect climate. As has been noted, intense wildfires can alter the timing of snowmelt and storm runoff, creating higher peak flows and potentially lengthening the period of dry-season streamflows. Reducing canopy density may also reduce the amount of snow that is intercepted by the canopy and evaporates into the atmosphere, thus increasing the snowpack and subsurface flow as well as surface runoff. Restoring watersheds to more-historical forest structure through fuel treatment thinnings would likely recharge groundwater and improve dry-season streamflows (Sampson *et al.* 2001).

Even in the absence of wildfire, overcrowded forests with higher canopy closure intercept more rain and snowfall, directing it back into the atmosphere via evapotranspiration before it reaches the ground. Less rainfall flows through the watershed as surface flow and less is added to groundwater. Seasonal flows are altered. The net effect is reduced water yield from watersheds in overcrowded conditions compared to yield if the forests were in more natural condition (Morris 1999).

A final beneficial impact on water quality, if forest biomass is used to produce ethanol, is the potential for increased replacement of methyl tertiary butyl ether (MTBE) with ethanol as an oxygenate in reformulated gasoline. Oxygenates are used to improve combustion and provide for cleaner burning. However, MTBE has been found to be carcinogenic in animals and is a highly persistent contaminant in water. As a result, MTBE was phased out for use in gasoline in California in 2002. Other states may follow suit. Ethanol is the only known alternative oxygenate and is judged to be a safe alternative to MTBE. To the extent that increased production of ethanol from woody biomass replaces MTBE use in gasoline, water quality and human health risks will be reduced (Graf and Koehler 2000).

On the other hand, biomass harvesting is dependent on mechanical treatment of the site, and the impact on soils represents a largely unknown risk. Mechanical harvesting of many small trees requires additional machine traffic and can contribute to increased soil disturbance (Fitzgerald 2002b). Currently, there is a lack of information on the effects of mechanical fuel reduction treatments linked with commercial logging operations. One study in southwest Oregon indicated that a fuel reduction operation in a 20-acre mixed conifer stand did not have significant effects on soil strength value. However, the study notes that the effect is dependent on soil characteristics prior to harvest and the study site may have already been compacted by previous operations. Nevertheless, the treatment did not cause soil strength values to exceed levels that are thought to have a meaningful effect on site productivity (Bolding *et al.* 2005).

Negative impacts of thinning on site productivity are also raised as a concern. Miller and Anderson (2002) point out that although ground-based harvest equipment used to thin overstocked forests disturbs the soil over much of the harvested areas, the consequences of this disturbance in terms of subsequent site productivity have been measured only at a limited number of locations and usually only for short periods. The paper reviewed seven studies on 27 overstory removal and clearcutting sites east of the Cascades and found effects ranging from negative to neutral to positive impacts on tree growth. The study concludes that current claims of dire effects of soil compaction on long-term site productivity are based largely on assumptions, circumstantial evidence, and speculation (Miller and Anderson 2002).

Wildlife and Biodiversity Conservation – Short vs. Long Term Risk

Another short-term versus long-term risk to consider is that to wildlife and biodiversity from wildfires compared to impacts from extensive harvest of forest biomass.

Wildfire and wildlife have coexisted in the forests of western North America for eons, and wildlife communities have developed and adapted in historic fire regimes ranging from frequent, light ground fires to infrequent, high-intensity, stand-replacing fires. Over the last century, however, pre-settlement fire regimes have been disrupted. The major change has been exclusion of fire as a result of active wildfire suppression efforts. Grazing and timber harvest have also contributed. Wildlife habitat has been changed with resulting impacts on populations. Some species have benefited while others have been negatively affected by changes in habitat conditions. The greatest effect on wildlife communities have been where low-severity regimes have been converted to high-severity regimes, such as those found in the interior ponderosa pine and Douglas-fir forests (Rochelle 2002).

Removal of hazardous fuels may have short term negative impacts on habitat, these are generally less severe than those from an uncharacteristic forest fire, and can be mitigated with due diligence during planning and operations. Protection of habitat in short supply should be a consideration in planning fuel treatments to meet forest restoration goals. In some cases, this may mean treatment of adjacent areas, rather than the rare habitat itself, in order to create fuelbreaks. (Mason *et al.* 2006).

On federal forestlands, concern over protection of threatened and endangered species, including the northern spotted owl and marbled murrelet, led to creation of late successional reserves (LSRs) in which active management is almost entirely excluded. The risk to wildlife and other ecological values in late successional reserves is recognized in the Northwest Forest Plan, which directs management policy within the LSRs. However, management efforts to address these risks have not adequately addressed the need to deal with the accumulated fuel loads, and so the risk continues to grow that LSRs will be lost to stand-replacing wildfires. The short-term risk of temporarily reducing habitat quality as a result of treatment practices is outweighed by the long-term and more significant risk of losing entire LSRs to stand-replacing fires (Rochelle 2002).

Environmental impacts resulting from uncharacteristic wildfires have been documented to cause direct mortality to fish, including salmonids. However, the longest-lasting and most dramatic negative impacts were from loss of forest cover along streams. Uncharacteristic wildfires sometimes produce localized extinction of fish populations. Relative risk assessments comparing the short-term risk of practices directed at reducing the long-term risk of uncharacteristic fires against the long-term risks of uncharacteristic fires themselves should be one of the state's top conservation priorities (Mealey and Thomas 2002).

In regards to treating small diameter timber, active management can be a viable wildlife management and diversity strategy. Forested landscapes in the interior PNW are currently dominated by small diameter forests, while older forest habitats have declined and associated wildlife populations have become imperiled. Middle-aged, small diameter stands may provide the greatest opportunity to accelerate the development of old forest structures that are currently lacking. Thinning in these stands can diversify habitat in the short-term as well as provide older forest conditions sooner than passive management (Lehmkuhl *et al.* 2002).

Small diameter timber harvesting can be good, bad, or neutral for wildlife, depending on the species and situation. Managers should consider habitat quality, quantity, and connectivity in conjunction with the population characteristics and life history of target species. Adaptive management, applying scientific principles for continuous learning, is critical (Lehmkuhl *et al.* 2002).

Forest Roads – a Mix of Costs and Benefits

One likely result of a landscape level effort to treat overstocked forests and recover biomass is the need to rebuild and expand road networks. Forest roads are likely to raise questions from environmental organizations, especially for efforts to install roads into previously roadless areas. Roads have impacts on ecosystem integrity including the potential to cause water quality degradation, erosion, and in some cases landslides. Roads also have impacts on wildlife by causing fragmentation of habitat and increasing human contact (Sampson *et al.* 2001).

Early forest roads were poorly constructed in comparison with today's standards. Many were built alongside stream channels within the riparian zones and caused stream damage. Others were built on steep, unstable hillsides using cut-and fill methods that subsequently failed (Sampson *et al.* 2001). Road engineering techniques are improved over the first generation of road building and will likely result in more stable, less damaging roads in the future. The question is whether they cause more or less damage than wildfires when the untreated area is burned (Sampson *et al.* 2001). Again, the trade-off is in the risk of ecosystem damage from active management to reduce wildfire severity and the risk of uncharacteristic wildfires themselves if the landscape is not actively managed.

It is also important to note that most analyses of fuel reduction treatments minimize or eliminate consideration of treatment in roadless areas, wilderness areas and late successional reserves (e.g. Sampson *et al.* 2001; USDA Forest Service 2005). It is usually assumed that treatment priority is given to areas near the wildland-urban interface, which are more likely to already have established road networks. Studies assessing biomass supply not only eliminate these areas from the calculation, but also exclude steep slopes because of costs of extracting biomass using cable systems (e.g. McNeil Technologies 2003; Fried *et al.* 2004).

Dollar Value Estimate of Benefits

An estimate of the dollar value of some of the environmental benefits ("ancillary services") of biomass energy was developed by the National Renewable Energy Laboratory (NREL) based on a review of the literature (Morris 1999). The net value of biomass energy was calculated as the difference between the costs of the impacts of energy production and the cost of alternative disposal options and alternative power production. This analysis fits the biomass benefits framework illustrated in Figure 1. It was based on the types and quantities of fuels used by the independent biomass power industry. More than half the fuel supply was sawmill residues with the remainder distributed between in-forest residues, agricultural resides and urban wood waste.

The value of the ancillary environmental benefits of biomass energy production was estimated by the NREL model at 11.4¢/kWh of electricity produced, with a range of 4.7 to 24.7¢/kWh. These ancillary benefits exceed the market value of the electricity produced by a significant margin. Value is based on four environmental benefits and varied by type of fuel and alternative means of disposal (Table 1).

Table 1 – Value of ancillary services (source: Morris 1999).

	¢ Per kWh
Value of Benefits	
Criteria Pollutants	4.3
Greenhouse Gases	5.9
Avoided Landfill	1.1
Timber Stand Improvement	0.1
Total benefits, US biomass mix	11.4
Value by Fuel Type	
In-forest residues	7.8
Urban wood waste	14.0
Value by Alternative Disposal Option	
Residues that would be open burned	8.9
Diverted from landfill	14.9
Left as overstocked forest	6.7

Some significant benefits are not quantified in the NREL model including energy diversity and security, the costs and damages of wildfire suppression, watershed damage, reduced water yield and lower water quality; and lost production and revenues from wildfires and smoke affecting recreation, manufacturing and education (Morris 1999).

The Western Governor's Association Biomass Task Force report analyzed the results of the NREL study and concluded that "energy produced from fuels that would otherwise be left as overgrowth in forests provides a very valuable package of benefits, due to the combination of ameliorating acute air pollution episodes during wildfires, protecting the stock of sequestered carbon in the forest from wildfire destruction, as well as reducing the losses of amenity and property values." The value from avoided forest overgrowth accumulation was estimated at 20.2¢ per kWh (WGA Biomass Task Force 2006).

A cost/benefit analysis of fuel removal treatments including market and non-market considerations indicates the cost of crown fires are underestimated and benefits of fuel removal are substantial (Mason *et al.* 2006). This study estimated the positive net benefits from fuel removals at $1,402+ per acre for high risk conditions and $606+ per acre for moderate risk conditions. Public value of environmental benefits and costs were listed but not quantified by the study. Results from the study are summarized in Table 2.

Table 2 – Summary table of present value costs and benefits associated with investments in fuel removals for fire risk reduction (from Mason *et al.* 2006).

	Value Per Acre	
	High Risk	**Moderate Risk**
Treatment Benefits		
Fire fighting costs avoided	$481	$231
Fatalities avoided	10	5
Facility losses avoided	150	72
Timber losses avoided	772	371
Regeneration & rehab costs avoided	120	58
Community value of fire risk reduction	63	63
Regional economic benefits	386	386
Habitat	?	?
Smoke and atmospheric carbon	?	?
Energy	?	?
Water quality & quantity	?	?
Erosion	?	?
Other values	?	?
Total Benefits	**$1,982+**	**$1,186+**
Treatment Costs		
Operational costs	(374)	(374)
Forest Service contract preparation costs	(206)	(206)
Environmental impacts of fuels removals	(?)	(?)
Total Costs	**($580)**	**($580)**
Positive Net Benefits from Fuel Removals	**$1,402+**	**$606+**

Summary

An analysis of the literature on the major environmental issues surrounding use of forest biomass for energy production shows that environmental benefits arise from two directions:

- First are the benefits that accrue from reducing the risk of catastrophic wildfire and restoring overcrowded western forests to a more natural, ecologically sustainable condition.

- Second, but no less important, are the benefits of replacing non-renewable energy sources such as coal, oil and gas with cleaner, more environmentally friendly and sustainable, renewable energy.

Some benefits accrue from both. For example, air quality is impacted by reduced wildfire emissions as well as reduced emissions from energy production as biomass is substituted for fossil fuel. Other impacts are characterized in terms of short-term versus long-term risk, such as soil and wildlife impacts.

- **Air quality** – use of forest biomass results in lower emissions that either prescribed fire or wildfire, and lower emissions than fossil fuel-based energy production.

- **Greenhouse gases –** biomass power can reduce production of greenhouse gases from energy production by reducing reliance on fossil fuels. In addition, use of forest biomass from fuel treatment efforts will reduce CO_2 and other greenhouse gas emissions from wildfire by reducing catastrophic fire occurrence and intensity.

- **Soil and water conservation –** short-term risk of damage to soil and water from mechanical treatment of overstocked forests and roads necessary to gain access to them must be weighed against the long-term risk of more severe damage from uncharacteristic wildfire if these forests are not brought back into historical conditions. Reduction in MTBE use in gasoline through increased substitution of wood-based ethanol is another potential, if indirect, benefit of forest biomass use for energy.

- **Wildlife and biodiversity –** short-term risks to wildlife habitat from fuel treatments and associated roads must be weighed against the long-term risk of landscape-scale losses of habitat to catastrophic fire and the need to restore the region's forests to more ecologically natural and diverse conditions.

A NREL study estimated the partial environmental benefits of biomass energy at 11.4¢/kWh of electricity produced, with a range of 4.7 to 24.7¢/kWh. In a related analysis, the value from avoided forest overgrowth accumulation was estimated at 20.2¢/kWh. Another cost/benefit analysis estimated a positive net benefit from fuel reduction treatments at $606 - $1,402+ per acre. These studies suggest that the environmental benefits of forest biomass use are in excess of the market value of electricity produced.

Literature Cited

Bolding, M.C., L.D. Kellogg, and C.T. Davis. 2005. Soil disturbance from an integrated mechanical forest fuel reduction operation in southwest Oregon. *In* Proc. 28th Annual Council on Forest Engineering Meeting; Fortuna, CA.

Fitzgerald, S.A (ed). 2002a. Fire in Oregon's forests: risks, effects, and treatment options. Oregon Forest Resources Institute, Portland, OR.

Fitzgerald, S.A. 2002b. Wildfire and prescribed fire effects on watersheds. P. 48-60 in Fire in Oregon's forests: risks, effects, and treatment options, Fitzgerald, S.A. (ed.) Oregon Forest Resources Institute, Portland, OR.

Fried, J.S., G. Christiansen, D. Weyermann, R.J. Barbour, R. Fight, B. Hiserote, and G. Pinjuv. 2005. Modeling opportunities and feasibility of siting wood-fired electrical generating facilities to facilitate landscape-scale fuel treatment with FIA Biosum. P.195-204 *in* Systems analysis in forest resources: proceedings of the 2003 symposium, Bevers, M.K. and T.M. Barrett (tech. comps.). USDA For. Serv. Gen. Tech. Rep. PNW-GTR-656.

Graf, A., and T. Koehler. 2000. Oregon cellulose-ethanol study: an evaluation of the potential for ethanol production in Oregon using cellulose-based feedstocks. Prepared for Oregon Office of Energy. Available at: http://www.oregon.gov/ENERGY/RENEW/Biomass/study.shtml

Lehmkuhl, J.F., C.O. Loggers, and J.H. Creighton. 2002. Wildlife considerations for small diameter timber harvesting. P. 85-92 in Proc. Small Diameter Timber: Resource Management, Manufacturing, and Markets. February 25-27, 2002; Spokane, Washington. Washington State University Cooperative Extension.

Mason, L.C., B.R. Lippke, K.W. Zobrist, T.D. Bloxton, K.R. Cedar, J.M. Comnick, J.B. McCarter, and H.K. Rogers. 2006. Investments in fuel removals to avoid forest fires result in substantial benefits. J. For. 104(1):27-31.

McNeil Technologies, Inc. 2003. Biomass resource assessment and utilization options for three counties in eastern Oregon. Prepared for Oregon Department of Energy. Available at: http://oregon.gov/ENERGY/RENEW/Biomass/assessment.shtml

Mealey, S.P., and J.W. Thomas. Uncharacteristic wildfire risk and fish conservation in Oregon. P. 85-95 in Fire in Oregon's forests: risks, effects, and treatment options, Fitzgerald, S.A. (ed.) Oregon Forest Resources Institute, Portland, OR.

Miller, D., and H. Anderson. 2002. Soil compaction: concerns, claims, and evidence. P. 97-106 in Proc. Small Diameter Timber: Resource Management, Manufacturing, and Markets. February 25-27, 2002; Spokane, Washington. Washington State University Cooperative Extension.

Morris, G. 1999. The value of the benefits of U.S. biomass power. NREL Report No. NREL/SR-570-27541. National Renewable Energy Laboratory, Golden, CO.

Oliver, C.D. 2002. Forests with crowded trees of small diameters – a global issue affecting forest sustainability. P.1-7 in Proc. Small Diameter Timber: Resource Management, Manufacturing, and Markets. February 25-27, 2002; Spokane, Washington. Washington State University Cooperative Extension.

Rochelle, J.A. 2002. Effects of wildfire on wildlife. P. 35-47 in Fire in Oregon's forests: risks, effects, and treatment options, Fitzgerald, S.A. (ed.) Oregon Forest Resources Institute, Portland, OR.

Sampson, N., M. Smith, and N. Gann. 2001. Western forest health and biomass energy potential: A report to the Oregon Office of Energy. Oregon Office of Energy. Available at: http://oregon.gov/ENERGY/RENEW/Biomass/forest.shtml

US Dept. of Energy and US Dept. of Agriculture. 2000. Report to the President of the United States in response to Executive Order 13134: Developing and promoting biobased products and bioenergy. Feb. 14.

WGA Biomass Task Force. 2006. Biomass Task Force Report. Report prepared for the Western Governor's Association. January, 2006. Available at: http://www.westgov.org/wga/initiatives/cdeac/index.htm.

Public Perceptions on Woody Biomass Utilization in Oregon

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Abstract: Understanding public perceptions on converting forest biomass to energy in Oregon will be important as management strategies are developed. It has been previously demonstrated that public support is important in the ultimate success of management strategies, particularly on federal forests. We reviewed documents pertaining to public perceptions on forest health, forestry, biomass and biomass utilization, and renewable energy. While there are multiple perspectives on what constitutes a healthy forest, most people agree that an unhealthy forest is one that is overstocked with small diameter trees. There is also agreement that active management can play an important role in improving the condition of unhealthy forests. Many citizens in Oregon support a balanced approach to forest management that incorporates both ecological and economic goals. However, public support for converting forest biomass to energy appears to be largely contingent on the projects being driven by forest restoration goals rather than economic interests.

Public Perceptions on Woody Biomass Utilization in Oregon

Converting forest biomass to energy[1] in Oregon is not a new concept; it has been practiced in the forest industry and in localized situations for a number of years. What is new about this issue in Oregon is both the proposed scale (converting forest biomass to energy throughout the state), and the idea that biomass will be removed with the specific objective of providing an energy source. While there have been numerous studies on public perceptions of forestry and forest health in the Pacific Northwest, there have been very few, if any, that have specifically addressed public opinions on using forest biomass for energy. As a proxy, this section will review numerous studies, reports and interest group position papers on the related topics of forest health, forestry, biomass utilization, and renewable energy.

Why public perceptions are important

Understanding public perceptions on this issue is important because much of the biomass that would be used as an energy feedstock is located on public land. As owners of the land, each member of the public has a say in how the forest is managed. If the public perceives a management strategy as negative, the strategy will ultimately fail (Shindler, Brunson et al. 2002). It stands to reason that management strategies will be much more socially acceptable if public opinions and perceptions are known beforehand and incorporated into the development of the strategy.

Unfortunately, the social acceptability of a practice is notoriously difficult to generalize. What is acceptable in one region may or may not be in another, depending on the unique social, political, economic and environmental context (Shindler, Brunson et al. 2002). For instance, removing forest biomass for energy may be socially acceptable in Oregon where there is a widely held perception of overstocked forests increasing the risk of wildfire. However, the same practice of removing biomass for energy may not be socially acceptable in Maine where fire danger is not as great. Public acceptance of any management strategy must be measured in the specific region in which it is being considered.

Perceptions on forest health

In Oregon, much of the discussion around utilizing forest biomass is intimately tied to forest restoration; utilization serving as both a potential mechanism to pay for the treatments (Almquist 2005), and as an end product for the material generated during the treatments (Western Governors' Association 2006). Thus, the social acceptability of woody biomass utilization depends in large part on the social acceptability of the forest treatments themselves. "Forest health" is a term that is often used to describe both the need for forest restoration treatments, and what the forest should look like once the treatments are complete. In identifying what people mean by the term "forest health" we can start to understand the public's desired future

[1] The term energy refers to electrical generation in this section, unless otherwise specified.

conditions. Knowing the desired future conditions of a forest stand can allow us to more accurately estimate how much biomass is socially available for use.

Forest health is a nebulous term with no single, simple definition. Participants in a 2002 focus group study on Oregon and Washington residents generally felt the term was too ambiguous: "it means different things to different people," (Shindler, Wilton et al. 2002). When pressed to describe what the term meant to them, participants not surprisingly chose terms that reflected their worldview. Participants with a utilitarian worldview of the forest tended to focus on trees (size, vigor, appearance, etc) when describing a healthy forest; participants with a holistic worldview used terms to convey the resiliency and sustainability of the forest as a functioning ecosystem (Shindler, Wilton et al. 2002). Gorte (2001), in a review of forest health research found that most parties agree that a healthy forest is one that can be "sustained into the foreseeable future." Disagreement arises on what is to be sustained and how (Gorte 2001).

Shindler and Wilton also had a survey component to their study of Oregon and Washington residents as a whole. When offered the choice of 17 forest characteristics, survey respondents generally chose terms that related to aesthetics to describe healthy forests. Most frequent responses included presence of green trees, abundance of wildlife and plants, low levels of disease, and trees of variable sizes and species (Shindler, Wilton et al. 2002).

As is true with most other nebulous terms, it is far easier to describe what it is not than what it is. There is nearly universal agreement in the printed literature that an unhealthy forest is overstocked with small-diameter trees that may or may not be infested with disease and insects (Gorte 2001; Shindler, Wilton et al. 2002; O'Laughlin 2005). What remains to be found is whether there is a universal vision of what an "overstocked" forest looks like.

Not only is it important to determine what forest health means to people, it is also important to identify what management practices, if any, are socially acceptable to treat "unhealthy" forests. Shindler and Wilton (2002) found that "almost all participants believed that some type of management is essential to achieving and maintaining forest health." Most participants equated "management" to fuels reduction by thinning, with prescribed fire being a more controversial option.

General support for management activities to reduce risk of wildfire was confirmed by two surveys of Oregonians in 2005. A 2005 survey of Oregon voters conducted by the Nature Conservancy found that 75% of the respondents agreed with the statement "Oregon's forests should be thinned to make them healthier and safer from wildfire." In late 2005 OFRI commissioned a study that reported 79% of Oregonians agreed that trees should be thinned or harvested from dense, overcrowded stands to prevent severe wildfire (Davis 2006). While these surveys indicate wide support for thinning to reduce fire danger and restore forest health, neither study specifically addressed whether the public would support using the thinned material as an energy source.

Perceptions on forestry

Any removal of forest biomass will require forest management practices; understanding the social acceptability of different forestry practices will help in the development of management strategies for biomass removal that are also socially acceptable.

Forestry practices are often judged by how they contribute to the aesthetics of the forest (Ribe 2005). Shindler et al. (2002) reported that public perceptions of beautiful forests are often associated with the following characteristics: presence of large trees spaced with moderate density, color variation, species diversity, and grasses and herbs covering the forest floor. Public perceptions on aesthetics are important to consider, as visual aspects of a forestry practice can be associated with that practice's impact on the forest ecosystem. Perceived negative impacts to the ecosystem can lead to the public questioning the motivations of foresters (Shindler, Brunson et al. 2002). If the public questions the motives of the foresters, they are less likely to trust their decisions regarding forest management. Even though biomass reduction projects are expected to improve the quality of forests, education programs and demonstration projects that explain the underlying motivations behind the projects (improve forest health, provide local jobs, etc.) will be valuable in gaining and maintaining public acceptance.

Many citizens of both Oregon and Washington support a balanced approach to forest management where goals for both sustainable ecosystems and economic vitality are met (Ribe and Silvaggio 2002; Shindler, Brunson et al. 2002). This is important for the issue at hand as thinning forests and using the material to supply a bioenergy industry is certainly a multi-use approach. More research will be needed to determine the parameters of the acceptance of multi-purpose management, as each individual's vision of what a balanced approach to ecosystem management actually looks like is almost certainly different. Another aspect to multi-use management techniques in relation to biomass thinning projects is whether trees that are of commercial value can be removed or not. Many silviculturists maintain that forest health cannot be achieved without removing some larger diameter trees along with the small trees, depending on site conditions, forest types, and management objectives. Certainly removing some commercial timber would make the project more economical, but this may not be acceptable to the public (Gorte 2001). Demonstration projects will be essential in the effort to identify the parameters of public support for biomass thinning projects.

Whether or not biomass reduction projects are successful may hinge on how much the public trusts forest managers to implement the project in the manner in which they say they will and for the reasons stated. It has been found that, in general, Oregon and Washington residents do not trust federal natural resource agencies (Ribe and Matteson 2002; Shindler, Brunson et al. 2002). Trust is critical in positive collaboration amongst stakeholders; in order for biomass projects to be successful trust between stakeholders will need to be built and nurtured. Trust can be built through active participation of stakeholders, particularly when stakeholders can see that their input has been used in management plans (Shindler, Brunson et al. 2002). Another method of improving trust could be for federal land managers to work in conjunction with other parties that are more trusted by the public. The recent OFRI values and beliefs study found that Oregonians trusted scientists from Oregon State University the most (84% of respondents), closely followed by professional foresters and forestry officials from the State of Oregon (both 72%), while federal forestry officials were only trusted by 49% of respondents (Davis 2006).

Perceptions on biomass and biomass utilization

Utilizing forest biomass for energy is a relatively new concept to Oregon's general public. The recent OFRI values and beliefs study found that six out of ten Oregonians had not heard of using forest biomass as a renewable energy source (Davis 2006). With general knowledge of the concept low, it makes sense that there have been no studies that measured the public perceptions of utilizing forest biomass for energy. However, insight can be gained through position papers of interested parties, a study that looks at experiences of groups actively engaged in biomass utilization projects in southwestern Oregon, and research in the eastern U.S.

There appears to be wide (although sometimes cautious) support for biomass utilization for energy in Oregon. This support is driven by three primary motivations: the need to reduce fire danger caused by high densities of small-diameter trees (LeVan 1998; Almquist 2005; ONRC 2005; Rural Voices for Conservation 2005; SAF 2005; Hoeflich 2006; Mosby 2006; Western Governors' Association 2006), the opportunity for rural economic development (LeVan 1998; Almquist 2005; Rural Voicesfor Conservation 2005; Mosby 2006), and the need to increase use of renewable energy to reduce dependence on fossil fuels and lower CO2 emissions (Almquist 2005; Rural Voices for Conservation 2005; SAF 2005; Western Governors' Association 2006). However, there are some caveats to this support.

Rural Voices for Conservation, a group of 28 rural Western stakeholders, wrote a position paper on biomass utilization in 2005 that stated biomass utilization is a land management issue, not simply an avenue for energy production. This indicates that public support would need to be remeasured if forest thinnings did not supply enough feedstock for sufficient bioenergy production and additional forest material was needed. Rural Voices advocates for policies that encourage the greatest economic stability and benefits to rural communities. Policy suggestions include: development of a wide range of value-added products made from small-diameter timber, and small-scale bioenergy facilities that serve the local community (1-10MW).

Oregon Natural Resources Council (ONRC) supports biomass utilization, but only when it is the result of valid forest restoration projects. They consider biomass removal and utilization as a short-term management strategy that will help transition forests back to conditions where natural fire regimes can be re-established. It is very important to them that biomass utilization not be seen as a replacement for fire's role in the forest ecosystem. ONRC does not support removal of large trees, snags or down woody material, or the construction of new roads to gain access to material. They state that any environmental risks involved with biomass projects should be honestly considered, and sincere measures to mitigate potential environmental harms need to be implemented. ONRC recommends that biomass energy facilities be conservatively scaled, capable of accepting multiple fuel sources, and engineered to be able to operate efficiently at less than full capacity; these would ensure that the focus remained on forest restoration and not energy production.

The Nature Conservancy views utilizing forest biomass for energy as an opportunity to "restore the forest structure, composition, and dynamics that [they] feel are essential to maintaining Oregon's native biodiversity," (Hoeflich 2006). They support using a science-based approach to identify forest stands that would benefit from active management to restore them to historic conditions. The Nature Conservancy is actively involved in conducting and funding research to determine how many forest acres need treatment in Oregon, with a focus on the wildland urban interface, and stands that traditionally had a high frequency, low intensity fire regime. As with the ONRC, the Nature Conservancy considers biomass utilization a short-term strategy that would aid forest managers in re-introducing fire to forests thought to be at risk of uncharacteristic, high severity fires due to overstocking.

Sierra Club[2] would likely support biomass to energy projects that are demonstrated to be sustainable; however they have serious doubts about the sustainability of forest biomass projects. They raise multiple concerns about forest biomass projects resulting in more environmental harm than good, and would prefer to see more emphasis on efforts to increase energy efficiency and conservation. Specifically they question the likelihood of sustainable forestry practices coming from the government and forest industry, based on previous lack of commitment to preservation, conservation and restoration efforts. They caution that biomass projects could end up releasing CO2 into the atmosphere through damage to forest soils, rather than being carbon neutral as they are often said to be. They are also concerned that developing a biomass energy industry could create incentives for unsustainable forest practices (i.e. clear-cutting, excessive removal of forest material, and conversion of native forests to non-native species), and any initial focus on sustainable land management practices would be lost. Sierra Club encourages the following when considering biomass to energy projects: the use of the precautionary principle; open and honest communication between forest managers and the public regarding all aspects of biomass projects, including potential risks; and meaningful public participation in all phases of biomass projects (Sierra Club 2000).

Groups and organizations actively involved in biomass utilization efforts tend to focus more on challenges that they encounter, rather than specific guidelines pertaining to forest management practices. Southwestern Oregon groups involved with biomass utilization universally supported the idea (as long as the projects were based on ecological principles), but were encountering significant barriers (Almquist 2005). These barriers included: difficulty in making a profit or getting started due to lack of funds, difficulty for small businesses to compete with larger companies, difficulty in arranging necessary supply agreements with federal agencies, transportation costs involved with getting biomass from the forest to a bioenergy facility, and lack of available markets for small-diameter timber. Despite the barriers, these groups are still interested in utilizing biomass for the wide range of potential societal benefits: offsetting costs of forest restoration treatments, providing a boost to the southwestern Oregon economy, cleaner air resulting from use of material that would otherwise be burned in the forest through treatment efforts or wildfires, and generation of energy from a sustainable source.

Collins Pine Company, an Oregon based forest products company, is actively involved in the efforts to install a biomass fired co-generation energy facility in Lakeview, Oregon. Challenges that they have encountered include the following: the length of forest stewardship contracts (10 yrs) do not match what is needed by investors in bioenergy facilities (20 yrs) to justify the large

[2] While this is a national position paper, it was referred to the researchers by the Oregon Sierra Club chapter.

capital investment; the length of time it takes the Forest Service to conduct a NEPA assessment (several years); prohibitively expensive transportation costs when biomass is located beyond a 40 mile radius of the facility; inequities in the production tax credit for renewable power (biomass power receives half of the credit given to other renewable sources); and the transportation subsidy in the most recent energy bill remaining unfunded. While biomass utilization projects would likely be revenue neutral for them, they are still highly interested due to the benefits to forest health and local communities (reduced fire risk, improved water and air quality, and local high paying jobs).

Outside of Oregon, Peelle (2000) interviewed representatives of national and eastern U.S. environmental groups about their opinions on biomass utilization. At that time interest in utilizing biomass for energy was less widespread than today, and many participants needed explanations on what biomass is and how it could be converted to energy. After the introductory information, interviews centered on three focus areas: biomass in general, biomass feedstocks, and issues of developing more productive trees and seed crops for energy production. Roughly half of the study participants were supportive of converting biomass to energy. Of those that were not outright supportive, opinions ranged from conditional support to opposition. Support by participants was largely driven by the desire to reduce fossil fuel use and curb global warming. Most participants raised some concerns; most concerns could be categorized as having to do with the sustainability of forestry and agriculture practices when an additional end-product would be energy. Specific concerns regarded the amount of land that would be required for energy crops, what the cost of raising energy crops would be if they were raised sustainably, potential use of genetically modified organisms, and lack of information on what a full-fledged bioenergy cycle would look like (Peelle 2000). It should be noted that participants were primarily from the Eastern and Midwestern states where agricultural feedstocks are more prominent than in the West and forestry debates have different focal points. In information specific to the West there is little to no mention of energy crops since it is assumed that supply will come from forests that are perceived to be overstocked (Almquist 2005; ONRC 2005; Rural Voices for Conservation 2005; Hoeflich 2006).

In another national study that seemed focused on the Eastern U.S., concerns were also raised over producing energy from forest feedstocks (Cook and Beyea 2000). Cook and Beyea (2000) predicted that support for using forest biomass for energy would be mixed; it would be high if biomass could be removed without negatively impacting ecosystem functions and biodiversity. However, for the United States to significantly reduce its reliance on fossil fuel a substantial amount of feedstock would be required. The authors did not think the public would support heavy extraction from forests to produce energy, when the public currently doesn't support large-scale extraction for the wood products industry (Cook and Beyea 2000). When the discussion is to remove forest biomass to improve forest health and to reduce fire risk there appears to be widespread support in Oregon. However, if by some definition forest health is achieved sometime in the future (e.g., forests no longer overstocked) it is hard to say whether the public would still support utilizing forest biomass for energy.

Perceptions on Renewable Energy

While converting forest biomass to energy is primarily driven by forest restoration needs in Oregon, it is useful to consider the social acceptability of renewable energy since it will be created as an end product. In 1996 Farhar synthesized over 700 national polls on public opinions regarding renewable energy. She found that public support for renewable energy increased from 1973 to 1996. This support appeared to be driven by concern for the environment. The public expressed high levels of support for both development of renewable energies and improved energy efficiency. Interestingly, the national polls also showed a high level of support for paying more for renewable energy, even if taxes were raised (Fahrar 1996). However, more research is needed in this area as some respondents may indicate a willingness to pay that is only hypothetical in nature.

Conclusions

Based on studies that examined public perceptions on forest health and forestry, it appears there is widespread support for removing excess biomass from Oregon forests by means of mechanical thinning. Position papers from community, conservation and industry interest groups indicate that the public would support using the biomass removed from the forest for energy, as long as biomass removal was the result of legitimate forest restoration needs. Further research will be needed to conclusively determine how the public at large perceives using forest biomass for energy. Research will also be needed to determine the parameters of socially acceptable biomass thinnings. The current research will provide a starting place for further surveys of the broader public.

Literature Cited

Almquist, B. (2005). An Inventory and Analysis of Biomass Utilization Efforts in Southwestern Oregon. Eugene, Resource Innovations, University of Oregon.

Cook, J. and J. Beyea (2000). "Bioenergy in the United States: Progress and Possibilities." Biomass and Bioenergy **18**: 441-455.

Davis, H. M., Inc. (2006). Forestry Values and Beliefs: 2006 Benchmark Survey of Oregonians, Oregon Forest Resources Institute.

Fahrar, B. (1996). Energy and the Environment: The Public View, Renewable Energy Policy Project REPP.

Gorte, R. (2001). Forest Ecosystem Health: An Overview, Congressional Research Service.

Hoeflich, R. (2006). Restoring Forest and Woodland Ecosystems in Oregon. House Agriculture & Natural Resources Subcommittee on Alternative Fuels and Biomass, and the Senate Interim Alternative Fuels Task Force.

LeVan, S. (1998). Biomass Utilization for Forest Health and Community Development. BioEnergy '98: Expanding BioEnergy Partnerships, Madison, Wisconsin.

Mosby, R. W. (2006). Statement of R. Wade Mosby on GAO Report on Promoting Woody Biomass for Energy and Other Uses. Subcommittee on Forests and Forest Health, House Resources Committee.

O'Laughlin, J. (2005). Forest Health, Risk Assessment, and the National Fire Plan. Roundtable on Sustainable Forests 2005: Perspectives on America's Forests, Washington D.C.

ONRC (2005). Biomass Utilization Policy, Oregon Natural Resources Council.

Peelle, E. (2000). Biomass Stakeholder Views and Concerns: Environmental Groups and Some Trade Associations. Oak Ridge, TN, Energy Division, Oak Ridge National Laboratory.

Ribe, R. (2005). Comparing Changes in Scenic Beauty Produced by Green-Tree Retention Harvests, Thinnings and Clearcuts: Evidence from Three Pacific Northwest Experiments. Balancing Ecosystem Values: Innovative Experiments for Sustainable Forestry, Portland, Oregon, USDA Forest Service.

Ribe, R. and T. Silvaggio (2002). National Forest Management in Timber and Spotted Owl Country: A Survey of Interested People in Western Oregon and Washington. Eugene, Oregon, Institute for a Sustainable Environment, University of Oregon.

Ribe, R. G. and M. Y. Matteson (2002). "Views of Old Forestry and New Among Reference Groups in the Pacific Northwest." Western Journal of Applied Forestry **17**(4): 173-182.

Rural Voicesfor Conservation (2005). Community-based Forestry Perspectives on Woody Biomass. Biomass Briefing Paper**:** 6p.

SAF (2005). Utilization of Forest Biomass to Restore Forest Health and Improve US Energy Security. S. o. A. Foresters.

Shindler, B., M. Brunson, et al. (2002). Social Acceptability of Forest Conditions and Management Practices: A Problem Analysis. Corvallis, Oregon, United States Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Shindler, B., J. Wilton, et al. (2002). A Social Assessment of Ecosystem Health: Public Perspectives on Pacific Northwest Forests. Corvallis, OR, Department of Forest Resources, Oregon State University.

Sierra Club (2000). Sierra Club Conservation Policies: Biomass Guidance, Sierra Club.

Western Governors' Association (2006). Clean and Diversified Energy Initiative: Biomass Task Force Report.

Chapter 2
Assessment of Potential

2.1 Introduction

This chapter assesses and describes the potential for production of electricity, biofuels and other value added compounds from forest biomass in Oregon. We assess forest biomass supply using best-available resource data and models and identify some of the implications of collecting and using this resource for energy and biofuels production.

The focus of the forest biomass supply analysis is characterizing the potential supply that could result from implementation of fuel reduction thinning treatments across forests that have been identified as having the highest risk of catastrophic wildfire. We also briefly discuss additional sources of forest biomass including western juniper, recovery of logging slash from traditional commercial timber harvesting, and potential supply from hybrid poplar plantations.

Our statewide analysis focuses on biomass potential from 20 counties in eastern and southern Oregon. This analysis provides a broad estimate of the forest biomass potential from the dry forest region of the state.

We also developed local supply estimates for a 75-mile radius around Klamath Falls in southern Oregon and La Grande in eastern Oregon. These locations were chosen to illustrate the variation in treatment needs, biomass availability, and costs among different parts of the state.

2.2 Summary of Results

Results of this analysis suggest that a biomass supply of approximately 20 million BDT is possible. This would come from treatment of 4.25 million acres of eligible forestland, or approximately 27% of the total timberland area in these 20 counties. About 71% of the eligible forestland is publicly owned and nearly all of this is federal. Private lands account for 29% of the eligible treatment area. The largest areas of opportunity geographically appear to be in southern Oregon and to a lesser extent, northeast Oregon.

If harvested over a 20 year period, approximately one million bone dry tons (BDT) would be produced annually assuming no allowance for growth. Average delivered cost would be $59/BDT in today’s dollars based on integrated harvesting and collection costs and assuming processing facilities were well distributed across the region. Over the entire landscape, revenues from sale of merchantable timber and bio-mass could cover direct treatment costs (harvesting and hauling) if sawtimber revenues were allowed to subsidize biomass harvest and transport costs.

Previously published estimates of forest biomass from forest health thinnings in Oregon vary widely, ranging from 0.8 – 7.3 million bone dry tons annually depending on assumptions of area needing treatment, volume removed per acre, proportion of volume that is biomass versus commercial timber, and the number of years over which treatments are accomplished. We believe our results for biomass supply from forest restoration treatments are more realistic than some of the previously reported studies and are in line with more recent, rigorous analyses. We focused on potential supply from land conditions that are most in need of fuel reduction treatment and used yields that were based on plot level tree data and simulation of silvicultural regimes specifically designed to provide improvement in fire resiliency. In some respects, the results may be conservative; in others, it may be optimistic.

One million tons of feedstock under the assumptions shown below would be capable of producing about 146 MW of electrical power with a range 102 – 184 MW depending on assumptions used. Assuming eight plants at the hypothetical locations used in the analysis, average capacity would be about 18 MW. By comparison, the 2004 total installed electrical generation capacity in Oregon was 5,734 MW, with load growth expected to be about 2% or a little over 100 MW per year.

The average net cost of the biomass-produced electricity would be 8.1¢ per kWh for the first five years by taking advantage of the federal production tax credit (PTC) and 9.0¢ for the next five years. This net cost is competitive with natural gas but is not competitive with other renewables such as wind. In some ways, this is a worst case scenario since it is based on a stand-alone power plant with no market for the steam. A power plant associated with a lumber products mill, especially an expansion of existing power facilities, could result in significantly lower costs. Fuel savings are also possible from the combined use of mill wastes and chipped forest thinnings.

Assuming the entire one million annual BDT supply was to be directed to ethanol production when technology becomes available, it would produce approximately 61 – 66 million gallons per year. To put this into perspective, the ODOE estimates that in 2002, up to 60 million gallons of ethanol were used to oxygenate over 1.5 billion gallons of gasoline consumed by Oregonians.

Other sources of woody biomass are also considered including western juniper, logging slash from conventional timber harvesting and hybrid poplar plantations. In total, it is conceivable (though not proven economical) that these three additional sources could provide another one million BDT of woody biomass supply annually over at least a 20-year period.

In addition to the statewide analysis, we also conducted two sub-state assessments within a 75-mile radius of Klamath Falls in southern Oregon and La Grande, in northeast Oregon. Comparisons illustrate dissimilarities in forest types and conditions in the 2 areas. The Klamath Falls analysis found 1.1 million acres eligible for treatment within 75 miles, which would produce a total of 9.4 million BDT at an average delivered cost of $76/BDT. In the La Grande area, 292,000 acres were eligible for treatment yielding 1.0 million tons of biomass at average delivered cost of $73/BDT. These volumes are from forest types that typically experience surface and mixed fire severities. An additional 2.9 million tons for Klamath Falls and 1.5 million tons could be delivered to Klamath Falls and La Grande, respectively, from treatment of forest types that tend to have high intensity fires under natural conditions.

2.3 Methods

The answer to the question, "how much forest biomass supply is available from fuel reduction treatments," is "it depends." There is unquestionably a huge inventory of biomass material which could be used for energy production across the landscape of the state. How much of could be – and should be – accessed, harvested, and transported to a processing site is the central question.

The three fundamental questions that must be addressed are:

- What part of the landscape will be treated?
- How will it be treated?
- Over what period of time?

Analysis of potential biomass supply from forest thinnings was developed using the Fuel Treatment Evaluator (FTE version 3.0), a USDA Forest Service web-based application (Miles 2005). We attempt to address these by first applying a set of filters or criteria within FTE to define the landbase eligible for treatment. Next, we apply a set of alternative thinning regimes to determine the amount and type of biomass removed. Finally, we estimate volumes based on assumptions regarding the number of years needed to complete treatments across all eligible acres.

2.3.1 *Fuel Treatment Evaluator*

The FTE 3.0 model has been recently used in a Forest Service analysis of fuel reduction treatments in the Western States (Skog *et al.* 2006) and a biomass supply assessment by the Western Governor's Association (WGA Biomass Task Force 2006). The model combines Forest Inventory and Analysis sample plot data with an array of thinning treatments designed to reduce fire risk in overly-dense stand conditions. The landbase represented in the FTE model includes public and private timberlands. By definition, this excludes designated Wilderness Areas, national parks and other areas withdrawn from use for commercial timber production. FTE uses a series of screens to determine the landbase suitable for thinning. The model estimates the effects of treatment on fire hazard, total biomass removed, merchantable timber, net biomass, and harvesting costs.

We took the same general approach and adopted many of the assumptions of the WGA and Forest Service analyses. However, we modified some of the assumptions based on the objectives of this project and to refine the analysis for Oregon's forest conditions. The following sections summarize the major assumptions and procedures used in the analysis.

2.3.1.1 Forest Type Groupings

We grouped forest types into two classes based on their natural fire regimes. "Group I" includes forest types that tend to have surface or mixed fire severity. "Group II" types include those that tend to have high-intensity fire regimes, where severe fires are routine under natural conditions. Table 1 lists the forest types in each Group.

Table 1 – Forest type classification into fire regime groups

Group I Forest Types	Group II Forest Types
Douglas-fir	Lodgepole pine
Ponderosa pine	Fir-spruce
Western white pine	Hemlock-Sitka spruce
Larch	
Unclassified/other	
Pinyon/Juniper	

These are aggregated forest type classifications that may contain many more detailed forest types. The Fir-Spruce type group, for example, includes white fir, grand fir, red fir, Engelmann spruce, Engelmann spruce – subalpine fir and other types. The Hemlock-Sitka Spruce type includes western redcedar, mountain hemlock-subalpine fire, Sitka spruce, and western hemlock types.

The rationale for fuel treatments in Group I forest types is to restore normal ecological conditions and functions after nearly 100 years of fire exclusion.[1] Group II forest types, however, are naturally adapted to severe fire regimes, so the ecological rationale for fuel treatment is not as clear; thinning to avoid severe fire does not support normal fire ecology for these types. However, there may be other reasons to treat these types including public safety, protection of property and resource values from loss, and reduction in air emissions from wildfire. In addition to different rationales for treatment, Group I and II forests require different treatment regimes. Thinning in Group II forests generally is lighter – fewer trees are removed – in order to reduce the chances of windthrow damage which these types tend to be more susceptible to.

Recognizing these differences, we report results separately for each Group and describe the implications for treating or not treating Group II in terms of biomass supply.

2.3.1.2 Landscape Filters

We employed landscape filters to exclude various portions of the landbase from treatment. The filters generally address the question of what portion of the landbase to treat. The landscape filters we used include the following:

- **Exclude areas with low fire hazard** – We applied 2 sets of filters to exclude areas with low current fire hazard as follows:

    - We excluded Fire Condition Class 1 areas from consideration for treatment. This excludes areas where fire regimes are thought to be within the historical range and the risk of losing key ecosystem components is low. Mechanical thinning treatments are not needed in these areas. Where appropriate, they can be maintained within the historical fire regime by treatments such as prescribed fire.

    - We excluded areas where the Torching Index (TI) and Crowning Index (CI) are both above 25. These are measures of crown fire initiation and spread. Stands with CI and TI above 25 have a relatively low risk of having a crown fire initiate and spread through the crowns under normal wind conditions. These two fire risk filters overlap; a plot excluded based on FRCC class will also likely be excluded based on TI and CI values.

- **Exclude Roadless Areas** – fuel management activities in designated roadless areas are politically controversial and may be economically impractical. We exclude roadless areas

[1] The FTE model includes only the small fraction (221,000 acres) of the 6.8 million acres of western juniper forest and savannah in eastern Oregon that is classified as timberland. We address potential biomass supply from eastern Oregon's juniper forests in Section 2.4.3.3.

from consideration from treatment, consistent with most other studies of this type.

- **Exclude slopes > 30%** – many previous analyses have excluded steeper slopes under the assumption that these sites are uneconomic from a harvesting cost standpoint. However, we take the approach that we should show this volume and reflect its economic availability in terms of cost. Therefore, we use this filter in the statewide analysis only in a sensitivity analysis to illustrate how much volume is eliminated by excluding slopes greater than 30%. Similarly, in the regional analyses for Klamath Falls and La Grande, we show volumes from areas with less than 30% slope, and total volume.

- **Exclude plots where merchantable harvest is less than 300 ft^3** – This filter excludes plots that are not likely to have commercial timber value to offset the cost of a fuel reduction thinning. The WGA analysis included this filter in its analysis on the assumption that these areas may be more inexpensively treated using other mechanical or burning treatments without removing the biomass. We did not include this filter in our Base Case statewide analysis because we did not want to make the assumption that every acre treated had to "pay for itself." However, we do include it as a sensitivity analysis. In the Klamath Falls and La Grande analyses, we use this filter to approximate an "economic" treatment.

2.3.1.3 Treatment Options

The FTE model provides six alternative fuel treatment regimes as well as a user-defined regime. The objective of each treatment is to thin until CI and TI are both greater than 25 or CI is greater than 40. These goals were designed by model developers in consultation with USFS regional staff and fire scientists. The regimes vary in the selection of trees harvested and upper limits to the amount of the stand removed. As a result, they vary in their effectiveness in reducing fire risk for given stand condition and also in terms of the amount and characteristics of the biomass removed[2].

Torching Index is defined as the wind speed, 20 feet above ground, at which a crown fire can initiate (the tree "torches" when fire reaches into the crown). Crowning Index is the wind speed, 20 feet above ground, at which active crown fire behavior is possible in that environment. In other words, the fire is likely to spread from tree crown to tree crown when the wind speed is greater than or equal to the CI (Scott and Reinhardt 2001).

TI and CI are both improved by thinning the trees. TI is improved by raising the canopy base height – the distance from the ground to the lower branches of the crown. This can be done primarily by removing the smaller trees that form the fuel ladder that fire climbs from the ground into the crown. Smaller tree removal also increases CI as stand density is reduced; however, CI is improved primarily by removing the larger trees that form the crown, thus reducing the crown density. This makes the fire less likely to move from tree to tree.

We selected four treatments for use in our analysis and have summarized them below. Skog *et al.* (2006) provides a detailed description of the six treatments available in the FTE model. To maintain clarity in our assumptions and comparability with other studies that use FTE, we use

[2] CI and TI were estimated in the model assuming average fuel moisture conditions corresponding to "summer drought" conditions (Rothermel 1991) and mid-range surface fire behavior using fuel model 9. See Skog *et al.* (2006) for a further explanation.

the model's nomenclature for labeling treatments. Treatments 1A, 2A, and 3A were applied to the Group I forest types. Both 1A and 2A are uneven-aged management prescriptions which leave a residual forest that corresponds with the natural stand structure (diversity of tree sizes) of most inland forests. Treatment 3A leaves a stand structure in which tree sizes are more uniform(less diversity of tree sizes).

Treatment 1A – this uneven-aged treatment thins across all diameters present in the stand. It leaves an uneven-aged stand with higher structural diversity than 2A. It does this by leaving relatively more small trees and removing relatively more large trees compared to 2A. Tree removal continues until the TI and CI targets are reached; however, total removal is limited to no more than 50% of the stand's basal area. This treatment is the most aggressive of the four considered in terms of removing larger trees.

Treatment 2A - this uneven-aged treatment also thins across all diameters present in the stand but leaves an uneven-aged stand with lower structural diversity than 1A. It does this by removing relatively more small trees and leaving more large trees compared to 1A. Tree removal continues until the TI and CI targets are reached; however, total removal is limited to no more than 50% of the stand's basal area (BA). This treatment is less aggressive in terms of removing larger trees than 1A but more aggressive than 3A.

Treatment 3A - this even-aged treatment does a thin from below, taking trees in smaller diameter classes first, and removing progressively larger trees until the TI and CI targets are reached or the maximum of 50% of the BA has been removed. This is called an "even-aged" treatment because the stand has a narrower range of tree diameters present after treatment, resulting in what looks like a more uniform, even-aged stand. Normally, this type of treatment would be associated with a regime where the intent is to eventually remove the remaining trees in a final harvest and regenerate the stand. It is the least aggressive treatment in terms of removing large trees.

Treatment 4A – this even-aged treatment was specifically designed for forest types with high-severity fire regimes such as the Group II types. The treatment is similar to the 3A thin from below but removal is limited to 25% of the BA so as to avoid wind throw in shallow-rooted tree species such as lodgepole.

Other treatments available in FTE (1B - 4B) are similar to the regimes described above except that they do not restrict removal to 50% of BA. We selected 1A – 4A to portray the range of treatments that are likely to be implemented across the range of public and private ownerships, while being conservative in removal of large trees because of perceived low social acceptability of this practice on a landscape scale on public lands.

2.3.1.4 Volume Estimates

The FTE model provides an estimate of total biomass volume removed including merchantable timber volume as well as sub-merchantable trees, branches and tops. Total biomass is measured in bone dry tons (BDT) while merchantable volume is reported in cubic feet. In order to estimate the "net forest biomass" that may be available for energy production, we converted the cubic foot merchantable volume in trees 7" DBH and larger to BDT and subtracted this volume from total biomass. Our conversion factor was 25.6 bone dry lbs. per cubic foot of wood.[3]

2.3.1.5 Harvest Cost Estimates

The FTE model provides an estimate of the cost of harvesting the site and bringing volume to the roadside using the Fuel Reduction Cost Simulator (FRCS) harvest cost model (Fight *et al.* 2006). The model estimates the harvest cost for up to eight harvesting systems, depending on site specific conditions, and selects the lowest cost method suitable for the site. Harvesting systems include ground-based and cable-based whole tree and log length systems and include chipping and loading cost for small trees, branches and tops. The FTE model uses FRCS to provide a break-down of biomass volume by harvest cost ranges. This cost is the *integrated* cost of harvesting both merchantable and non-merchantable volume. The total harvest cost per acre is divided by total removals including both merchantable timber volume and biomass. The integrated cost under-estimates the true cost of biomass harvest because it ignores the fact that small material (small trees, tops, branches) is more costly to harvest and bring to the landing than merchantable volume.

2.3.1.6 Transportation Cost Estimates

Estimation of the cost of transporting biomass from the forest harvest site to a processing site requires information on the location of the harvest operation and alternative processing facilities. The FTE model provides information about the location of harvest sites at a relatively small geographic scale using the national EMAP grid of 160,000 acre hexagons. EMAP is the Environmental Monitoring and Assessment Program of the US EPA. Use of this grid system provides the approximate location of the biomass in the forest. Processing facilities used in this analysis are hypothetical. In Section 2.4.1.2 we identify the locations of eight potential processing sites for the statewide analysis. For the regional analyses, the towns of Klamath Falls and La Grande serve as the assumed location of processing.

Calculating actual road distances using GIS road network data would be the most precise method of determining actual haul miles between forest and processing site. However, this was not possible within the time and budget constraints of the study. Instead, we conducted a GIS analysis to calculate the straight line distance from the center of each EMAP Hex containing biomass volume to each of the eight processing locations and then identified the closest processing facility for each Hex.

We then multiplied this shortest straight-line distance by a "circuity factor" developed for rural Oregon to estimate road distance from forest to mill. The circuity factor is the average ratio of road miles to air miles between two points on a landscape. For Oregon, this has been calculated as 1.4 –1.5[4]; we used 1.5 to estimate of haul distance from each EMAP hex to its closest processing

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[3] The conversion factor was based on a weighted average specific gravity of 0.41 for tree species in Oregon. The average specific gravity was weighted based on the 2004 FIA growing stock inventory by species in the 20 subject counties. Specific gravity and wood density data was taken from Briggs (1994).

[4] Personal communication with Jeffery Prestemon, Southern Research Station, 3/13/2006 and Dr. Robert Huggett, Southern Research Station, 3/17/2006. The circuity factor for Oregon was calculated based on average county to county road distances from the geographic center of forest cover in each county and a road network layer from a national atlas. The methodology may not fully account for logging road distances and may therefore underestimate true road distance, but no other published circuity factor was identified.

facility. McNeil Technologies (2003) used the same 1.5 circuity factor to estimate road distance from straight line distance.

A range of transportation costs associated with forest biomass transport is estimated as $0.20 – $0.60/BDT-mile (WGA Biomass Task Force 2005). We assumed a mid-point rate of $0.40/BDT-mile. Multiplication of the road distance between the EMAP hex center and the closest processing facility by the haul cost per mile yielded an estimate of the total haul cost from each harvest location.

2.4 Statewide Analysis

2.4.1 Introduction

2.4.1.1 Study Area Description

Our statewide analysis was limited to 20 counties in eastern and southern Oregon with predominantly dry forest types. These counties were selected because current fire regime condition class maps of the U.S. show much of the area is in FRCC 3.[5] These lands have significantly altered vegetation composition, diversity, and structure due to altered fire return intervals so that they verge on the greatest risk of ecological collapse due to loss of key ecosystem components from fire and are thus likely to receive high priority for fuel treatment (USDA, USDI 2002). Western counties with mostly wet forest types have long fire return intervals and fuel reduction treatments may not be appropriate (Skog *et al.* 2006). However, we included Douglas County, a transitional area where fuel reduction treatments may be needed.

Total timberland area in the 20 counties is 14.9 million acres. Sixty-nine percent is under federal ownership, including the national forest, BLM and other federal lands. Thirty percent is privately owned and the remaining 1% is owned by state and local government (Table 2). Timberland includes forestland that has not been withdrawn from timber utilization by statute or regulation and is capable of producing 20 ft^3/acre/year of merchantable wood in natural stands. It excludes parks, monuments, Wilderness Areas and other designated withdrawals.

Table 2 – Timberland acres by county and ownership for 20 study counties (thousand acres).

County	Total	National Forest	Bureau of Land Mgmt	Other federal	State	County and Municipal	Private
Baker	624	523	-	-	-	-	101
Crook	441	367	-	-	-	-	74
Deschutes	863	762	24	-	-	-	76
Douglas	2,569	902	595	-	34	17	1,020
Gilliam	-	-	-	-	-	-	-
Grant	1,584	1,294	22	-	22	-	246
Harney	460	448	8	-	-	-	4
Jackson	1,170	395	324	3	-	3	444
Jefferson	308	140	-	-	-	-	168
Josephine	811	317	283	-	9	28	173
Klamath	2,303	1,449	82	-	29	-	742
Lake	1,144	897	-	-	-	-	247
Malheur	8	4	-	-	-	-	4
Morrow	213	122	-	-	-	-	91
Sherman	-	-	-	-	-	-	-
Umatilla	539	344	-	-	5	-	190
Union	649	445	-	-	-	-	205
Wallowa	514	268	8	-	4	-	234
Wasco	398	155	-	-	9	-	234
Wheeler	309	143	14	-	-	-	153
Total	14,906	8,976	1,360	3	112	49	4,406

Source: 2002 RPA Tabler web application: http://ncrs2.fs.fed.us/4801/fiadb/rpa_tabler/webclass_rpa_tabler.asp

[5] For a background discussion of historical fire regimes and Fire Regime Condition Class, refer to Appendix B.

Stocking condition is a measure of the tree density relative to optimal density. Stocking condition classes are defined by FIA as follows:

- Overstocked (100+ % of full stocking)
- Fully stocked (60 – 99%)
- Medium stocked (35 – 59%)
- Poorly stocked (10 – 34%)
- Nonstocked (0 – 9%)

Overstocked stands tend to be susceptible to forest health problems as competition for limited moisture weakens the trees, especially in the dry pine and mixed conifer forests of the Inland Northwest. Insects and pathogens attack weakened trees. Increased mortality leads to an accumulation of surface fuels. Under natural fire regimes, relatively frequent low-severity wildfires kept the accumulation of surface and crown fuels in check by maintaining more open stands with less fuel. The fire suppression of the past century, however, eliminated this function and allowed development of large expanses of overstocked stands (Fitzgerald 2002; Agee 2002; Filip 2002).

Nearly 40% the timberland acreage, or 5.6 million acres, in the 20 counties is in an overstocked condition, as shown in Table 3. Federal lands have the highest proportion of acres in the overstocked condition; 52% of federal ownership is classified as overstocked. Conversely, only 5% of state and county lands, and 4% of private lands, are overstocked. Federal lands also have a higher proportion of fully stocked stands compared to private lands.

Table 3 – Timberland acreage by stocking condition and ownership for 20 study counties (thousand acres).

Stocking Condition	Total	National Forest	Bureau of Land Mgmt	Other federal	State	County and Municipal	Private
Overstocked	5,618	4,693	735	-	9	-	182
Fully stocked	2,092	1,374	221	-	25	-	472
Medium stocked	3,725	1,631	241	3	64	12	1,774
Poorly stocked	2,393	1,021	164	-	13	9	1,184
Nonstocked	1,078	257	-	-	-	27	793
Total	14,906	8,976	1,360	3	112	49	4,406

Source: 2002 RPA Tabler web application: http://ncrs2.fs.fed.us/4801/fiadb/rpa_tabler/webclass_rpa_tabler.asp

The FTE model excludes non-stocked acreage from analysis, and contains a total of 13.8 million acres of timberland in the 20 counties. Of this, 12.4 million acres (90%) is classified as FRCC 2 and 3 (Table 4). These are conditions in which fire regimes are moderately to significantly altered from their historical range and where risk of losing key ecosystem components in the event of a wildfire is moderate to severe.

Table 4 – Timberland acreage by Fire Regime Condition Class and ownership for 20 study counties, excluding non-stocked area (thousand acres).

Fire Regime Condition Class	Total	National Forest	Other federal	State and local govt	Private
FRCC 1	1,412	590	294	43	485
FRCC 2	4,952	3,289	357	19	1,287
FRCC 3	7,464	4,716	688	49	2,011
Total	13,828	8,595	1,340	111	3,782

Source: FTE 3.0 web application: http://www.ncrs2.fs.fed.us/4801/fiadb/FTE_Version3/WC_FTE_version3.asp

It is important to note that the FRCC value assigned to a plot was based on remote sensing analysis at a coarse resolution (1 km^2) and may not necessarily reflect the actual conditions of the sample plot.

2.4.1.2 Processing Sites

For the statewide analysis, we assumed hypothetical biomass processing facilities exist at the following eight locations to enable us to calculate delivered biomass costs:

- Bend
- Grants Pass
- John Day
- Klamath Falls
- La Grande
- Roseburg
- Warm Springs
- Wallowa

The eight locations were chosen to allow full utilization of the forest biomass identified by the FTE model, as shown geographically in Figure 4. This represents a best case scenario in which the majority of biomass volume was expected to be within a reasonable haul distance (less than 50 miles) of a processing facility.

2.4.1.3 Treatment Assumptions

The method of treatment that would be imposed on any given acre of forest is dependent on ownership objectives, financial considerations, and site specific conditions. The choice owners will make between alternative treatment approaches is unknown but has large implications for biomass supply. In our analysis, we made the following assumptions by ownership:

On Group I forest types, we assume:

- **Private owners will implement Treatment 1A and 2A on equal proportions of the private forestland base**. These uneven-aged treatments involve removal of a proportion of the trees from all diameter classes, including merchantable timber. These treatments are likely to be more economically viable than the thin from below treatment, 3A.

- **Public owners will implement Treatment 2A and 3A on equal proportions of the public land base.** As described in Section 2.3.1.3, Treatment 2A is an uneven-aged treatment that removes trees from all diameter classes, but relatively fewer from larger diameters. Treatment 3A is an even-aged thin from below which removes small diameter trees first. These treatments remove fewer larger trees and may be more socially acceptable on public lands.

Public lands represent approximately 70% of the treatable landbase in the 20-county area. As a result of this and the above assumptions for treatment by ownership, 15% of Group I forests would be treated with Treatment 1A, 50% with 2A, and 35% with 3A. We have created a "blended" treatment using these percentages.

On Group II forest types, we assume treatment 4A would be applied on eligible acres on all ownerships. This is a thin from below treatment which removes small trees first. A maximum of 25% of the basal area is removed.

2.4.2 Results

2.4.2.1 Treatment Area

In order to demonstrate the effect of applying different landscape filters on the acreage available for treatment, we conducted a series of FTE model runs which incrementally applied landscape filters one at a time to exclude portions of the landbase. The results show the cumulative effect of the landscape filters on remaining treatable acres.

- The total timberland area, excluding non-stocked areas, in the 20 counties is 13.8 million acres.
- Filtering out areas of low fire hazard reduces the area for possible thinning to 4.7 million acres. This eliminates FRCC 1 forest and areas where TI and CI are both above 25 mph.
- Excluding designated Roadless Areas eliminates 426,000 acres, further reducing the acreage eligible for thinning to 4.25 million acres, 29% of the total timberland. For purposes of comparisons we shall refer to this as the **Base Case** and designate this area as the "**eligible treatment area**."
- If treatments were further limited to slopes of no more than 30%, the eligible treatment area would be further reduced to 2.9 million acres. This is a reduction of 31% from the Base Case.
- If a removal of minimum of 300 ft^3/acre of merchantable volume is necessary to offset harvesting costs, the eligible treatment area, including all slopes, would be 1.5 million acres, or only 10% of the total timberland area and 35% of the Base Case.

Table 5 summarizes the acres that are available and could be effectively treated under various landscape filters. Group I forest types represent 68% of the total timberland acres. When low fire hazard and roadless areas are excluded, Group I types represent 57% of the acres. The question of whether Group II forests, which represent 42% of eligible treatment area, should be treated is an important determinant of biomass supply.

Table 5 – Treatable acres by forest type group and landscape filter applied (thousand acres).

	Col. A	Col. B	Col. C BASE CASE	Col. D	Col. E
Forest Type Group	All stocked timberland acres	Area after excluding low fire hazard areas from Col. A	Area after excluding Roadless areas from Col. B	Exclude Slopes > 30% from Col. C	Exclude areas where treatments remove < 300ft3 of merch. timber from Col.C
Group I	9,435	2,568	2,423	1,401	1,079
Group II	4,393	2,109	1,827	1,521	405
Total	13,828	4,676	4,250	2,923	1,484

Table 6 summarizes similar information by ownership. Federal lands represent 73% of all stocked timberland acres (Col. A) and 71% of eligible treatment area, or 3.0 million acres, under the Base Case (Col. C).

Table 6 – Treatable acres by ownership and landscape filter applied (thousand acres).

	Col. A	Col. B	Col. C BASE CASE	Col. D	Col. E
Forest Type Group	All stocked timberland acres	Area after excluding low fire hazard areas from Col. A	Area after excluding Roadless areas from Col. B	Exclude Slopes > 30% from Col. C	Exclude areas where treatments remove < 300ft3 of merch. timber from Col.C
National Forest	8,719	3,039	2,618	1,881	784
Other federal	1,363	398	398	94	189
State and local govt	133	20	20	12	14
Private	3,613	1,220	1,214	936	496
Total	13,828	4,676	4,250	2,923	1,484

Figure 1 summarizes the eligible treatment area under the Base Case by county and forest type[6]. Douglas and Klamath counties each exceed 500,000 acres of eligible land. The next tier of counties in terms of eligible acreage is Grant, Jackson, and Lake; each with over 400,000 acres. The latter may be somewhat of a surprise, but it is a large county with a high percentage of federal timberland (Table 2). A third tier of counties have approximately 175,000 – 200,000 acres each. Baker, Union and Wallowa counties in northeast Oregon; Deschutes in central part of the state; and Josephine in the southwest comprise this third tier.

Acres in Douglas and Jackson counties include mainly Group I forest types, whereas Grant, Klamath, and Lake counties are mostly Group II types.

[6] The reader is cautioned that the statistical reliability of FIA data at the county level is relatively low due to small sample size and is worse at the EMAP grid level. FIA data is more reliable for larger geographical scales.

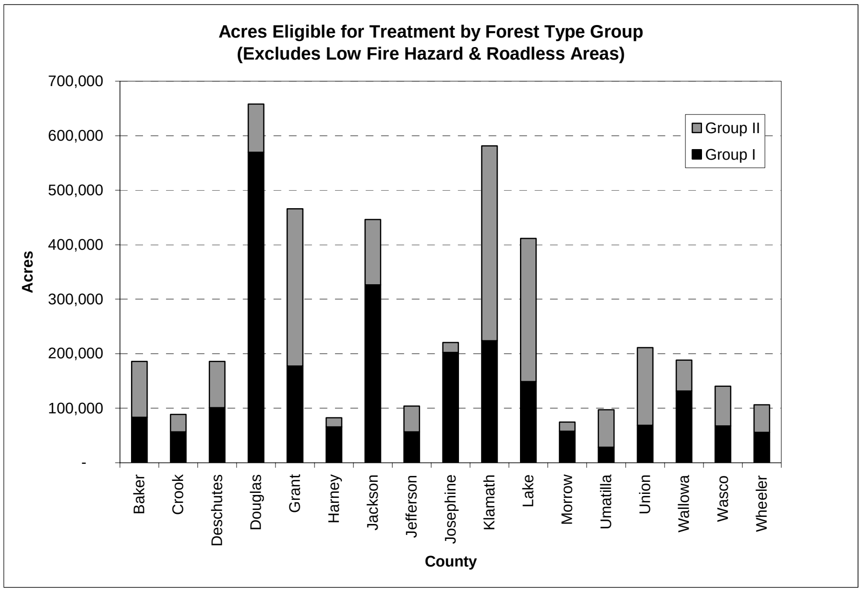

Figure 1 – Eligible treatment area under the Base Case by Forest Type Group and County.

Eligible acres can also be mapped at a smaller geographic scale using the national EMAP grid of 160,000 acre hexagons. The FTE model provides results spatially by using the standard EMAP grid. Figure 2 illustrates this for the 4.3 million treatable acres in the Base Case.

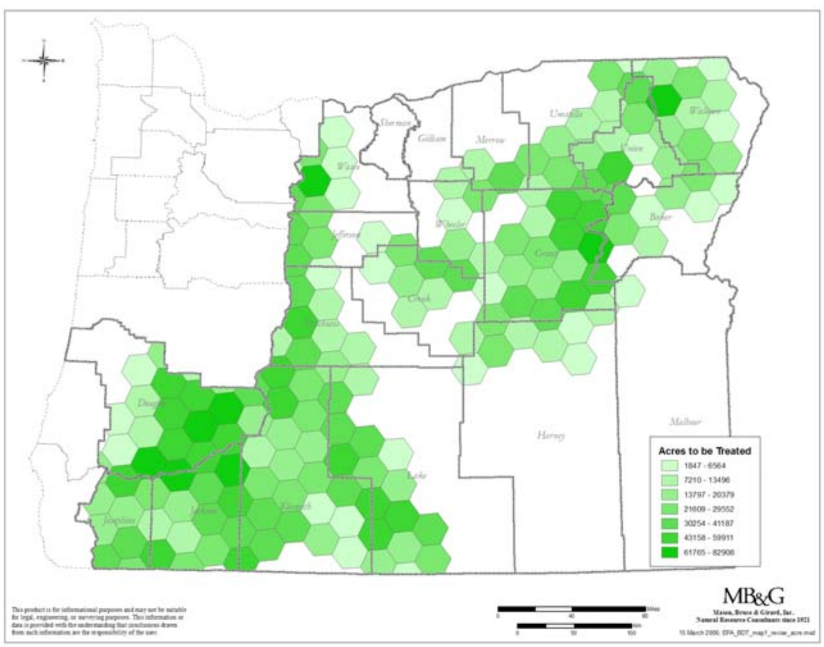

Figure 2 – Acres eligible for treatment under the Base Case by 160,000 acre EMAP hexagon.

Both Group I and Group II treatable acreages are included in Figure 2. Figure 3 maps the same data for Group I forest types only. This figure points out that the largest concentration of Group I forests eligible for treatment under the Base Case is in southwest Oregon and particularly in Douglas and Jackson counties.

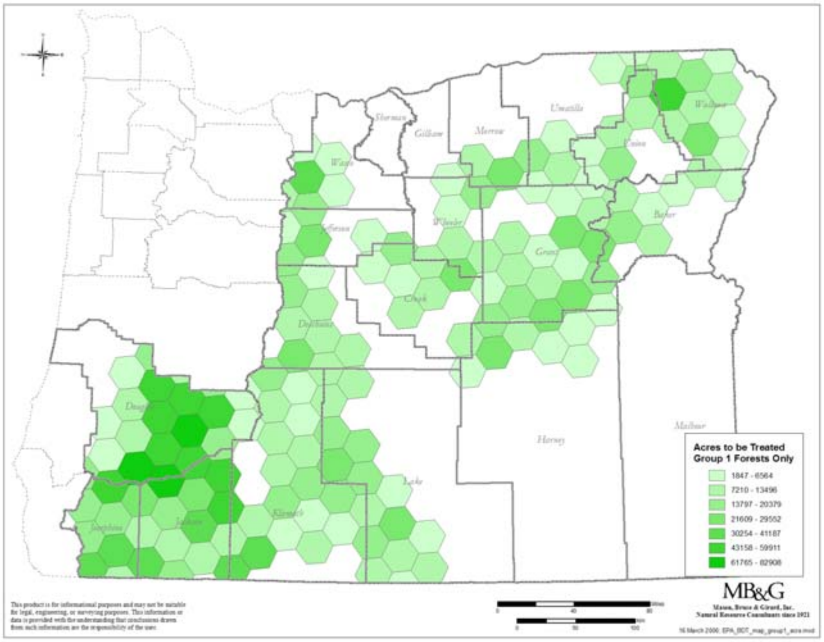

Figure 3 – Group I forest type acres eligible for treatment under the Base Case by 160,000 acre EMAP hexagon.

2.4.2.2 Biomass Volume Removed

Estimated biomass volume removals from fuel treatments under various landscapes filters are summarized in Table 7. For Group I forests, this assumes the blended treatment proportions of 1A, 2A and 3A described in Section 2.4.1.2. The Base Case (Col. C), would yield 45.5 million BDT of total biomass. About half of this of this, 22.4 million tons is net biomass, the non-merchantable trees, branches and tops that could be used for energy production or other non-traditional wood products.

Seventy six percent of the net biomass volume in the Base Case – 17.1 million BDT – comes from Group I forests. Although these forests represent 57% of the acres eligible for treatment, they produce a larger proportion of the volume because higher volumes per acre are removed from the treatments implemented in these forest types.

Table 7 – Estimated biomass volume removed during fuel treatments by forest type group and landscape filter applied (million BDT).

	Col. C BASE CASE	Col. D	Col. E
Forest Type Group and Biomass Component	**Eligible Treatment Area**	**Exclude Slopes > 30% from Col. C**	**Exclude areas where treatments remove < 300ft3 of merch. timber from Col.C**
Group I			
Total Biomass	36.5	15.5	33.4
Merch. Biomass	19.4	8.4	18.6
Net Biomass	**17.1**	**7.1**	**14.7**
% Net Biomass	47%	46%	44%
Group II			
Total Biomass	9.0	7.3	5.8
Merch. Biomass	3.7	2.7	3.4
Net Biomass	**5.3**	**4.5**	**2.3**
% Net Biomass	59%	62%	41%
Total			
Total Biomass	45.5	22.8	39.1
Merch. Biomass	23.1	11.2	22.0
Net Biomass	**22.4**	**11.6**	**17.1**
% Net Biomass	49%	51%	44%

Reducing the operable area by excluding slopes above 30% drops volumes by about half (Col. D) relative to the Base Case. Treating only areas where at least 300 ft^3 of merchantable timber are removed, but including all slopes, reduces net biomass by 24% to 17.1 million tons compared to the Base Case. These results serve to illustrate that:

- About half the net biomass is found on slopes greater than 30% where cable logging systems may be required.
- About one quarter is removed in treatments where merchantable timber volume is unlikely to cover treatment costs.

Table 8 lists the per acre biomass volume removed under the alternative cases. Under the Base Case, treatment of Group I forests yields 15.1 BDT of material per acre, including an average of 7.1 BDT of net biomass. Treatment of Group II forests yields 4.9 BDT per acre of total biomass and 2.9 BDT of net biomass. The lower removals per acre on Group II forests is a result of application of the 4A treatment which is limited to removing 25% of the initial stand basal area. Lower pre-treatment volume per acre may also be a factor.

Table 8 – Estimated biomass volume removed per acre during fuel treatments by forest type group and landscape filter applied (BDT/acre)

	Col. C BASE CASE	Col. D	Col. E
Forest Type Group and Biomass Component	**Eligible Treatment Area**	**Exclude Slopes > 30% from Col. C**	**Exclude Areas where Treatments Remove < 300ft3 of merch. timber from Col.C**
Group I			
Total Biomass	15.1	11.1	30.9
Merch. Biomass	8.0	6.0	17.2
Net Biomass	**7.1**	**5.1**	**13.7**
% Net Biomass	47%	46%	44%
Group II			
Total Biomass	4.9	4.8	14.2
Merch. Biomass	2.0	1.8	8.4
Net Biomass	**2.9**	**3.0**	**5.8**
% Net Biomass	59%	62%	41%
Total			
Total Biomass	10.7	7.8	26.3
Merch. Biomass	5.4	3.8	14.8
Net Biomass	**5.3**	**4.0**	**11.5**
% Net Biomass	49%	51%	44%

Column D of the table indicates that excluding steeper slope ground reduces the average recovery per acre to 5.1 BDT of net biomass for Group I forests. It appears from this finding that steeper slopes may have, on average, a larger accumulation of excess biomass. This is perhaps a function of less intensive management on these steeper slopes over the past decades.

Limiting treatment to areas where at least 300 ft^3 - or the equivalent of approximately 1,750 board feet - of merchantable timber increases the total volume per acre removed to 30.9 BDT on Group I lands and 14.2 BDT on Group II. Net biomass removed per acre nearly doubles compared to the Base Case.

By volume, Douglas County far exceeds all other counties, accounting for 16.1 million (35%) of the 45.5 million BDT of total biomass. Jackson County, just to the south, also stands out representing another 20% of the volume. This is because of the higher volumes per acre removed from treatment of the Group I forests in these counties. This is indicative of higher volume stands in the Douglas-fir types west of the Cascades.

Table 9 details acres treated, total biomass removed, and removal per acre by county and forest type group for the Base Case.

Table 9 – Acres treated, total biomass removed and removal per acre under Base Case, by county and forest type group.

	Area Treated (acres)			Total Biomass Removed (Thousand BDT)			Biomass Removal Per Acre (BDT/acre)		
County	Group I	Group II	Total	Group I	Group II	Total	Group I	Group II	Total
Baker	83,665	102,162	185,827	459	265	724	5.5	2.6	3.9
Crook	56,837	32,054	88,891	273	68	341	4.8	2.1	3.8
Deschutes	101,209	84,832	186,041	535	269	804	5.3	3.2	4.3
Douglas	569,759	88,318	658,077	15,833	282	16,114	27.8	3.2	24.5
Grant	177,359	288,568	465,927	1,096	873	1,968	6.2	3.0	4.2
Harney	65,654	16,810	82,464	197	35	233	3.0	2.1	2.8
Jackson	326,426	119,714	446,140	7,771	1,114	8,885	23.8	9.3	19.9
Jefferson	56,789	47,154	103,943	377	557	934	6.6	11.8	9.0
Josephine	202,413	18,358	220,771	3,811	192	4,003	18.8	10.5	18.1
Klamath	223,734	357,801	581,535	1,390	1,447	2,837	6.2	4.0	4.9
Lake	148,835	262,890	411,725	821	1,179	2,000	5.5	4.5	4.9
Morrow	57,843	16,686	74,529	327	50	377	5.7	3.0	5.1
Umatilla	28,589	68,775	97,364	140	347	487	4.9	5.0	5.0
Union	68,643	142,649	211,292	577	649	1,226	8.4	4.6	5.8
Wallowa	131,676	56,766	188,442	1,528	320	1,848	11.6	5.6	9.8
Wasco	67,598	72,990	140,588	1,065	1,111	2,176	15.8	15.2	15.5
Wheeler	55,839	50,583	106,422	292	234	526	5.2	4.6	4.9
Total	**2,422,868**	**1,827,110**	**4,249,978**	**36,492**	**8,992**	**45,484**	**15.1**	**4.9**	**10.7**

Table 10 summarizes removal volume for merchantable timber and net biomass by county and forest type group. The net biomass removed is the amount available for energy production under the Base Case. Twelve counties in three regional groupings account for nearly all of the net biomass supply:

- Counties in southern Oregon including Douglas, Jackson, Josephine, Klamath and Lake would produce a combined 16.8 million BDT of net biomass.
- Northeastern Oregon counties – Baker, Grant, Umatilla, Union and Wallowa – would produce a combined total of 3.2 million BDT of net biomass from treatments described here.
- The central Oregon counties of Deschutes, Jefferson and Wasco would produce 1.8 million BDT of net biomass from treatment.

Net biomass volume by 160,000 acre EMAP hexagon is illustrated in Figure 4.

Table 10 – Breakdown of merchantable and net biomass removed by county and forest type group under the Base Case.

County	Merch Biomass Removed (Million Cu.Ft.)			NetBiomass Removed (Thousand BDT)		
	Group I	Group II	Total	Group I	Group II	Total
Baker	21	10	32	185	133	318
Crook	14	2	16	91	40	131
Deschutes	29	9	39	162	148	310
Douglas	651	10	661	7,497	153	7,650
Grant	56	24	80	382	568	950
Harney	10	1	11	72	17	89
Jackson	293	49	343	4,017	481	4,498
Jefferson	17	16	32	166	356	522
Josephine	143	9	152	1,984	78	2,062
Klamath	65	39	104	558	950	1,508
Lake	41	28	69	300	820	1,121
Morrow	14	2	16	147	24	171
Umatilla	7	10	17	50	219	269
Union	30	17	47	196	431	628
Wallowa	59	8	67	770	220	990
Wasco	51	47	98	417	510	926
Wheeler	13	7	20	122	142	265
Total	1,514	289	1,803	17,116	5,292	22,408

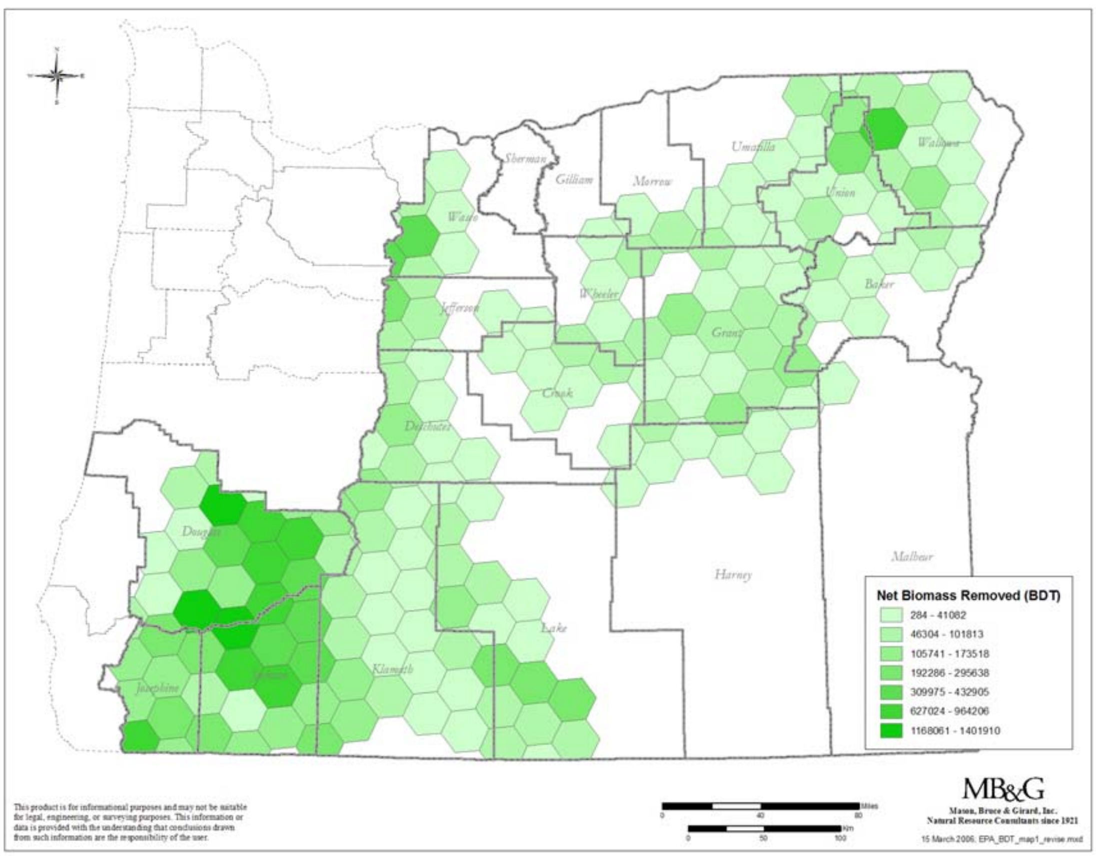

Figure 4 – Net biomass removed under the Base Case by 160,000 acre EMAP hexagon.

2.4.2.3 Harvesting Cost

Figure 5 illustrates the distribution of total biomass volume by harvest cost range. This includes both merchantable timber and non-merchantable net biomass volume. Each bar represents the volume of biomass that can be harvested for the cost range on the x-axis. The black line indicates the cumulative volume at or below the cost range and is read using the axis on the right side of the graph. Table 11 presents the same data in tabular form.

According to the model, 54% of the Base Case biomass volume can be harvested and brought to the roadside for less than $40/BDT and 78% would be less than $60/BDT. Only 12% can be harvested and brought to roadside for less than $20/BDT. As noted previously, this integrated harvesting cost averages the per acre harvesting cost over all volume removed including merchantable sawtimber and non-merchantable net biomass. We are unable to separate the harvest cost of harvest for the net biomass component.

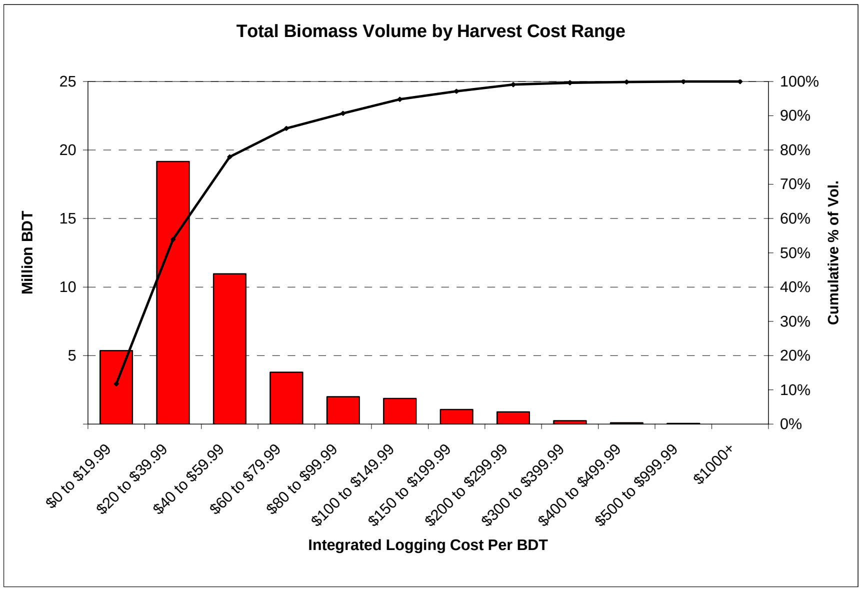

Figure 5 – Total biomass volume by harvest cost range for the Base Case.

Table 11 – Total biomass volume by harvest cost range for the Base Case.

Harvest Cost	Total Biomass Volume		
$/BDT	*Thous. BDT*	*%*	*Cumulative %*
$0 to $19.99	5,361	12%	12%
$20 to $39.99	19,157	42%	54%
$40 to $59.99	10,958	24%	78%
$60 to $79.99	3,784	8%	86%
$80 to $99.99	1,998	4%	91%
$100 to $149.99	1,866	4%	95%
$150 to $199.99	1,064	2%	97%
$200 to $299.99	888	2%	99%
$300 to $399.99	249	1%	100%
$400 to $499.99	100	0%	100%
$500 to $999.99	56	0%	100%
$1000+	1	0%	100%

2.4.2.4 Transportation Cost

Haul cost from the woods to a processing facility represents a significant portion of biomass recovery cost. The destination of the fiber must be known in order to estimate haul costs. For the statewide analysis, we assumed hypothetical biomass processing facilities exist at the eight locations listed in Section 2.4.1.2. The procedures to estimate transportation cost are described in Section 2.3.1.6.

The volume-weighted average haul distance from forest to the closest of the eight processing sites is 48 miles. The maximum haul distance is 120 miles; however, 85% of the volume is within 70 miles of the closest facility. Assuming a rate of $0.40/BDT-mile, average haul cost would be $19.20/BDT. Sixty four percent of the total volume could be hauled from forest to the closest processing facility for less than $20.00/BDT and 85% would cost less than $28.00/BDT. Figure 6 illustrates net biomass volume by cost range. Table 12 presents the same data in tabular form.

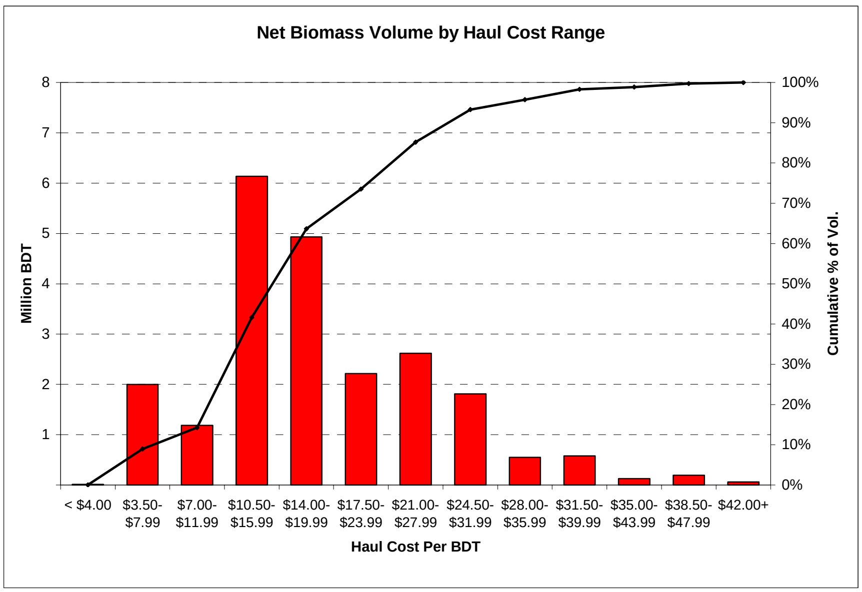

Figure 6 – Net biomass volume by haul cost range for the Base Case.

Table 12 – Net biomass volume by haul cost range for the Base Case.

Haul Cost	Net Biomass Volume		
$/BDT	*Thous. BDT*	*%*	*Cumulative %*
< $4.00	12,297	0%	0%
$4.00-$7.99	1,997,924	9%	9%
$8.00-$11.99	1,184,218	5%	14%
$12.00-$15.99	6,133,978	27%	42%
$16.00-$19.99	4,931,626	22%	64%
$20.00-$23.99	2,215,160	10%	74%
$24.00-$27.99	2,616,623	12%	85%
$28.00-$31.99	1,809,916	8%	93%
$32.00-$35.99	548,804	2%	96%
$36.00-$39.99	577,173	3%	98%
$40.00-$43.99	125,498	1%	99%
$44.00-$47.99	193,674	1%	100%
$48.00+	60,868	0%	100%

These transportation costs are contingent on the eight processing locations we assumed. Fewer facilities would imply longer haul distances. The Western Governor's Association analysis, for example, assumed an average 100 mile haul distance (WGA Biomass Task Force 2005).

2.4.2.5 Net Revenues (Costs) by Treatment Type

Do fuel treatments pay for themselves through revenue from merchantable timber and biomass? The answer to this is site and treatment specific and will vary widely. For some sites and treatments revenues will exceed costs while for other sites the cost of harvest and haul will exceed value of the products.

In order to provide some insight into this question, we estimated average revenue per acre for treatments 1A, 2A and 3A in the Group I forests and treatment 4A in Group II forests based on average per acre values from the Base Case FTE model runs. The FTE model provides an estimate of softwood sawtimber board foot volume removed. For sawtimber volume, we assumed a delivered value of $400/MBF-Scribner[7]. We assumed all other biomass was sold at a delivered value of $36/BDT[8].

Average harvest cost per acre was calculated for each model run from cost information provided by the FTE model. Haul cost was assumed to be the average $19.20/BDT calculated above and was applied to both merchantable timber and biomass volume.

Results are displayed in Table 13. Treatment 1A produces net revenue of $1,270 per acre, indicating that revenues from sale of merchantable timber and biomass exceed the cost of harvest and delivery under average conditions. Average removals include 6.4 MBF/acre of sawtimber and 9.6 BDT/acre of net biomass. Treatment 2A returns net revenue of $484/acre from removal of 3.7 MBF/acre of sawtimber and 7.7 BDT/acre of biomass. Treatment 3A loses an average of $93/acre across all sites eligible for treatment under the Base Case. Less than one MBF of merchantable timber is removed per acre and net biomass volume removed is lower as well, averaging 5.0 BDT/acre.

[7] Estimated based on 4Q2005 delivered prices in the Inland NW and Southwest OR as reported by *Pacific Rim Wood Market Report*, weighted by the mix of species in 20-county inventory.
[8] Fried *et al.* (2004) reported energy biomass in northern California sold for $18/green ton which is equivalent to $36/BDT assuming a 50% moisture content.

Table 13 – Estimated revenues and costs for average acres by forest type group and treatment.

		Forest Type Group and Treatment			
		Group I			Group II
	Units	1A	2A	3A	4A
Total Biomass Removed	BDT/ac	24.6	17.2	7.9	4.9
Volume by Component					
Sawtimber	MBF/ac	6.4	3.7	0.8	0.4
Net Biomass	BDT/ac	9.6	7.7	5.0	2.9
Revenue & Cost					
Sawtimber Revenue	$/ac	$ 2,548	$ 1,474	$ 313	$ 169
Biomass Revenue	$/ac	$ 346	$ 278	$ 181	$ 104
Harvest Cost	$/ac	$ 1,151	$ 937	$ 435	$ 301
Haul Cost	$/ac	$ 472	$ 331	$ 152	$ 94
Net Revenue (Cost)	**$/ac**	**$ 1,270**	**$ 484**	**$ (93)**	**$ (122)**

Treatment 4A was applied to Group II forests – lodgepole, fir-spruce, and hemlock-Sitka spruce types. Harvest and transportation costs exceed revenues by an average of $122/acre for this treatment across all conditions.

Slope has a significant effect of treatment costs as well as revenue. Table 14 compares cost and revenues for gentle versus steep slopes for Treatments 2A and 3A. Under Treatment 2A, higher treatment costs are more than offset by increased revenue as more merchantable timber and biomass need to be removed to reach TI and CI improvement targets. Results for 3A, however, indicate that the treatment can return a small positive net revenue on gentler slopes.

Table 14 – Effect of slope on treatment costs and net revenue for Treatments 2A and 3A.

		Treatment 2A		Treatment 3A	
	Units	Slope < 30	Slope > 30	Slope < 30	Slope > 30
Total Biomass Removed	BDT/ac	12.7	23.5	5.5	11.2
Volume by Component					
Sawtimber	MBF/ac	2.5	5.3	0.4	1.2
Net Biomass	BDT/ac	5.8	10.3	3.6	7.0
Revenue & Cost					
Sawtimber Revenue	$/ac	$ 998	$ 2,128	$ 179	$ 495
Biomass Revenue	$/ac	$ 210	$ 372	$ 129	$ 252
Harvest Cost	$/ac	$ 489	$ 1,560	$ 182	$ 755
Haul Cost	$/ac	$ 244	$ 451	$ 105	$ 215
Net Revenue (Cost)	**$/ac**	**$ 476**	**$ 489**	**$ 21**	**$ (223)**

Costs and revenues are also sensitive to forest type and volume per acre. Because Douglas County contains generally higher volume stands and more Douglas-fir than eastside forests, a final sensitivity was conducted excluding Douglas County from the cost and revenue analysis.

The results are shown in Table 15. In comparison to Table 14, net revenue is $395/acre lower for Treatment 1A and $305/acre lower for 2A. Net revenues were more negative for Treatments 3A and 4A.

Table 15 – Estimated revenues and costs for average acres by forest type group and treatment, excluding Douglas County.

		Forest Type Group and Treatment			
		Group I			Group II
	Units	1A	2A	3A	4A
Total Biomass Removed	BDT/ac	18.9	13.0	5.4	5.0
Volume by Component					
Sawtimber	MBF/ac	4.6	2.3	0.3	0.4
Net Biomass	BDT/ac	9.6	7.7	5.0	2.9
Revenue & Cost					
Sawtimber Revenue	$/ac	$ 1,825	$ 914	$ 114	$ 162
Biomass Revenue	$/ac	$ 346	$ 278	$ 181	$ 104
Harvest Cost	$/ac	$ 920	$ 735	$ 348	$ 306
Haul Cost	$/ac	$ 363	$ 249	$ 103	$ 96
Net Revenue (Cost)	**$/ac**	**$ 887**	**$ 208**	**$ (157)**	**$ (136)**

2.4.2.6 Treatment Over 20 Years

If the 4.25 million acres of eligible forestland in the Base Case were treated equally over a 20 year period, an annual net biomass supply of over 1 million BDT would be available for energy production or other uses. Table 16 summarizes results of such a scenario.

Table 16 – Acres treated, volume by product, costs and revenues for a 20-year Base Case treatment program.

		Group I			Group II	Base Case
	Units	1A	2A	3A	4A	Total
Area Treated	Acres	18,157	60,522	42,464	91,356	212,499
Sawtimber Volume	MMBF	116	223	33	39	410
Net Biomass Volume	000 BDT	174	468	214	265	1,120
Total Revenue	Million $	53	106	21	25	205
Total Costs	Million $	29	77	25	36	167
Net Revenue	Million $	23	29	(4)	(11)	37

Approximately 212,500 acres would be treated annually across all ownerships yielding 410 million board feet (mmbf) of timber products and 1.1 million BDT of biomass. Overall, revenues would exceed costs by $37 million or $174/acre. Approximately 151,000 acres of federal land would be treated annually along with 61,000 acres of private land. This simplistic scenario does not take into account growth during the period or addition of new acres needing fuel reduction treatment.

2.4.2.7 The Sawtimber Subsidy

The preceding cost and revenue data suggests that on average revenue from the sale of merchantable timber and biomass would exceed treatment costs including harvest and transportation of the products. This is particularly true of Treatments 1A and 2A which remove higher proportions of merchantable timber. However, comparing the assumed delivered price of biomass of $36/BDT with average costs per ton for harvest and transport makes it apparent that biomass by itself is a money losing proposition. The cost of harvesting and transporting the biomass material is nearly always subsidized by the sale of more valuable merchantable products.

Consider, for example, Treatment 2A on slopes less than 30% as shown Table 14. The analysis indicates that the cost per acre for harvesting and hauling all products is $733/acre. This equates to $57.72/BDT when divided evenly across the total biomass volume of 12.7 BDT per acre. In this case, net biomass costs $21.72/BDT more to produce than it returns ($57.72 cost - $36.00 revenue = net loss of $21.72/BDT)[9]. The net revenue from the acre is positive only because the revenue from sawtimber exceeds costs by enough of a margin to also cover the removal of smaller biomass material.

On steeper slopes the loss per ton of biomass is greater. For Treatment 2A, the cost of harvest and transportation is $85.57/BDT resulting in a loss of $49.57/BDT for each of the 10.3 tons of biomass removed per acre. This represents a loss of $511/acre.

The worse case, Treatment 3A on steep slopes implies a loss of $50.60/BDT or $354.25 per acre. In this case, revenue from sawtimber does not cover biomass removal costs, resulting in an overall loss of $223/acre.

The concept of using sawtimber revenues to cover, or subsidize, the costs of fuel reduction treatments may make sense from the standpoint of a public land management agency charged with reducing fire hazard over large acreages with minimal outside funding. However, an economically rational, profit-maximizing private landowner would likely make a different calculation. He/she is likely to view biomass removal cost at the *marginal* or incremental cost. They would compare the harvest cost per acre with and without biomass recovery and attribute all of the additional cost to the biomass rather than spreading it over the merchantable volume. For example, if a planned logging job would cost $500/acre for merchantable volume and $900/acre including biomass removal, the incremental $400/acre (plus haul cost) would be compared against the market value of the biomass. Unless the landowner can at least break even on the biomass, or there are other objectives attained through biomass removal (e.g. timber stand improvement or fire risk reduction), the landowner would not be motivated to incur the loss of profit from biomass harvest.

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[9] The actual loss per ton of biomass is actually worse than we have shown. We are using the average harvest cost per BDT of material removed without regard to the differential costs based on material size. Small material (tree tops, branches, small trees) is more costly to process and handle per BDT than larger, merchantable logs, and may even require different or additional equipment. This is not reflected in the integrated, average harvest cost.

2.4.2.8 Net Biomass Supply Curve

Given the information on harvest and haul costs, a marginal cost curve (supply curve) can be constructed showing the estimated biomass volume that can be delivered to the various processing facilities at or below any given cost. Unfortunately, since the FTE model does not provide harvest cost distributions by EMAP hexagon, it is necessary to make an assumption regarding this. Without more specific information, we assumed that each EMAP hex a distribution of harvest costs similar to the statewide distribution shown in Figure 5. This simplifying assumption may not be realistic given the diversity of forest and site conditions in different parts of the state.

Figure 7 illustrates the marginal cost curve for the Base Case. The horizontal axis is the cumulative volume delivered. The total volume shown, 21.8 million BDT, represents 97% of the net biomass volume estimated for the Base Case. The remaining 3% of volume has a harvesting cost alone exceeding $200/BDT and was dropped from the analysis.

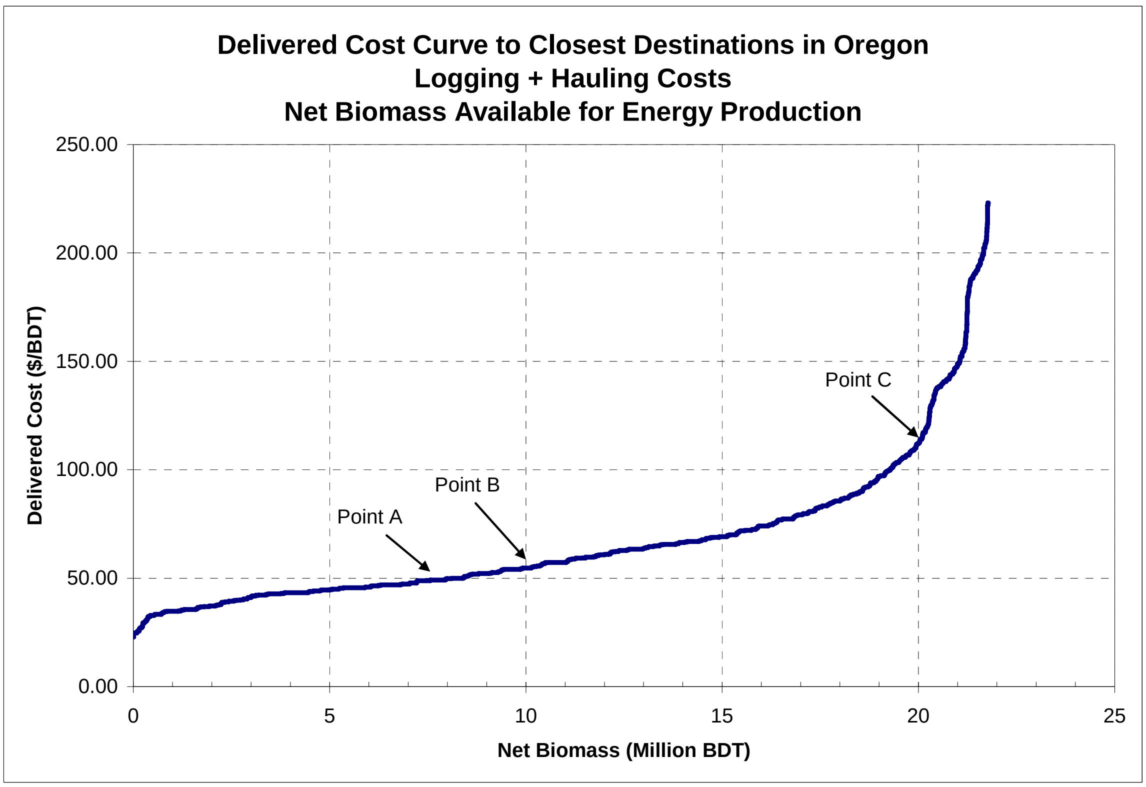

Figure 7 – Supply curve for delivered net biomass volume to closest hypothetical processing point, for the Base Case.

To read Figure 7, from a given price on the left axis, move right horizontally to the curve then drop vertically to the volume axis; this is the volume that can be delivered at or below the given price. For example, Point A indicates that approximately 8 million BDT could be delivered for less than $50/BDT. Conversely, move vertically up from any given volume to the cost curve line, then move left horizontally to read the delivered cost from the vertical axis. This is the marginal cost (or cost of the most expensive unit) at which the volume can be delivered. For example, Point B indicates that 10 million BDT could be delivered for less than about $55/BDT (the most expensive incremental ton would cost $55).

The supply curve makes a sharp, upward turn at approximately 20 million BDT, where the marginal cost approaches $120/BDT (Point C). Beyond this point, large increases in marginal delivered cost bring only small increments of additional volume. Although somewhat arbitrary, this point might represent a practical maximum limit of supply since beyond this point, costs escalate rapidly with little apparent supply benefit.

From this cost data, it is also possible to calculate an annual supply and the average delivered cost for biomass delivered up to alternative marginal cost levels. To do this, we have to make an assumption about the number of years over which treatments are made. Results assuming a 20-year harvesting period are summarized in Table 17. For example, the table indicates that approximately one million BDT is available for a delivered cost of less than $120/BDT. The average delivered cost for this volume is $59/BDT.

It should be noted that the high marginal cost wood (e.g. above $100/BDT) is *very* high cost fuel; however the relatively small volume of this material has a minimal effect on average fuel cost.

Over time, costs would improve due to growth which would add to the volume removed per acre. Another result of this analysis is that there appears to be relatively little volume, about 420,000 BDT per year, available at a delivered cost of less than $40 per BDT.

Table 17 – Annual net biomass volume available and average cost per BDT at alternative marginal costs, assuming a 20-year harvesting period, Base Case.

Delivered Cost Less Than…	Volume Available BDT/Yr	Avg. Delivered Cost $/BDT
$ 40.00	140,092	$ 35.08
$ 60.00	588,684	$ 45.89
$ 80.00	859,158	$ 53.07
$ 100.00	964,021	$ 56.94
$ 120.00	1,011,595	$ 59.36
$ 140.00	1,031,645	$ 60.80
$ 160.00	1,060,119	$ 63.11
$ 250.00	1,088,484	$ 66.47

This analysis is sensitive to the assumptions. The type of thinning treatment applied determines harvest cost. Increased use of Treatment 3A in place of 2A on public lands to avoid removal of the larger, merchantable trees would drive up costs and reduce the supply available for a given price.

It is also sensitive to the number of years over which treatments occur. If treatments occurred over ten years, for example, the annual volume available at a given cost would be doubled. Volumes would be reduced (ignoring growth) if treatments were extended longer than 20 years.

The result is also sensitive to the assumptions regarding delivery locations and circuity factor. We have placed hypothetical processing facilities at sites throughout the range where the biomass is found. If there were fewer facilities, longer haul distances would drive costs up.

Finally, we have also assumed that each geographic area has the same distribution of harvesting costs, so the cost curve should be interpreted with caution. For example, if more remote hexagons also tend to have steeper slopes and higher harvesting costs, the cost curve could be steeper than shown.

To test the sensitivity of the results to some of these factors, we constructed an alternative cost curve eliminating the processing facilities in Bend, Grants Pass, Wallowa and John Day and assuming a high-end $0.60/BDT-mile haul rate and a 2.0 circuity factor. This increased average haul distance to 87 miles, resulting in an increase in marginal and average costs as shown in Table 18.

Table 18 – Sensitivity Analysis: Annual average biomass volume available and average cost per BDT at alternative marginal costs, assuming a 20-year harvesting period, fewer processing facilities, higher haul cost rate, and a higher circuity factor.

Delivered Cost Less Than…	Volume Available BDT/Yr	Avg. Delivered Cost $/BDT
$ 40.00	8,907	$ 36.31
$ 60.00	126,925	$ 52.00
$ 80.00	390,865	$ 64.50
$ 100.00	656,261	$ 74.60
$ 120.00	830,219	$ 82.01
$ 140.00	941,547	$ 87.57
$ 160.00	1,004,094	$ 91.42
$ 250.00	1,083,872	$ 98.79

The volume available at less than $120/BDT marginal cost dropped to 830,000 BDT while average delivered cost for this volume increased 38% to $82/BDT.

2.4.2.9 Conversion to Electrical Power

The analysis above supports a finding that approximately 1.0 million BDT of biomass from forest thinnings could be available annually statewide for 20 years at an average delivered cost of $59/BDT (Point C on supply curve). How much electricity could be produced from this feedstock and at what unit cost?

Figure 8 below provides an estimate of electrical power production and costs assuming 1.0 million BDT of biomass from forest thinnings was directed at electrical generation using conventional technologies at stand-alone biomass power plants. The capital cost of the plant is assumed to be $1.4 million per installed megawatt, a value that appears reasonably constant over a range of 13.4 MW to 34 MW of stand-alone power plants built in the early 1990s. Plants in the 5 MW range will be at least 25% more per installed megawatt. Very few new biomass plants have been built since that time, so it is difficult to know what a plant might cost in 2006.

Cost of debt service is calculated using 6.5% financing with a ten year loan duration, 100% debt financing, and assumes the developer takes advantage of Oregon's BETC pass-through option, reducing capital cost by $2.55 million. The cost of non-fuel operations & maintenance (O & M) is $17 per MWh, based on actual stand-alone biomass plants of similar size.

One million tons of feedstock under the assumptions shown below would be capable of producing about 146 MW of power statewide. By comparison, the 2004 total installed electrical generation capacity in Oregon was 5,734 MW, with load growth expected to be about 2% or a little over 100 MW per year.

The average net cost of the biomass-produced electricity would be 8.1¢ per kWh for the first five years by taking advantage of the federal production tax credit (PTC) and 9.0¢ for the next five years[10]. This net cost is competitive with alternatives such as natural gas. For example, a 500 MW natural gas plant with a capital cost of $560,000 per installed MW using the same financing assumptions used above and a $10 per mmbtu natural gas price yields a power cost of 8.5¢ per kWh.

Assuming eight plants at the hypothetical locations used in the analysis, average capacity would be about 18 MW. However, capacity would vary from site to site based on the geographic distribution and delivered costs of feedstock[11].

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[10] Many people understand this credit to be valid for 10 years. See discussion in Section 5.5.5 (*Incentive Programs*).

[11] We have not attempted to predict plant sizes for the eight locations. Optimal facility size is determined by many factors outside the scope of this report.

Assumptions

Plant Heat Rate	15,000	btu/kWh
Fuel Higher Heat Value	9,100	btu/lb
Plant Capacity Factor	95%	
Number of Plants	8	
O & M Cost/MWh	$ 17.00	
Capital Cost/MWh	$ 24.60	
Fuel Available	1,000,000	BDTs/Yr
Average Delvd. Cost	$ 59	$/BDT

Abbreviations

kWh	kilowatthour
MWh	Megawatthour
MW	Megawatt
btu	British thermal units
BDT	bone dry tons

Calculations

(1) Megawatt-hours (MWH) per BDT

	Fuel Energy Value - btu per BDT	18,200,000
÷	Plant Heat Rate	15,000
	kWh produced per BDT	1,213
=	**MWh produced per BDT**	**1.21**

(2) Total Megawatts Produced & Avg. Plant Capacity

	Fuel Available per year	1,000,000
X	MWh produced per BDT	1.21
	Total MWH produced	1,213,333
÷	Total Operating Hours/Yr @ 95%	8,322
	Total Megawatt Capacity	**146**
÷	Number of Plants	8
	Average Plant Capacity	**18**

(3) Average Fuel Cost Per MWh & KWh

	Delvd Fuel Cost	$ 59
÷	MWh produced per BDT	1.21
	Average Fuel Cost per MWh	**$ 48.63**
÷	KWh per MWh	1,000
	Average Fuel Cost per kWh	**$ 0.049**

(4) Total Production Cost

		$/MWh	$/kWh
	Average Fuel Cost	$ 48.63	$ 0.049
	Operating & Mtce.	$ 17.00	$ 0.017
+	Capital Cost	$ 24.60	$ 0.025
	Production Cost	**$ 90.23**	**$ 0.090**
-	Federal PTC @ $0.009/KWh for 5 yrs	$ 9.00	$ 0.009
	Net Production Cost for first 5 yrs	$ 81.23	$ 0.081
	Net Production Cost for second 5 yrs	$ 90.23	$ 0.090

Figure 8 – Electrical generation model using conventional technologies.

It is important to understand the sensitivity of these results to the assumptions. One key assumption is the fuel's Higher Heat Value (HHV). This is a measure of the btu output from combustion of an oven dry pound of fuel. A higher HHV is better; more btu's are produced per unit of fuel. Our assumption of 9,100 btu/lb. is an approximation based the HHV values shown in Table 19 for western conifer species. A recent national study by the American Forest & Paper Association used the same HHV assumption of 9,100 btu/lb. (AF&PA 2005). Sampson et al. (2001), in a report to the Oregon Office of Energy, assumed 17 million btus per dry ton, which is equivalent to 8,500 btu/lb. Assuming this lower HHV, the production cost, before the PTC, would be 9.4¢/kWh.

Table 19 – Higher heating value for some wood and bark species (Ince 1979)

Species	*Wood* btu/oven dry lb.	Bark *btu/oven dry lb.*
Douglas-fir	8,800 -9,200	9,400 – 10,100
Lodgepole pine	8,600	10,760
Ponderosa pine	9,100 – 9,140	9,616
Sitka spruce	8,100	n/a
White fir	8,000 – 8,300	n/a

Plant heat rate is another important factor. A lower heat rate is better since it indicates that fewer btu's are required to produce a given amount of electricity. Our assumption of 15,000 btu/kWh is based on data from four existing plants and is consistent with the assumption used in the AF&PA

report. The Western Governor Association study reported a range of 12,400 – 20,000 at eight direct-combustion plants with an average of heat rate of 15,625 (WGA Biomass Task Force 2006). The resulting range of production costs (before PTC) would be 8.2 – 10.6¢/kWh, holding other assumptions constant as shown in Figure 8.

Both of these factors also affect the total megawatt production capability of the 1.0 million BDT annual fuel supply. Holding all assumptions constant except HHV and heat rate, a best case could be 184 MW of production assuming a HHV of 9,100 and plant heat rate of 12,400. A worse case would be 102 MW assuming HHV a 8,500 and average plant heat rate of 20,000.

The fuel cost assumption is also critical. To produce electricity in the 6.5 – 7.5¢/kWh range for example, fuel costs would need to be in the range of $45/BDT. At an average delivered cost of $45/BDT, electricity production cost drops to 7.9¢/kWh and the net production cost for the first five years, after the PTC, would be 7.0¢/kWh (with all other assumptions are as shown in Figure 8). However, based on our cost curve, only 554,000 BDT per year could be delivered at that cost. Total electric capacity falls to 81 MW when average delivered cost is limited to $45/BDT.

A biomass fuel incentive of $20/BDT would bring the average delivered cost of the annual 1.0 million BDT of fuel down from $59/BDT to $39/BDT. The resulting production cost of electricity given our other assumptions would be 7.4¢/kWh. After the PTC, net cost would be 6.5¢/kWh. Congress authorized a $20 per green ton subsidy for biomass in the 2005 Energy Bill, but has not received funding.

The WGA estimates the value of tradable carbon credits at 3¢/kWh if policies were adopted to address the sequestration of carbon (WGA Biomass Task Force 2006). This additional incentive would conceivably reduce net production cost to 5.1¢/kWh for the first 5 years of operation.

A recent AF&PA report, using different assumptions, estimated generating costs for direct fire wood biomass plants in Oregon at 10.9 – 11.7¢/kWh. This was based on fuel costs of $29 per green ton or $58/BDT (AF&PA 2006). The report concluded that wood generated electricity is uncompetitive with coal in Oregon without an incentive of 2.5¢/kWh but noted that Oregon was unlikely to allow another coal-fired power plant in the state. The AF&PA report concludes that wood may be competitive with natural gas in Oregon; a finding that is supported by the current analysis.

Cost savings from these estimates are possible depending on additional subsidies that may be available from the Energy Trust or federal development grants, but these are not assured. In addition, if a power plant were associated with a lumber products mill, especially an expansion of existing power facilities, there could be significant savings in non-fuel O & M due to existing plant staff being available. Fuel savings are possible as well from the combined use of mill wastes and chipped forest thinnings.

In some ways, this is a worst case scenario since it is based on a stand-alone power plant with no market for the steam. Electrical plant efficiencies are highest with an integrated power plant, using a back-pressure turbine, and the resulting low pressure steam matched to the heat needs of the mill. While our stand-alone biomass power plant example below has a heat rate of 15,000 BTU/kWh, a thermally matched power plant at an existing mill could have a heat rate of about

5,000 BTU/kWh. This is a much better use of the fuel resource, with a possible additional offset of fossil fuel use if the existing plant steam system is fueled by natural gas.

2.4.2.10 Conversion to Ethanol

Ethanol yield per BDT of forest thinnings was estimated to be 61 gallons by McNeil Technologies (2003) based on NREL data for softwood forest thinnings. Other studies assumed higher ethanol yields. The Oregon Ethanol Study for example cites a yield of 66 gallons per BDT (Graf and Koehler 2000). McNeil Technologies estimates the theoretical yield at 81.5 gallons per BDT and assumes a practical yield of 75% of this maximum.

Assuming the entire one million annual BDT supply was to be directed to ethanol production, yield would produce approximately 61 – 66 million gallons per year. To put this into perspective, the ODOE estimates that in 2002, up to 60 million gallons of ethanol were used to oxygenate over 1.5 billion gallons of gasoline consumed by Oregonians (ODOE 2005). Average feedstock cost would be $0.97/gallon based on the average delivered cost of $59/BDT and yield of 61 gallons/BDT. This is feedstock material cost only; full production costs for cellulosic ethanol are not known.

2.4.3 Discussion

2.4.3.1 Potential Supply from Fuel Reduction Treatments

The analysis of biomass supply from fuel reduction treatments across 20 eastern and southern Oregon counties suggests that a net biomass supply of approximately 20 million BDT is possible. This would come from treatment of 4.25 million acres of eligible forestland, or approximately 27% of the total timberland area in these counties.

The eligible area was defined as public and private timberland with high fire risk outside of designated roadless areas, Wilderness areas, parks and other forestlands where harvesting is excluded. High fire risk areas were defined as those classified as Fire Condition Classes 2 and 3 having either Crowning or Torching Index below 25 mph. Both Group I forest types adapted to surface or mixed severity fire regimes and Group II types, which are adapted to high severity fire regimes, forest types were included.

If harvested over a 20 year period, approximately 1 million BDT would be produced annually assuming no allowance for growth. Average delivered cost would be $68/BDT in today's dollars based on integrated harvesting and collection costs and assuming processing facilities were well distributed across the region. Over the entire landscape, revenues from sale of merchantable timber and biomass could cover direct treatment costs (harvesting and hauling) if sawtimber revenues were allowed to subsidize biomass harvest and transport costs.

All of these finding are based on the specific assumptions used in the analysis, including the availability of acreage for treatment, the mix of different treatments assumed, distribution of processing plants and economic assumptions.

2.4.3.2 Some Caveats to this Analysis

There are numerous caveats and cautions that should be mentioned in relation to the foregoing analysis. This type of analysis is inherently and unavoidably subject to much uncertainty and many assumptions. Some of the most significant caveats are as follows:

- **The FTE Model is based old inventory data.** The FTE Model uses data compiled for the 2002 Resources Planning Act (RPA) national timber assessment. Data for non-federal lands is from the 1992 FIA inventory. Data for federal lands is from agency inventories of similar vintage. The age of the data creates uncertainty in the results. Growth and harvesting, large fires, and land use change have all occurred in the intervening period and are not accounted for in the data.

- **Our analysis is a snapshot view of conditions based on data collected in the early to mid 1990's**. Available data indicates that net annual growth of 4,385 million board feet (mmbf) accumulates across all Oregon forests annually. Eastside forests had positive net growth during the 1990's of 681 mmbf. On both eastside and westside federal forests, removals are low, while mortality and net growth are high (E.D. Hovee & Company, 2005). Because the inventory data used in FTE model is more than 10 years old, the biomass volume estimates resulting from this analysis are conservative. Additional growth has occurred since the inventory was measured. As a result, our estimates of biomass volume are probably conservative for federal lands.

  We have also not factored in the dynamics of continued forest growth and change in the future. Biomass volumes will likely continue to increase across the landbase during the treatment phase, particularly on federal lands. Additional acres will need treatment as they age and accumulate fuel. FRCC 1 lands and those with current CI and TI values above our threshold values may over time shift to higher fire risk categories and need treatment. Conversely, some acres within the eligible treatment area will be lost to wildfire before they are treated.

- **FTE Model database excludes dead trees and down woody biomass**. The FTE Model includes only live tree volume. In some forests, a significant amount of standing dead and down woody material is present and contributes to excess fuel loading. To the extent that this volume is recoverable, the results presented here underestimate biomass volumes.

- **We have made assumptions regarding the treatment of private lands** for fuel reduction goals that may not be consistent with the objectives and economic constraints of private landowners. Approximately 29% of the eligible treatment area in the Base Case is private land. To the extent that private landowners do not undertake fuel reduction treatments, we have overestimated supply.

- **We have included both Group I and Group II forests.** The latter forest types include lodgepole pine, hemlock-Sitka spruce and other types that are naturally adapted to severe fire regimes. Group II forests represent 43% of the eligible treatment area and produce 24% of the net biomass under the Base Case. As we have noted, fuel treatments in these types may be more controversial because the ecological need to treat them is less clear. However, these may require treatment for goals other than ecological restoration such as public safety and property protection, a desire to reduce air emissions from wildfire, and protection of existing forest cover. To the extent that the Group II forests are not treated, we have overestimated available volume.

- **The use of even-aged thinnings on public lands may be controversial.** We have assumed a 50/50 mix of even-aged and uneven-aged treatments. The latter form of treatment removes a proportion of larger trees which may not be an acceptable practice on public lands. Increased use of treatments that only remove small diameter trees (3A) would increase the cost of biomass supply.

- **We may have been overly restrictive in excluding FRCC 1 lands.** We eliminated Fire Regime Condition Class 1 lands from the eligible treatment acreage in order to reduce the chance of overestimating the potential biomass supply. Thus was done under the assumption that restoration efforts would focus on FRCC 2 and 3 areas first. However, since FRCC codes were developed from coarse scale remote sensing analysis, it is likely that we may have excluded some high hazard condition forests within a generally low hazard landscape. Treating these areas would increase available supply above what we have estimated.

- **We excluded Oregon's westside forests.** Our focus in this analysis was to identify potential biomass supply from areas where fuel reduction treatments are most likely to occur. Nearly all the attention related to forest restoration in Oregon has been outside the wet forests of the westside Cascade and Coast Range. Previous studies have discounted the use of fuel reduction treatments in these wet forests. However, others have pointed out that some westside forests are in FRCC 2 and 3 and in addition, there is a large amount of logging slash left during commercial logging operations that could be captured for energy production. This would reduce open burning and resulting carbon release and air pollution impacts. Also, the fact that most of the state's population live west of the Cascades implies the need for fuel and power is there as well. Further study is needed on the questions surrounding forest restoration needs in westside forests.

2.4.3.3 Other Sources of Woody Biomass

The foregoing analysis focused on forest biomass from fuel treatments as the largest untapped source of woody biomass and because of the need to restore forests to more natural conditions, particularly on public lands. Other sources of woody biomass could supplement this supply. These are discussed in the literature review (see Chapter 1, *Forest Biomass Supply*) and summarized here.

The largest source of forest biomass, outside fuel treatment of overstocked forestlands, is the 3.6 million acres of western juniper forest in 14 eastern Oregon counties, nearly all of which is not included in the FTE model because it is not counted as timberland. The control and eradication of juniper is a significant issue for range management and ecology. Juniper biomass has a high fuel value (Higher Heating Value of 8,700 btu/lb.) and few alternative uses.

Total biomass volume greater than 5" in diameter is 11.8 million BDT on juniper forest land (Azuma *et al.* 2005). Some additional volume - less than 1.0 million BDT - is found in less dense juniper savannahs. Harvesting over a 20-year period would involve treatment of 178,000 acres per year, producing 600,000 BDT of juniper biomass. The delivered cost per BDT is unknown at this time. The utilization of juniper biomass in Oregon is an area that requires additional research.

Logging slash from commercial timber harvests other than fuel treatments could also contribute to the forest biomass supply. Walsh *et al.* (1999) estimated the volume harvest residues could be recovered at alternative delivered costs. The lower estimate of 1.3 million BDT was based on maximum delivered cost of $30/BDT in 1995 dollars (equivalent to $37/BDT in inflation-adjusted 2005 dollars). At $50/BDT ($62 in 2005 dollars), up to 2.5 million tons could be delivered.

In another study, CH2MHILL (2005) estimated that 1.8 million BDT of material is left in the forest after logging operations. Much of this volume is located in westside counties outside our 20-county study area. Only 19% of the state's harvest during 1990-2004 was in east-side counties (E.D. Hovee & Company, 2005). Since we have included some westside counties in the analysis, perhaps 25% of statewide logging residues – 450,000 BDT – could be considered available within the 20-county study region.

Finally, relatively small supplies of forest biomass could be recovered from the 45,000 acres of hybrid poplar plantations in Oregon. Based on an 11-year rotation, harvest residues of 24 – 51 thousand BDT could be delivered annually to energy facilities. Most of these are on the west-side.

In total, it is conceivable (though not proven economical) that these three additional sources could provide another 1 million BDT of woody biomass supply annually over at least a 20-year period. If that were the case, a 2 million BDT annual supply would look like Figure 9.

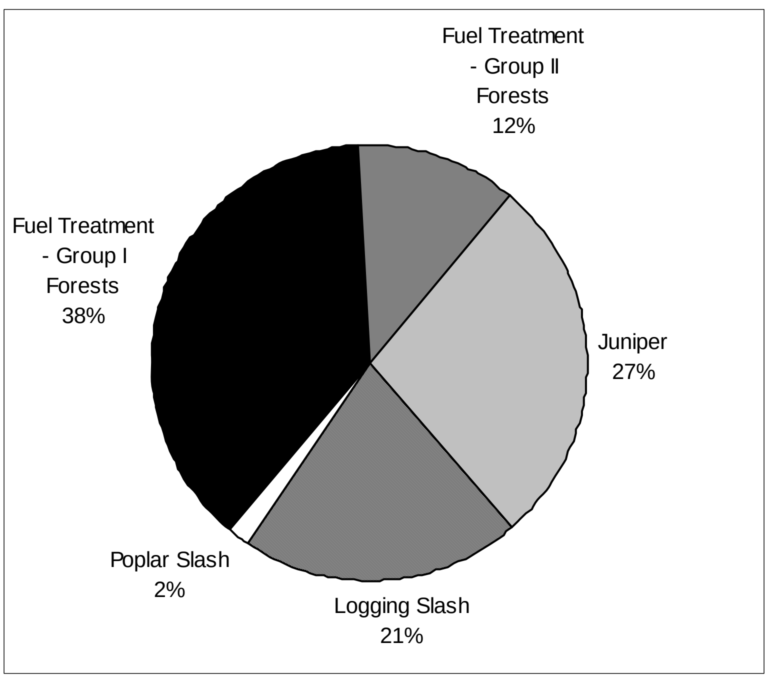

Figure 9 – Composition of a 2 million BDT annual woody biomass supply.

One additional source of woody biomass which we have not included in the analysis is the potential for an increase in production of mill residues associated with an expansion of primary wood manufacturing. Under our Base Case, approximately 410 mmbf of sawtimber would be harvested annually during fuel treatments, if spread over 20 years. This represents a 31% increase in harvest in the 20-county area compared to 2004 harvest.

If not offset by reductions in other harvesting, and if added primary processing takes place locally, regional mill residue production would increase. While some of this may go to higher value uses such as paper production, it is likely that a portion would be used on-site as fuel or be available to local energy producers (either electrical or biofuel plants). In general, up to 40% of the cubic wood volume in a log is converted to residuals. Conceivably, energy production from existing or new wood manufacturing facilities could combine use of these added residuals with biomass directly received from fuel reduction treatments. We have not included this additional mill residue volume in the analysis because we cannot predict to what extent the sawtimber harvest from fuel reduction thinnings would be offset by lower harvests elsewhere or to what extent mill capacities and residual production within the region might expand.

2.4.3.4 Comparison of Results with Other Studies

A number of studies have estimated forest biomass supply potential for Oregon. These include national studies that provide state-level details (Walsh *et al.* 1999; USDA Forest Service 2005) as well as studies developed specifically for Oregon (Graf and Koehler 2000; CH2MHILL 2005). Each of these prior studies was reviewed in Chapter 1 under, *Forest Biomass Supply*. How do the results of the current analysis compare with these previous studies?

Table 20 compares the biomass volume estimates from forest health thinnings only, from these studies with results from our analysis added. Our analysis is among the most conservative in biomass volume predicted from forest health thinnings.

Table 20 – Summary of statewide reports on biomass from forest health thinnings in Oregon.

Study	***Total Area Treated***	***Treat-ment Period***	***Biomass Volume***	Comments
	Million Acres	*Years*	*Million BDT/yr*	
Walsh *et al.* (1999)	n/a	n/a	n/a	Does not include forest health thinnings
CH2MHILL (2005)	n/a	n/a	2.5	Assumptions for thinning not provided
Graf and Koehler (2000)	7.0	50	2.9	Thin 140,000 ac/yr
	7.0	20	7.3	Thin 350,000 ac/yr
USDA Forest Serv (2005)	16.9	20	6.3	"All treatable"
	10.1	20	3.8	60% of "all treatable" acres
	12.2	20	4.2	FRCC 2 & 3 only
	7.3	20	2.5	60% of FRCC 2 & 3 only
	5.6	20	1.3	FRCC 3 only
	3.4	20	0.8	60% of FRCC 3 only
WGA Biomass Task Force (2006)	n/a	n/a	1.5**	**Volume just from forest health thinnings is unknown. Includes other sources as well
Current Analysis	4.25	20	1.1	From thinning 212,500 acres in 20 counties annually for 20 yrs.

Walsh *et al.* (1999) did not include an estimate of volume from fuel reduction treatments and so no comparison is possible. CH2MHILL (2005) estimated 2.5 million BDT/year from overgrown forests, roughly 2.5 times the volume found in our analysis. The source and analytical method used by CH2MHILL is not described in the report, so no evaluation of these results is possible either.

Graf and Koehler (2000) estimated 2.9 million BDT/year from thinning of 140,000 acres annually for 50 years. For purposes of comparison with our study, we have added the estimated volume as if treatments were made over the same 20 year time period we have assumed. The resulting annual volume of 7.3 million BDT is 663% of our estimate. The Graf and Koehler estimate was based on an assumed need to treat 7 million acres in Oregon and a yield of 21 BDT per acre. The 7 million acre treatment need is based on an ODF estimate that one quarter of the state's 28 million acres has severe health problems and is in need of thinning treatments. No supporting data is offered for this assumption but we suspect it is a statewide estimate based on high level FRCC data. Our analysis focused on dry forest types and found that about 29% of the timberland in the 20-county study region could benefit from fuel reduction treatment. We identified 4.25 million acres for treatment out of a total timberland area of 14.9 million acres.

Another significant difference between Graf and Koehler (2000) and our report is the assumed yield per acre. Graf and Koehler used an estimated removal volume based on the yield from "a normal thinning." It is not clear if this includes merchantable volume; however, the assumed biomass yield of 21 BDT/acre is similar to the *total* yields estimated in several other studies (USDA Forest Service 2005; WGA Biomass Task Force 2005). It appears that the report may have assumed that all material removed, including merchantable timber, was available for energy conversion. By comparison, the average yield per acre from our Base Case was 10.7 BDT of total biomass, including merchantable volume. Yield of net biomass suitable for energy conversion was 5.3 BDT/acre. Our yields per acre were based on removals required to bring the stand into lower fire risk conditions as defined by our modeling methodology.

The more rigorous analyses have yielded results closer to our own. Our findings are generally in line with the results from USDA Forest Service (2005) when differences in assumptions are taken into account. The Forest Service study does not postulate a time period for treatment, so we have assumed 20 years in Table 20 so the numbers can be easily compared to our results.

As a general statement, the Forest Service study was an analysis of what could, potentially, be treated and as a result provides a very broad range to demonstrate the range of results, while our analysis was more directed at what realistically, from a practical and scientific basis could and should be treated. There are many differences in methods and assumptions. The Forest Service study used an earlier version of the FTE model. Also, the Forest Service study covered all of Oregon including westside forests.

At the upper end of the supply range, the Forest Service study treated "all treatable timberland" totaling 16.9 million acres. Some of this is classified as FRCC 1 which by definition does not require mechanical fuel treatment to restore the forest to natural conditions. The study narrowed this further, however, by identifying 12.2 million acres in FRCC 2 and 3 and then assumes that only 60% is available for treatment. This resulted in 7.3 million acres needing treatment statewide. Excluding counties outside our study area would further reduce this number closer to our 4.25 million acre estimate. In addition, we excluded lands based on Torching and Crowning Index values, which is more restrictive than the Forest Service criteria.

Total volume removed per acre differ between studies, averaging 23.9 BDT/acre from FRCC 2 and 3 lands for the Forest Service study compared to 10.7 BDT/acre in our analysis. The Forest Service study only treated acreages where at least 300 ft^3 of merchantable volume could be removed, in order to make the treatment at least break-even economically. Conversely, our analysis did not include a minimum volume. This resulted in the higher average per acre removal in the Forest Service analysis.

We also assumed a different mix of even-aged and uneven-aged treatments based on an assumption about what public and private ownerships may do. The Forest Service study used uneven-age treatments exclusively. The result is a different mix of merchantable timber and net biomass. Only 29% of total removals was non-merchantable biomass while our analysis indicated that closer to 50% of volume removed was net biomass.

The Western Governor's Association analysis estimates biomass availability from forestry in Oregon at 1.5 million BDT/year; however, this includes volumes from other forest lands (e.g. juniper forests and woodlands) and unused mill residues in addition to fuel reduction thinnings (WGA Biomass Task Force 2006). The WGA analysis used the same FTE 3.0 model we did to assess supply from fuel reduction treatments using somewhat different assumptions. Unfortunately, a breakdown of supply by source is not available at the state level from the WGA study. Our combined estimate of 1.0 million BDT/year from forest restoration and 0.6 million BDT/year from juniper comes very close to the WGA estimate.

In summary, we believe our results for biomass supply from forest restoration treatments are more realistic than some of the previously reported studies and are in line with more recent, rigorous analyses. We focused on potential supply from land conditions that are most in need of fuel reduction treatment and used yields that were based on plot level tree data and simulation of silvicultural regimes specifically designed to provide improvement in fire resiliency. In some respects, the results may be conservative; in others, it may be optimistic. Returning to our original questions, the answer depends on:

- What part of the landscape will be treated?
- How will it be treated?
- Over what period of time?

2.4.4 Impacts

2.4.4.1 <u>Timber Markets</u>

Full implementation of fuel reduction treatment on 4.25 million acres over a 20-year period would result in the release of approximately 410 MMBF/year of softwood sawtimber into Oregon log markets under our Base Case assumptions. This represents only a 9% increase over Oregon's 2004 timber harvest but is a 31% increase over the 2004 harvest for the 20-county region included in the analysis.

We can only speculate on possible impacts to eastern Oregon timber markets. If the sawtimber volume from fuel treatments is incremental to the current timber harvest, there could be impacts on log markets including a reduction in stumpage prices unless mill capacity expands in concert with the increase in harvest. This is a concern of private forestland owners in the region who do not want to see stumpage prices depressed by an increase in federal harvesting.

Mill capacity may expand to meet the rising supply of sawtimber. This could create new and stronger log markets in the region. Prices could stabilize or even rise depending on the new balance of supply and demand. Mill capacity expansions would be contingent on a perception that the incremental long term supply is available, and also on end-use markets. Interior Ponderosa pine markets in particular have been gradually shrinking over the last decade in response to global competition from radiate pine as well as shrinking supplies of quality ponderosa pine sawtimber. New end-use markets for ponderosa pine, particularly for small diameter material, may be needed to absorb the additional harvest volume and avoid a collapse of stumpage prices. The same holds true for small diameter timber of other species.

Forest landowners could be disadvantaged by a long term decline in stumpage prices in addition to the already relatively weak market conditions present in eastern Oregon. On the other hand, private landowners would benefit from reduced fire risk from adjacent public lands and could benefit if log markets strengthened as a result of new regional milling capacity.

2.4.4.2 Energy Markets

As stated previously, 1 million BDT of feedstock would be capable of producing approximately 150 MW of power. By comparison, the 2004 total installed electrical generation capacity in Oregon was 5,734 MW. The additional capacity from 1 million BDT of fuel reduction thinnings would add 2 – 3% to current capacity.

A comparison with current woody biomass energy production also lends perspective to the estimated additional biomass supply. Wood fiber biomass boilers exist at 49 industrial sites in Oregon. These facilities consumed over 1.6 million BDT of biomass fuel in 2004. Ten of these sites along with two pulping liquor combustion facilities produce about 228 MW of electric power. Four of these cogeneration facilities, with a total capacity of 122 MW, sell power to the grid (see Chapter 1, *Market Conditions for Woody Biomass in Oregon*).

The expected electrical load growth in Oregon in the near term is about 100 MW per year. Given the advantages of a biomass facility in terms of being a non greenhouse gas emitting resource, having little or no expected fuel price volatility, and the likelihood of needing renewables in our resource portfolios, 150 MW of additional biomass-fueled capacity does not seem difficult to integrate into the system. Biomass fueled power plants are essentially base-load facilities, providing a steady supply of predictable power.

ODOE (2005) estimated that ethanol use in Oregon was as much as 60 million gallons in 2002. By comparison, we have estimated that one million BDT/year of woody biomass could be converted to between 61 and 66 million gallons of ethanol, more than double the most recent documented use. Currently, there are no ethanol production facilities in Oregon and all ethanol is imported from other states. By producing ethanol from woody biomass or other waste at in-state facilities, Oregon's economy would benefit instead of sending dollars outside the state.

2.4.4.3 Forest Health and Fire Resilience

One direct measure of forest health and fire resilience we can quantify from our analysis is the improvement in Crowning and Torching Index. Table 21 details the acreage distribution by CI and TI before and after treatment of 4.25 million acres under the Base Case assumptions.

Before treatment, 31% of eligible Base Case acres had a Crowning Index of less than 30 mph. After treatment, this percentage drops to 2% of eligible acres. Sixty-eight percent of acres had a Torching Index below 25 mph compared to 33% after treatment.

Table 21 – Acreage by Crowning Index and Torching Index before and after treatment under the Base Case.

	Forest Type Group I		Forest Type Group II		Total	
	Before thinning	After thinning	Before thinning	After thinning	Before thinning	After thinning
Crowning Index	*Thousand Acres*					
0 TO 10 mph	59	1	83	3	142	4
10 TO 20 mph	641	18	669	71	1,310	90
20 to 30 mph	1,070	1,096	924	1,229	1,994	2,326
30 to 40 mph	641	561	533	526	1,175	1,087
40 to 50 mph	11	717	7	374	18	1,091
50 to 60 mph	-	25	-	11	-	36
60+ mph	-	4	-	2	-	6
Torching Index	*Thousand Acres*					
0 TO 5 mph	298	150	291	85	589	234
5 TO 10 mph	204	131	202	76	406	207
10 to 15 mph	274	131	302	91	576	222
15 to 20 mph	343	225	328	112	671	337
20 to 25 mph	471	355	423	198	894	553
25 to 30 mph	212	433	195	411	407	843
30+ mph	622	1,000	474	1,243	1,096	2,243

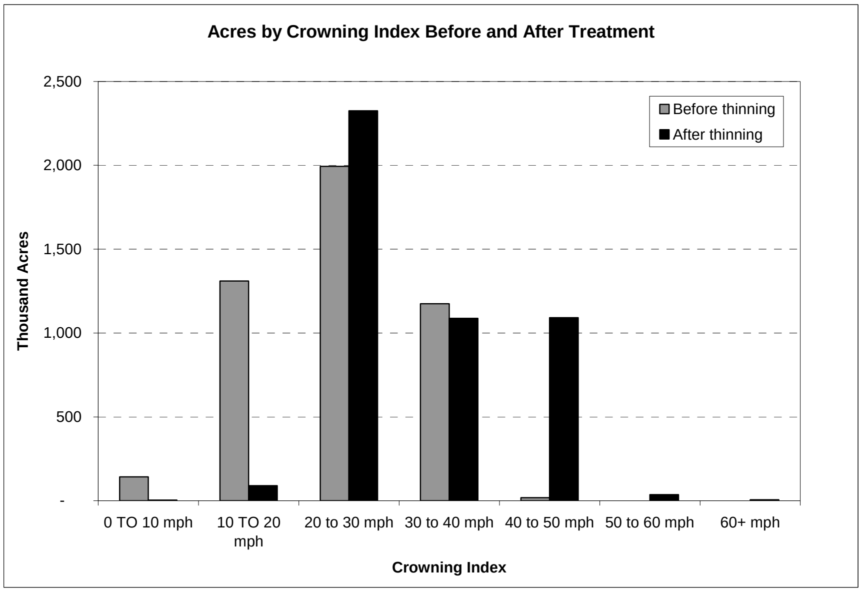

Figure 10 – Distribution of acres by Crowning Index before and after treatment under the Base Case.

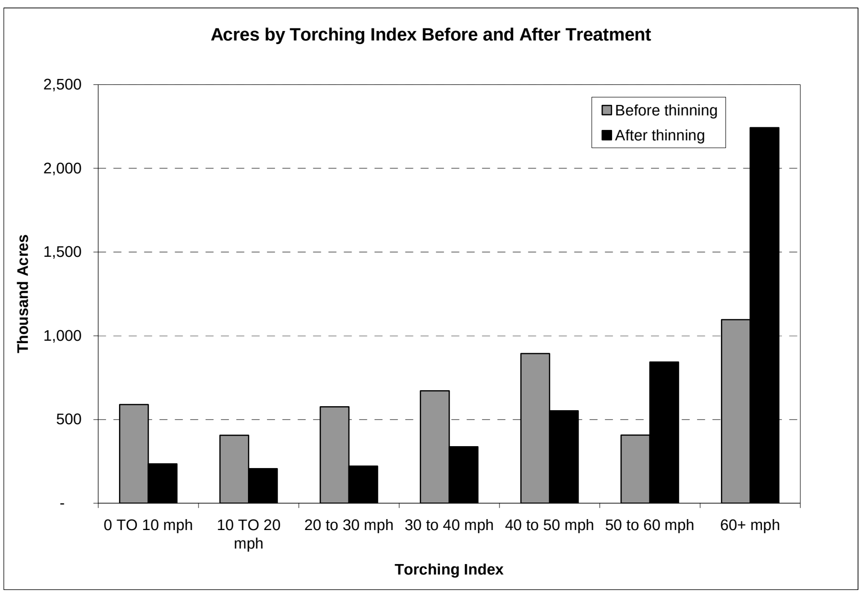

Figure 11 – Distribution of acres by Torching Index before and after treatment under the Base Case.

2.4.4.4 Other Environmental Values

The environmental impacts of forest biomass use for energy production were described in detail in the literature review (see Chapter 1, *Environmental Impacts*).

Environmental benefits from use of forest biomass for energy production arise from two directions:

- First are the benefits that accrue from reducing the risk of catastrophic wildfire and restoring overcrowded western forests to a more natural, ecologically sustainable condition.

- Second, but no less important, are the benefits of replacing non-renewable energy sources such as coal, oil and gas with cleaner, more environmentally friendly and sustainable, renewable energy.

Some benefits accrue from both. For example, air quality is impacted by reduced wildfire emissions as well as reduced emissions from energy production as biomass is substituted for fossil fuel. Other impacts are characterized in terms of short-term versus long-term risk, such as soil and wildlife impacts.

- **Air quality –** use of forest biomass results in lower emissions that either prescribed fire or wildfire, and lower emissions than fossil fuel-based energy production.

- **Greenhouse gases –** biomass power can reduce production of greenhouse gases from energy production by reducing reliance on fossil fuels. In addition, use of forest biomass from fuel treatment efforts will reduce CO_2 and other greenhouse gas emissions from wildfire by reducing catastrophic fire occurrence and intensity.

- **Soil and water conservation –** short-term risk of damage to soil and water from mechanical treatment of overstocked forests and roads necessary to gain access to them must be weighed against the long-term risk of more severe damage from uncharacteristic wildfire if these forests are not brought back into historical conditions. Reduction in MTBE use in gasoline through increased substitution of wood-based ethanol is another potential, if indirect, benefit of forest biomass use for energy. MTBE has been found to be carcinogenic in animals and is a highly persistent contaminant in water.

- **Wildlife and biodiversity –** short-term risks to wildlife habitat from fuel treatments and associated roads must be weighed against the long-term risk of landscape-scale losses of habitat to catastrophic fire and the need to restore the region's forests to more ecologically natural and diverse conditions.

A NREL study (Morris 1999) estimated the partial environmental benefits of biomass energy at 11.4¢/kWh of electricity produced, with a range of 4.7 to 24.7¢/kWh. Another analysis estimated the value from avoided forest overgrowth accumulation at 20.2¢/kWh (WGA Biomass Task Force 2006). These studies, which are reviewed in *Environmental Impacts* section of Chapter 1, suggest that the environmental benefits of forest biomass use are in excess of the market value of electricity produced.

2.4.4.5 Local and State Economies

A direct economic impact from forest biomass utilization is job creation, which would occur predominantly in rural areas of the state. It is estimated that six full time jobs are created for each MW of installed electrical generation capacity (McNeil Technologies 2003). This includes jobs at the power plant and jobs in fuel processing and delivery. Hence, our Base Case scenario of 150 MW of installed capacity would employ approximately 900 people – mostly in rural Oregon.

Plant employment and incomes vary by plant size with smaller plants generally having more employment per MW than larger plants due to economies of scale. A 25-MW power plant for example, would employ approximately 17 people with an annual payroll of $641,250 according to McNeil Technologies (2003). A 5-MW plant would employ 15.5 fulltime employees with an annual payroll of $598,050 in 2003 dollars. The McNeil Technology report also estimates fuel procurement employment of 18 people for a 5-MW plant and 54 employees for a 25-MW plant.

Levels of employment for a cellulose ethanol facility are not documented as there are no commercial plants in operation. According to one estimate, a 15-million gallon per year cellulose ethanol plant would create about 30 direct plant jobs and an additional 78 jobs in feedstock supply for a total of 108 jobs per plant (McNeil Technologies 2003). Use of 1 million BDT of woody biomass for ethanol production would support 4 such plants for a total annual capacity of at least 61 million gallons and 432 jobs. The location of the feedstock supply would likely put these jobs in rural areas.

In either case, construction-related jobs would be created during development of processing facilities. These employment estimates do not account for indirect employment – such as harvesting and trucking equipment maintenance, additional forestry-related jobs that might be created – as a result of increased forest-based activities. Indirect employment multipliers are usually in the range of 2 to 3 indirect jobs per direct job.

A number of other economic benefits could be cited. Some of these include:

- Increased local, state and federal tax revenues
- Reduced fire suppression expenditures
- Reduction in the state's premium for wildfire insurance[12]

Some of these benefits may be offset by the public burden of tax credits and other incentives programs.

2.4.4.6 Net Benefits

Mason *et al.* (2006) provide a more comprehensive estimate of benefits per acre of fuel treatment. They conclude the net positive benefit ranges from $606 per acre for moderate risk forest conditions to $1,402+ per acre for high risk acres. The breakdown of treatment benefits is provided in Table 22. Assuming these estimates apply in Oregon with 25% of the acres assigned to "high risk" and 75% to "moderate risk", the net benefit of treating 4.25 million Base Case acres would exceed $3.4 billion.

[12] Oregon is the only state which purchases insurance to cover excessive wildfire suppression expenses. (McNeil Technologies 2003).

Table 22 – Summary table of present value costs and benefits associated with investments in fuel removals for fire risk reduction, from Mason *et al.* (2006).

	Value Per Acre	
Treatment Benefits	**High Risk**	**Moderate Risk**
Avoided firefighting costs	$ 481	$ 231
Fatalities avoided	$ 10	$ 5
Facility losses avoided	$ 150	$ 72
Timber losses avoided	$ 772	$ 371
Regeneration and rehabilitation costs avoided	$ 120	$ 58
Community value of fire risk reduction	$ 63	$ 63
Regional economic benefits	$ 386	$ 386
Habitat	?	?
Smoke and Atmospheric Carbon	?	?
Energy	?	?
Water Quality & Quality	?	?
Erosion	?	?
Other Values	?	?
Total Benefits	**$ 1,982**	**$ 1,186**
Treatment Costs		
Operational Costs	$ (374)	$ (374)
Forest Service contract preparation costs	$ (206)	$ (206)
Environment impacts of fuels removals	?	?
Total Costs	**$ (580)**	**$ (580)**
Net Benefits from Fuel Removals	**$1,402+**	**$606+**

2.5 Regional Analyses

For the regional analyses, a 75-mile radius was delineated around two locations: Klamath Falls in southern Oregon and La Grande in northeastern Oregon. The landscape filters used to generate the statewide analysis were also used to select treatable forestland for each location. Since the makeup of the forests in each of these locations is different, results are discussed separately below.

Treatment assumptions generally followed those used in the statewide analysis with two exceptions. We simplified the regional analyses by eliminating use of treatment 1A which was only applied to 15% of the acreage in the statewide analysis. Treatment percentages therefore are slightly different in the regional analysis. Secondly, we applied an economic filter to eliminate land where the merchantable volume removed was less than 300 ft^3 for Treatment 2A. Thus, acres are treated with 2A only if they meet this minimum volume threshold. We used this filter as a means of highlighting the differences between treatment alternatives. In 2A, treatments were only implemented if the value of the commercial timber harvested was likely to offset thinning costs (2A). In3A and 4A, treatment costs could exceed the revenues generated under the assumption that achieving restoration goals was more important that covering treatment costs.

Removed volumes are shown by treatment; 2A and 3A treats acres in Forest Type Group I while 4A treats Forest Type Group II acres. Since one treatment is not likely to be applied across all public and private acreage, a weighted average was calculated for Forest Type Group 1 acres and is labeled as the "Blended Treatment." For public acreage, the blended treatment assumes that 50% of the total would be treated using the 2A treatment and 50% using the 3A treatment. For private acreage, the blended treatment assigns the 2A treatment to 75% of the total and 3A treatment to 25% of the total, assuming that private owners would be more likely to require revenues to exceed cost of treatment. Treatment 4A was applied to all Forest Type Group II acreage, independent of ownership.

Results are also broken down by slope classification. Ground-based harvesting methods are applicable on slopes less than 30% and less expensive than cable-based harvesting methods. Results are also shown for all slopes to depict the sensitivity of the less than 30% slope filter. Results for acres with slopes less than 30% will be referred to henceforth as "with slope filter" and acres inclusive of all slopes will be referred to as "all slopes" (AS).

2.5.1 Klamath Falls

A 75-mile radius around Klamath Falls includes both Oregon and California lands. Oregon counties include Douglas, Jackson, Josephine, Klamath, and Lake. California counties include Lassen, Modoc, Shasta, and Siskiyou.

2.5.1.1 <u>Treatable Acreage</u>

Treatable acreage was highest when employing Treatment 3A, both with and without the slope filter applied (Table 23). The blended treatment treated more acreage of Forest Type Group I than Treatment 2A alone. The difference in treatable acreage between treatments 3A and 2A was primarily the result of the minimum merchantable harvest level filter applied with the 2A treatment. Removing this minimum merchantable harvest volume qualifier for the 2A treatment would increase selected acres by 386,253 with the slope filter and by 520,788 for all slopes. Including forest land on all slopes increased treated acreage by a minimum of 42% across all Forest Type Group I treatments (3A, 2A, and Blend).

Table 23 – Treatable acreage for Klamath Falls by treatment.

	Treatment			
	3A	2A	Blend	4A
< 30%	997,365	611,112	767,576	655,942
All slopes	1,416,074	902,524	1,115,327	749,566
% increase	42%	48%	45%	14%

Most of the treatable acres for Forest Type Group II selected under treatment 4A were less than 30% slope. Including forest land on all slopes only contributed 14% more treatable acreage than when applying the slope filter. Treatable acreage selected using treatment 4A was distributed primarily in Klamath and Lake counties of Oregon, accounting for 60% of the total acreage. For this Forest Type Group, the Spruce-Fir component (type 230) accounted for 74%, the Lodgepole pine component (type 260) 25%, and the Hemlock-Sitka Spruce component (type 240) only 1% of the total treatable acres including all slopes.

2.5.1.2 Ownership

Ownership patterns proved to be similar regardless of whether the slope filter was used so the results presented here include all slopes. For simplicity, this analysis only broke down ownership into two categories: public and private. In general, ownership was just above 50% public for treatments 3A and 2A and 75% public for treatment 4A (Figure 12). This result makes sense since most private ownership does not occupy a large amount of acreage where Forest Type Group II species exist.

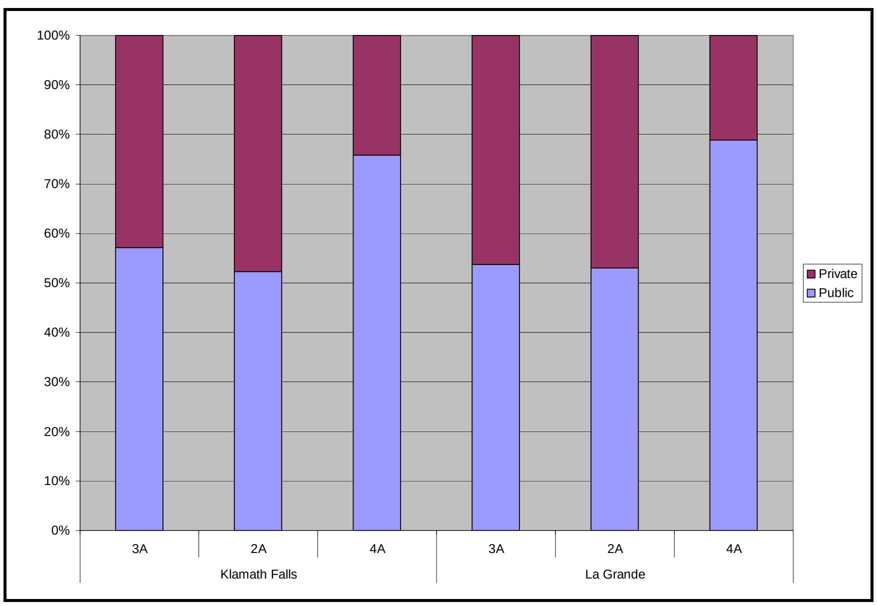

Figure 12 – Ownership percentages of treatable acreages including all slopes.

2.5.1.3 Trees per acre: Removed and Residual

In general, as a percentage of initial standing trees, treatments 3A and 4A removed more trees per acre than did Treatment 2A (Table 24). Treatments 3A and 4A removed a similar amount of trees. This makes sense since both 3A and 4A thin from below, meaning they prioritize smaller diameter trees for removal over larger diameter trees. In contrast, Treatment 2A thins more evenly across all diameter classes and satisfies the CI and TI goals by removing larger trees than 3A, thus removing fewer trees overall.

Table 24 – Removed and residual trees for Klamath Falls. Numbers are on a per acre basis across all treatable acreage.

		Trees per acre		
Slopes	Treatment	Removed	Residual	% Removed
< 30 %	3A	319	196	62%
	2A	286	260	52%
	4A	367	234	61%
All	3A	325	193	63%
	2A	279	266	51%
	4A	365	221	62%

To show removal effects by diameter groups, results were broken into three size classes: < 9" DBH, 9 – 21", and > 21". Figure 13 shows the results for removed and residual trees for the three treatments, expressed as a percent of initial stocking. Although Treatment 2A removes a smaller percent of initial trees, as shown in Table 24, it removes a larger portion of trees in the 9-21" and > 21" categories than 3A or 4A. Removals by size class were similar for treatments 3A and 4A.

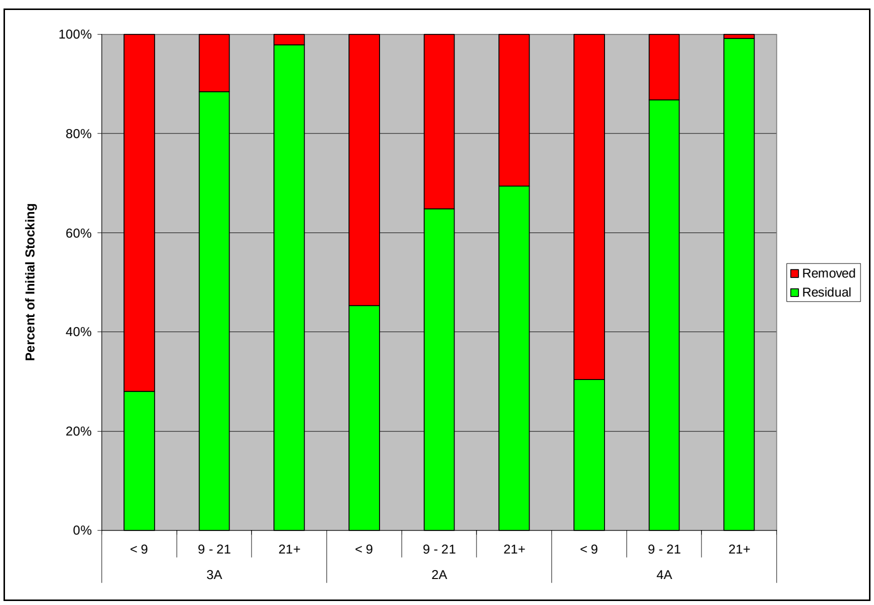

Figure 13 – Trees as a percentage of initial stocking per acre for Klamath Falls.

2.5.1.4 Crowning Index and Torching Index

An analysis of the Crowning Index and Torching Index yielded a manner to estimate the effectiveness of each individual treatment. The fire hazard reduction goal of the FTE treatments was to increase both the CI and TI to at least 25 mph or to increase the CI to 40 mph or greater for each treatment. Treatments that remove smaller trees (3A and 4A) tend to remove ladder fuels that initiate individual torching in larger trees. Treatments that remove larger trees (2A) disperse tree crowns, discouraging fire spread in the crown. Given this, 3A and 4A were expected to have a higher TI and a lower CI than Treatment 2A. Results proved similar with the slope filter applied and with all slopes included and are discussed here for all slopes. Reported values are the percentages of acres following treatment that meet the CI or TI criterion in each category.

Including all slopes, Treatment 2A was the most effective in terms of increasing CI (Figure 14), especially when examining higher index values. After treatment, 2A resulted in 62% of treated acreage with a CI greater than 30 mph and 36% of treated acreage with a CI greater than 40 mph. The difference between these values and the corresponding CIs for 3A and 4A was the direct effect of large tree removal under Treatment 2A. The removal of more, large diameter trees spaced canopy tree crowns farther apart, requiring more wind speed to initialize crown fire spread. Resultant CI and TI values were similar for treatments 3A and 4A since the stem removal strategies of these treatments were similar (the difference was that 4A only considered removing up to 25% of the initial basal area and 3A removed up to 50% if necessary to meet the CI and TI objective). Results by category and trends were similar for stands with the slope filter applied although slope and aspect can have a significant impact on the rate of fire spread.

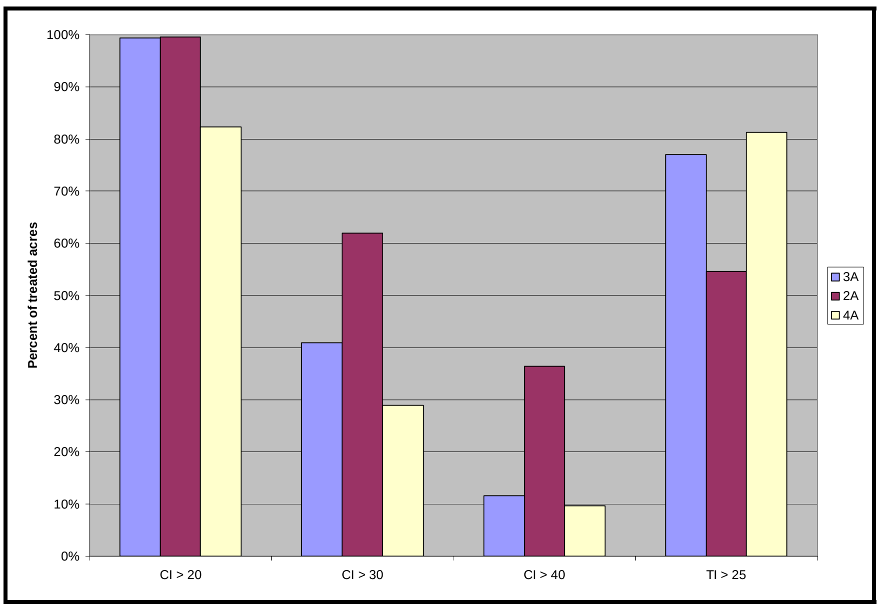

Figure 14 – Fire effectiveness indices for Klamath Falls, including all slopes.

For TI, treatment 4A was the most effective, followed by 3A and then 2A. This reversal of results compared to CI is best explained by the tree removal strategy of each treatment in which 3A and 4A remove a greater proportion of small trees than 2A. Focusing removals on small trees will aid in reduction of ladder fuels that allow surface fires to spread upwards to the crowns of canopy trees.

2.5.1.5 Volume Removed

Volume removed by treatment was broken down into two categories: merchantable timber and net biomass. Merchantable timber volume included the volume in trees larger than 7" DBH. Net biomass volume consists of all trees less than 7" DBH and the tops and limbs of larger trees.

Treatments 2A, 3A, and Blend were applied in Forest Type Group I stands and treatment 4A was applied in Forest Type Group II stands. The volumes reported in Table 25 come from both stand types. The volumes removed for the different Forest Type Groups vary because each group of species has different characteristics in terms of stand density and volume per tree. However, differences between 2A, 3A, and Blend are the result of tree removal strategy by treatment for Group I forests. The Base Case scenario is defined as the Blend treatment on Group I forests only, including all slopes. Unless otherwise stated, discussion will focus on results that include all slopes.

For the Base Case, 55% of volume removed was considered merchantable and 45% was net biomass that could be transported to a bio-energy facility. Total volume removed increased by 67% when all slopes were included. By category, including all slopes increased net biomass volume by 78% and merchantable volume by 59% over results for just slopes less than 30%. For the Base Case, total volume removed equaled 18.7 BDT/acre. By product, the average volume removed was 10.3 BDT/acre of merchantable volume and 8.4 BDT/acre of net biomass.

Table 25 – Removed tons for Klamath Falls by treatment.

		Biomass		Merchantable	
Slopes	Treatment	BDT	Percent	BDT	Percent
< 30 %	3A	4,495,366	66%	2,272,369	34%
	2A	6,992,648	43%	9,343,798	57%
	Blend	**5,284,974**	**43%**	**7,149,141**	**57%**
	4A*	2,581,157	60%	1,751,167	40%
All	3A	8,052,172	67%	4,045,286	33%
	2A	12,281,828	45%	14,841,386	55%
	Blend	**9,418,172**	**45%**	**11,428,718**	**55%**
	4A*	2,917,407	59%	2,034,255	41%

* 4A treatment volume is from Forest Type Group II only.

Since 3A focused removals on smaller trees, the percentage of net biomass was higher than for 2A, 67% for 3A and 45% for 2A. However, removal percentages by category were similar for the Blend treatment and the 2A treatment.

The volume resulting from treatment 4A came from treating Forest Type Group II stands. In general, this treatment removed a larger percentage of biomass than merchantable volume. Net biomass accounted for 59% of the total volume removed while merchantable volume was 41% of the total. Treating all slopes only resulted in 14% more volume than when treating only gentler slopes. This indicates that most of the volume from Forest Type Group II stands was on slopes less than 30%. On this terrain, ground-based harvesting methods are applicable. However, the average volume removed per acre for 4A was relatively low, which may limit harvesting opportunities. Total volume removed only equaled 6.6 BDT/acre (3.9 BDT/acre of net biomass and 2.7 BDT/acre of merchantable timber).

Figure 15 shows the distribution of total volume removed by EMAP hexagon for the Base Case. These volumes are the result of treating Forest Type Group I only and include both net biomass and merchantable timber for each hexagon. The largest share of volume occurs to the west of Klamath Falls. Volume coming from California had a significant impact on the results at Klamath Falls. By counties, Jackson County, Oregon and Siskiyou County, California contributed the most total volume.

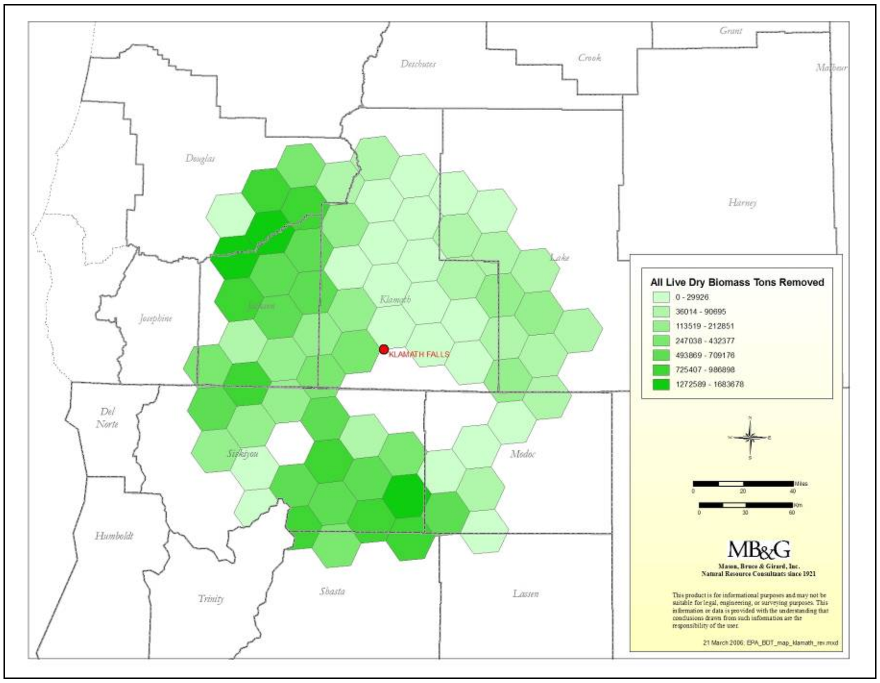

Figure 15 – Total volume removed (in BDT) for Klamath Falls Base Case Blend treatment by EMAP hexagon, assuming a 75 air mile supply radius.

2.5.1.6 Harvesting costs

Production costs include harvesting costs (delivered to the roadside) and transportation costs. The harvesting costs reported by FTE are the integrated costs of harvesting the merchantable and the biomass volume simultaneously (see Section 2.3.1.5). Harvesting large diameter trees is more cost effective than harvesting small diameter trees. As a result, large stem removal subsidizes the removal of more costly, smaller trees. Thus, the harvesting costs to roadside reported here underestimate the removal costs of the biomass portion alone.

Figure 16 shows the integrated harvesting costs for volume resulting from the Blend treatment. Costs are categorized over a range of harvesting costs as provided by FTE. "Ground" volume is limited to stands with slopes less than 30% where ground-based harvesting methods are applicable. In steeper terrain, more expensive cable harvesting systems are generally employed. The volume labeled, "cable" is the volume from stands with slopes greater than 30%.

Ninety percent of total volume removed under the Blend treatment, including ground and cable, cost less than $60.00/BDT to remove to the roadside (Figure 16). By harvest type, 86% of volume on slopes less than 30% cost less than $40.00/BDT and 85% of volume from cable-based volume cost less than $80.00/BDT.

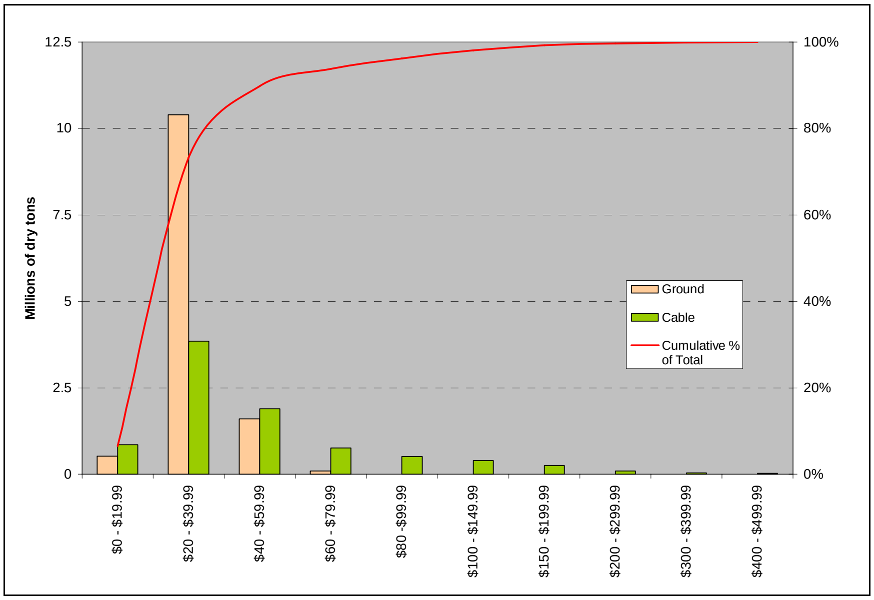

Figure 16 – Integrated harvesting costs for Blend treatment at Klamath Falls. Ground based harvesting was limited to slopes < 30%.

2.5.1.7 Net biomass supply curve

Figure 17 depicts a supply curve including harvesting costs to the roadside and transportation costs to Klamath Falls for the biomass portion of total volume removed via the Blend treatment of Group I forests (the Base Case). Transportation costs were calculated in a similar manner to the statewide analysis, using the straight line distance from the center of each EMAP hexagon to the center of town and applying a circuity factor of 1.5 to determine road miles traveled. This distance was multiplied by $0.40/BDT to establish a transportation cost that was distributed to the volume in each EMAP hexagon.

For all biomass volume included in the supply curve, the average delivered cost was $76/BDT. The average road mileage haul distance for all biomass volume to Klamath Falls was 91 miles, resulting in a cost of $36/BDT for transport alone. Point C on the curve may represent a maximum practical volume. This point represents volume up to a marginal delivered cost of $120/BDT. Beyond this point, the curve slopes sharply upward, indicating little additional volume is available even at much higher costs. Point C indicates a total availability of 9.0 million BDT (95% of total volume) at an average delivered cost to Klamath Falls of $71/BDT.

A total delivered cost of $45/BDT and a maximum haul distance of 75 miles are often cited as threshold values for profitability when considering the economics of biomass conversion. The cost curve analysis for Klamath Falls makes it clear that very little volume can be delivered at a cost of less than $45/BDT.

The supply curve shows the impact of including stands in which cable harvesting must be employed; notice the increase in costs above $100/BDT. Cable systems are more costly to operate than ground-based harvesting systems and this difference is magnified when harvesting small diameter trees.

The Base Case includes treatment of Group I forests only. An additional volume of up to 2.9 million BDT of net biomass could be supplied from treatment of Group II forests within the 75-mile radius.

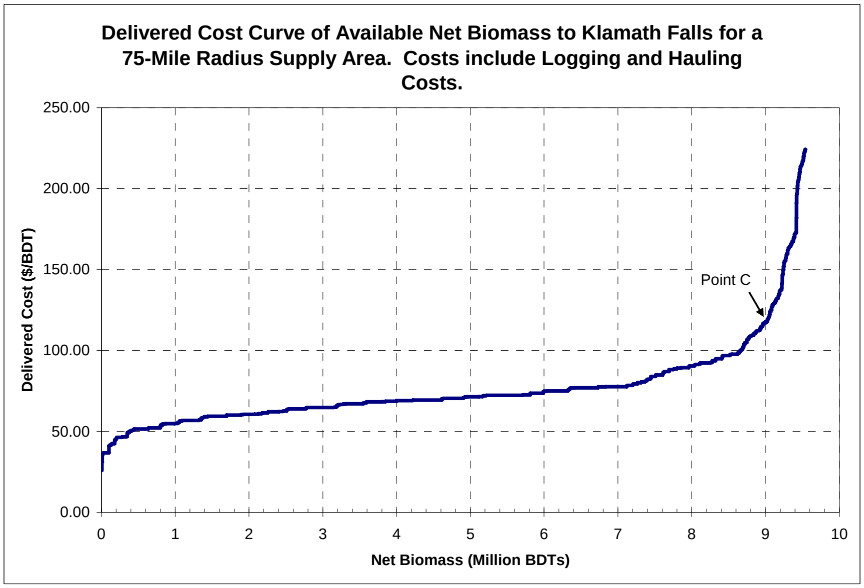

Figure 17 – Supply curve for delivered net biomass to Klamath Falls, Base Case.

2.5.2 La Grande

Results for La Grande include both Oregon and Washington data. Although some acreage in Idaho falls within 75 air miles of La Grande, it was excluded from analysis due to lack of transportation routes across the Snake River in this area. Oregon counties include Baker, Grant, Malheur, Morrow, Umatilla, Union, and Wallowa. Washington counties include Asotin, Columbia, Garfield, and Walla Walla.

2.5.2.1 Treatable Acreage

Among Forest Type Group I, acreage treated was highest under Treatment 3A, both with and without the slope filter applied (Table 26). The blended treatment treated more acreage than Treatment 2A alone. As was true for Klamath Falls, the difference in treatable acreage between treatments 3A and 2A was primarily the result of the minimum merchantable harvest level filter applied with the 2A treatment. Removing this minimum harvest volume filter for the 2A treatment would increase selected acres by 156,021 with the slope filter and by 240,836 for all slopes; the difference between treatable acres for 3A and 2A. If Treatment 3A were subjected to the same merchantable filter, treatable acreage would decrease accordingly.

Including forest land on all slopes had more impact at La Grande than Klamath Falls due to the relative difference among stand conditions for each location, particularly the steeper terrain for forests surrounding La Grande. At a minimum, treated acreage increased by 60% across all Forest Type Group I treatments (3A, 2A, and Blend) when all slopes were included.

Table 26 – Treatable acreage for La Grande by treatment.

	Treatment			
	3A	2A	Blend	4A
< 30%	273,859	117,838	175,596	446,363
All slopes	439,431	198,595	291,556	618,982
% increase	60%	69%	66%	39%

Most of the treatable acres for Forest Type Group II selected under treatment 4A were less than 30% slope. However, including all slopes had a more pronounced effect on treatable acreage at La Grande than Klamath Falls, contributing 39% more treatable acreage than when applying the slope filter. Treatable acreage selected using treatment 4A was distributed relatively evenly across all counties. Grant County in Oregon had the largest area of Forest Type Group II acreage, accounting for 30% of the total. For this Forest Type Group, the Spruce-Fir component (type 230) accounted for 74%, the Lodgepole pine component (type 260) 20%, and the Hemlock-Sitka Spruce component (type 240) only 6% of the total treatable acres including all slopes.

2.5.2.2 Ownership

The results for ownership include all slopes and were similar when applying the slope filter. Ownership was broken into two categories: public and private. In general, ownership of Forest Type Group II was similar between treatments 3A and 2A at 53% public and 47% private (Figure 12). Ownership patterns were different for Forest Type Group II and treatment 4A where 79% of treated acreage was publicly owned. Interestingly, breakdown of ownership percentages by treatment was similar for treatable acreage around both La Grande and Klamath Falls.

2.5.2.3 Trees per acre: Removed and Residual

For Forest Type Group I stands, Treatment 3A removed more trees per acre than did Treatment 2A (Table 27). On a percentage basis, treatments 3A and 4A removed a similar amount of trees, at least 57% of initial trees in all cases, although initial stocking was much higher for Forest Type Group II sites. However, since both treatments prioritize smaller diameter trees for removal to achieve the same CI and TI goal, a similar removal percentage of understory trees was necessary.

Table 27 – Removed and residual trees for La Grande. Numbers are on a per acre basis across all treatable acreage.

		Trees per acre		
Slopes	Treatment	Removed	Residual	% Removed
< 30 %	3A	248	178	58%
	2A	230	264	47%
	4A	316	229	58%
All	3A	216	161	57%
	2A	203	233	47%
	4A	298	208	59%

To show stem removal effects by size categories, results were broken into three classes: < 9" DBH, 9 – 21", and > 21". Figure 18 shows the results for removed and residual trees for the three treatments, expressed as a percent of initial stocking. Although Treatment 2A removes a smaller percent of initial trees, as shown in Table 27, it removes a larger portion of trees in the 9-21" and the > 21" categories that 3A or 4A. Neither the 3A nor the 4A treatment removed any stem larger than 21" and less than 10% of trees greater than 9" DBH. As expected, removals by size class were similar for treatments 3A and 4A.

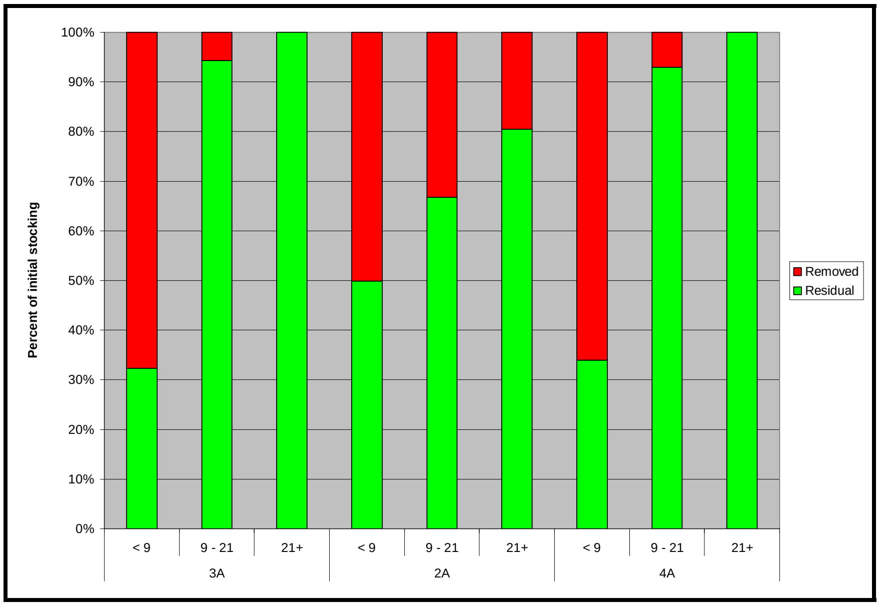

Figure 18 – Trees as a percentage of initial stocking per acre at La Grande.

2.5.2.4 Crowning Index and Torching Index

Including all slopes, Treatment 2A was slightly more effective treatment in terms of increasing CI (Figure 19). For CI > 20 mph, the effectiveness of all treatments was similar. The difference among treatments is more obvious as CI increases although this effect was dampened at La Grande. After treatment, 2A resulted in 52% of treated acreage with a CI greater than 30 mph and 28% of treated acreage with a CI greater than 40 mph. The difference between these values and the corresponding CIs for 3A and 4A was the direct effect of large tree removal under Treatment 2A. However, the removal of large trees did not have as large a positive effect on CI at La Grande probably due to the increase in average slope for treated acres. Increased slope would require the crowns of trees to be dispersed in order to combat the increased rate of fire spread on steep terrain. Resultant CI and TI values were similar for treatments 3A and 4A since the stem removal strategies of these treatments were similar. Results by category and trends were similar for stands with the slope filter applied.

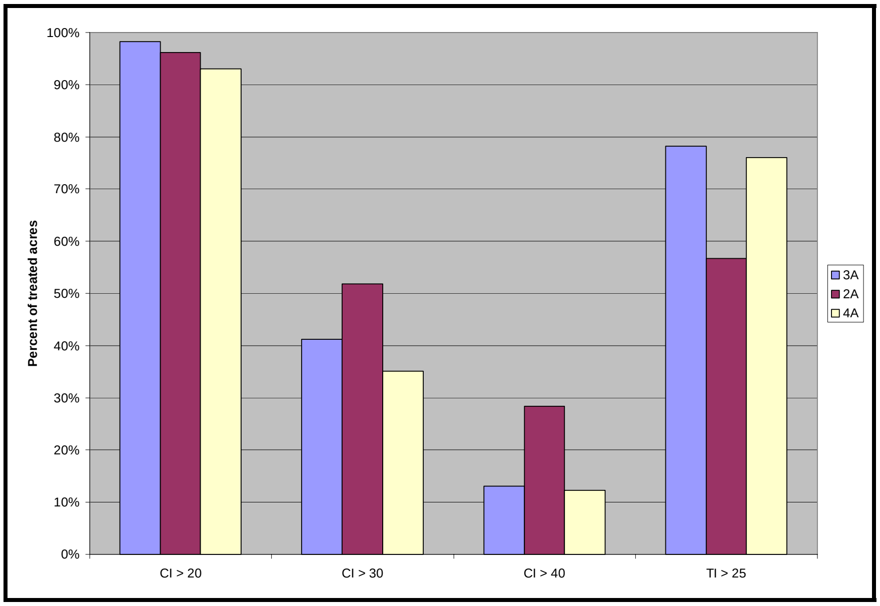

Figure 19 – Fire effectiveness indices for La Grande, including all slopes.

For TI, Treatment 3A was the most effective, followed by 4A and 2A. This reversal of trend from CI was best explained by the stem removal strategy of each treatment in which 3A and 4A remove a greater proportion of small trees that reduce ladder fuels.

2.5.2.5 Volume Removed

Removals by treatment and slope class are shown in Table 28. Similar definitions were used to categorize volume removed at La Grande as those used at Klamath Falls: merchantable volume and net biomass. The Base Case includes blended treatment of Group I forests only. For the Base Case, 62% of removed volume was merchantable and 38% was net biomass. Total volume removed was 67% more when including all slopes than when applying the slope filter. By category, 78% more biomass and 59% more merchantable volume resulted from including all slopes over the slope filter. Total volume removed averaged 8.8 BDT/acre (5.1 BDT/acre of merchantable volume and 3.7 BDT/acre of biomass) under the Base Case.

Seventy percent of removals under Treatment 3A were net biomass compared to just 39% for Treatment 2A, when including all slopes. This trend was expected since 3A focused removals on smaller trees. Removal percentages by product category were similar for the Blend and 2A treatments.

Treatment 4A volume came from treating stands of Forest Type Group II. In general, this treatment removed a larger percentage of biomass than merchantable volume; biomass accounted for 59% of total removed volume. In contrast to Klamath Falls, including all slopes for treatment significantly increased the removed volume for the 4A treatment; overall, volume removed increased by 44%. Volume increases by product category indicate that a significant amount of merchantable volume was available on steeper slopes in Forest Type Group II stands, increasing by 75% when including all slopes over utilizing the slope filter. By contrast, net biomass volume increased 32%. Harvesting costs on steeper ground are generally higher, especially for small diameter trees, but removals of larger trees could help subsidize overall harvesting costs. However, the average removed volume per acre for treatment 4A was relatively low, equaling 3.7 BDT/acre (2.4 BDT/acre of biomass and 1.3 BDT/acre of merchantable volume), including all slopes.

Table 28 – Removed tons for La Grande by treatment.

		Biomass		Merchantable	
Slopes	Treatment	BDT	Percent	BDT	Percent
< 30 %	3A	1,079,226	75%	367,611	25%
	2A	893,643	43%	1,163,116	57%
	Blend	**751,982**	**42%**	**1,021,743**	**58%**
	4A*	1,140,252	71%	460,115	29%
All	3A	1,366,743	70%	573,185	30%
	2A	1,204,963	39%	1,905,530	61%
	Blend	**965,661**	**38%**	**1,596,387**	**62%**
	4A*	1,504,849	65%	805,336	35%

* 4A treatment volume is from Forest Type Group II only.

Figure 20 shows the distribution of total volume removed by EMAP hexagon for the Base Case. These volumes are the result of treating Forest Type Group I only and include both net biomass and merchantable volume for each hexagon. The majority of the volume occurs to the northeast of La Grande. Volume coming from Washington had very little effect on the results.

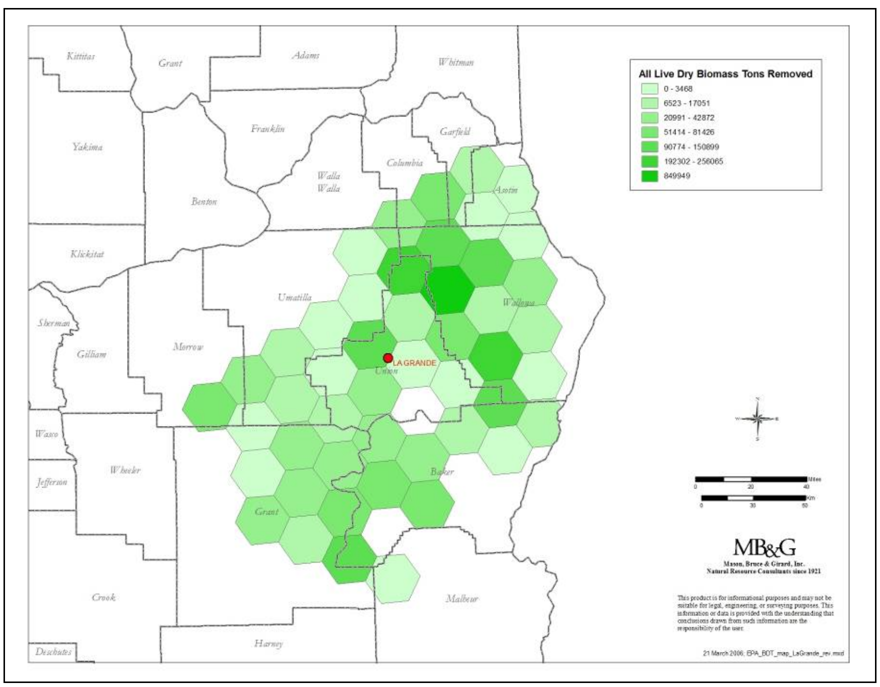

Figure 20 – Total biomass removed (in BDT) for La Grande Base Case Blend treatment by EMAP hexagon, assuming a 75 air mile supply radius.

2.5.2.6 Harvesting costs

Figure 21 shows the integrated harvesting costs to the roadside (not including transportation costs) for the Blend treatment volume. Volume categorized as 'Ground' was limited to stands with slopes less than 30% where ground-based harvesting methods are applicable; volume labeled 'Cable' is the result from stands with slopes greater than 30%.

Eighty-eight (88%) of total volume removed for the Base Case cost less than $100/BDT to remove to the roadside (Figure 21). By harvest type, 91% of volume where ground-based harvesting is applicable cost less than $60/BDT whereas only 21% of cable-based volume can be harvested for this same amount.

In general, harvesting costs to the roadside were more for La Grande than Klamath Falls. Since most harvesting cost variables were kept constant at both sites, it reasons that the increased costs are a direct result of increased slope percentages for treated acres (an input from FTE). It is hypothesized that average slope of harvested units, both ground and cable, would be greater at La Grande.

2.5.2.7 Net biomass supply curve

Figure 22 depicts a supply curve showing delivered cost, including harvesting costs to the roadside and transportation costs, to La Grande for the biomass volume removed in the Base Case (blended treatment of Group I forests only). The same methodology was used to generate the curve as was used for Klamath Falls above, using the same values for circuity factor (1.5) and transportation cost per mile ($0.40/ton/mile). The biomass portion was assumed to be similar across EMAP hexagons using the overall percentage for the Base Case, 38% (Table 28).

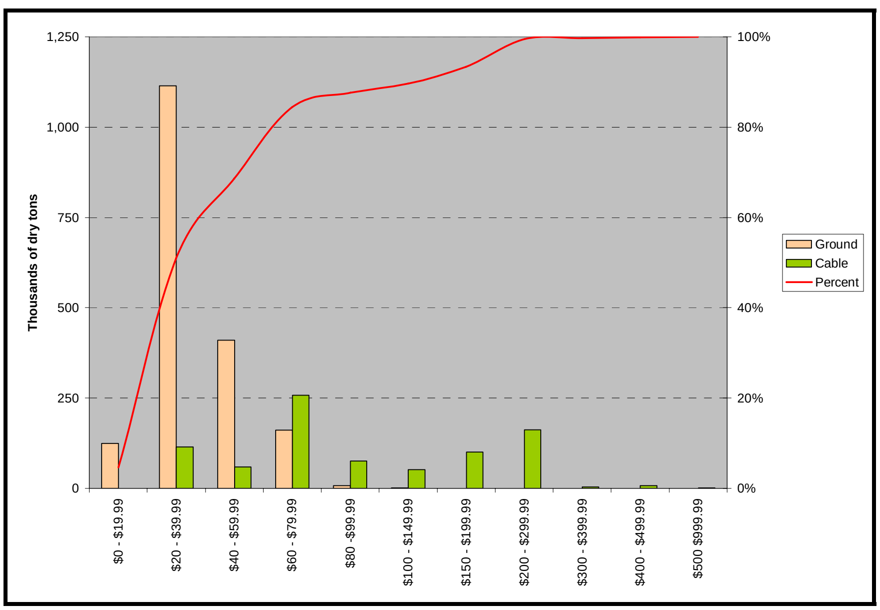

Figure 21 – Integrated harvesting costs for La Grande Base Case. Ground-based harvesting was limited to slopes < 30%.

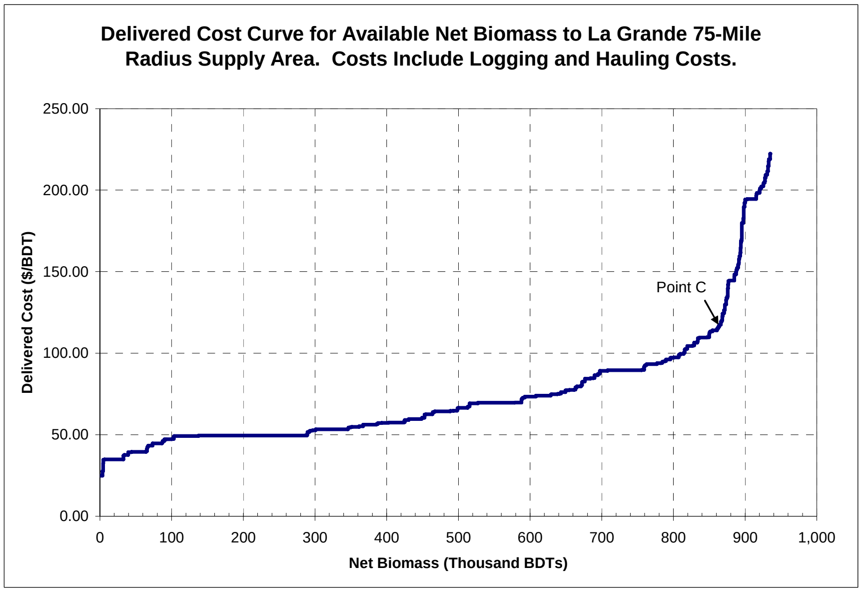

Figure 22 – Supply curve for delivered net biomass to La Grande, Base Case.

For all biomass volume included in the supply curve, the average delivered cost was $73/BDT. The average road mileage haul distance for biomass volume to La Grande was 59.2 miles, costing $24/BDT. A practical maximum volume might be represented by Point C on the curve, which indicates that 868,000 BDT (93% of total volume) could be delivered to La Grande at a marginal cost of less than $120/BDT and an average cost of $65/BDT. This is a total, non-annualized biomass volume. As for Klamath Falls, the results show that very little volume could be delivered for less than $45/BDT.

The La Grande supply curve shows the impact of including stands in which cable harvesting must be employed; notice the increase in costs above $125/BDT. Cable systems are more costly to operate than ground-based harvesting systems and this difference is magnified when harvesting small diameter trees.

2.5.3 Summary Statements

Comparisons between Klamath Falls and La Grande reveal differences that are related to the differences in forest types and stand conditions for the two areas. Table 29 provides summary of the key volume and cost figures for the two regions.

Table 29 – Volumes and costs for the Base Case treatments at Klamath Falls and La Grande. Volumes are reported in BDT and costs are reported as $/

	Klamath Falls	La Grande
Acres Treated (Group I forests only)	1,115,327	291,556
Total Volume		
Total Volume Removed	20,846,890	2,562,048
Total Volume Removed per Acre	18.7	8.8
Biomass Volume Removed	9,418,172	965,661
Percent Biomass	45%	38%
Delivered Cost of Biomass Volume*	$75.98	$73.23
Transportation Distance (road miles)	90.7	59.2
Transportation Costs	$36.28	$23.68
Integrated Harvesting Costs to Roadside*	$39.70	$49.55

* Using integrated harvesting costs. Integrated harvesting costs include costs to harvest merchantable volume and should underestimate the harvest costs for the biomass portion only.

Table 29 includes only volume from Group I forests. Additional volumes would be available from treatment of Group II forests (e.g. lodgepole pine) which typically experience high intensity fires under natural conditions. Because historical fire regimes for these types are typically stand replacement fires, the ecological rationale for fuel treatment in these types is more controversial. However, were they to be treated, the could provide up to an additional 2.9 million BDT to Klamath Falls and 1.5 million BDT to La Grande at costs that would be similar to those shown in the table above.

A few general trends regarding removed volume and costs can be taken from the data:

- Applying the minimum merchantable volume filter significantly reduced treatable acreage – compare treatments 2A and 3A for each site.
- The geographic distribution of biomass volume was closer to La Grande than Klamath Falls, resulting in lower transportation costs - compare Figure 15 and Figure 20.
- Integrated harvesting costs to the roadside were higher for La Grande than Klamath Falls. This difference was primarily driven by two factors: increased slopes for treated acreage and decreased volume per acre at La Grande.

Literature Cited

Agee, J.K. 2002. Fire ecology of Pacific Northwest forests. P. 19-27 in Fire in Oregon's forests: risks, effects, and treatment options, Fitzgerald, S.A. (ed.) Oregon Forest Resources Institute, Portland, OR.

American Forest & Paper Association. 2005. Final report: Biomass study. Washington, DC. December 6.

Azuma, D.L., B.A. Hiserote, and P.A. Dunham. 2005. The western juniper resource of eastern Oregon. USDA For. Serv. Resour. Bull. PNW-RB-249.

Briggs, D. 1994. Forest products measurements and conversion factors: with special emphasis on the U.S. Pacific Northwest. Institute of Forest Resources Contribution No. 75. College of Forest Resources, University of Washington, Seattle, WA.

CH2MHILL. 2005. Phase II Biopower market assessment: sizing and characterizing the market for Oregon Biopower projects. Prepared for EnergyTrust of Oregon, Inc.

E.D. Hovee & Company, LLC. 2005. Baseline forest growth and mortality assessment. Prepared for the Oregon Forest Resources Institute. November, 2005.

Fight, R.D., B.R. Hartsough, P. Noordijk. 2006. Users guide for FRCS: Fuel reduction cost simulator software. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-668.

Filip, G.M. 2002. Wildfire and forest health. P. 28-34 in Fire in Oregon's forests: risks, effects, and treatment options, Fitzgerald, S.A. (ed.) Oregon Forest Resources Institute, Portland, OR.

Fitzgerald, S.A. 2002. Wildfire and Oregon's forests. P. 13-16 in Fire in Oregon's forests: risks, effects, and treatment options, Fitzgerald, S.A. (ed.) Oregon Forest Resources Institute, Portland, OR.

Graf, A., and T. Koehler. 2000. Oregon cellulose-ethanol study: an evaluation of the potential for ethanol production in Oregon using cellulose-based feedstocks. Prepared for Oregon Office of Energy. Available at: http://www.oregon.gov/ENERGY/RENEW/Biomass/study.shtml

Ince, P. 1979. How to estimate recoverable heat energy in wood or bark fuels. USDA For. Serv. Gen. Tech. Rept. FPL 29.

Mason, L.C., B.R. Lippke, K.W. Zobrist, T.D. Bloxton, K.R. Ceder, J.M. Comnick, J.B. McCarter, and H.K. Rogers. 2006. Investment in fuel removals to avoid forest fires result in substantial benefits. J. For. 104(1):27-31.

McNeil Technologies, Inc. 2003. Biomass resource assessment and utilization options for three counties in eastern Oregon. Prepared for Oregon Department of Energy. Available at: http://oregon.gov/ENERGY/RENEW/Biomass/assessment.shtml

Miles, P.D. 2005. Fuel Treatment Evaluator web-application version 3.0. USDA Forest Service, North Central Research Station. Available at: http://www.ncrs2.fs.fed.us/4801/fiadb/FTE_Version3/Webclass1.asp.

Oregon Dept. of Energy. 2005. State of Oregon energy plan, 2005-2007. Available at: http://www.oregon.gov/ENERGY/docs/EnergyPlan05.pdf

Perlack, R.D., L.T. Wright, A.F. Turhollow, R.L. Graham, B.J. Stokes, and D.C. Erbach. 2005. Biomass as feedstock for a bioenergy and Bioproducts industry: the technical feasibility of a billion ton annual supply. Oak Ridge National Lab., Oak Ridge, TN.

Rothermel, R.C. 1991. Predicting fire behavior and size of crown fires in the Northern Rocky Mountains. USDA For. Serv. Res. Pap. INT-438.

Sampson, N., M. Smith, and N. Gann. 2001. Western forest health and biomass energy potential: A report to the Oregon Office of Energy. Oregon Office of Energy. Available at: http://oregon.gov/ENERGY/RENEW/Biomass/forest.shtml

Scott, J.H., E.D. Reinhardt. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. USDA For. Serv. Res. Pap. RMRS-RP-29.

Skog, K.E., R.J. Barbour, K.L. Abt, E.M. (Ted) Bilek, F. Burch, R.D. Fight, R.J. Hugget, P.D. Miles, E.D. Reinhardt, and W.D. Shepard. 2006. Evaluation of silvicultural treatments and biomass use for reducing fire hazard in the western states. USDA For. Serv. Res. Pap. FPL-RP-634.

USDA Forest Service. 2005. A strategic assessment of forest biomass and fuel reduction treatments in Western States. USDA For. Serv. Gen. Tech. Rep. RMRS-GTR-149.

USDA, USDI. 2002. A collaborative approach for reducing wildland fire risks to communities and the environment, 10-year comprehensive strategy. USDA Forest Service, US Department of Interior, Washington DC.

Walsh, M.E., R.L. Perlack, A.T. Turhollow, D. de la Torre Ugarte, D.A. Becker, R.L. Graham, S.E. Slinsky, and D.E. Ray. 1999. Biomass feedstock availability in the United States: 1999 state level analysis. Oak Ridge National Lab., Oak Ridge, TN. (Updated January, 2000). Available at: http://bioenergy.ornl.gov/resourcedata/index.html.

WGA Biomass Task Force. 2006. Biomass Task Force Report. Report prepared for the Western Governor's Association. January, 2006. Available at: http://www.westgov.org/wga/initiatives/cdeac/index.htm.

Chapter 3
Current Efforts to Promote Forest Biomass Use for Energy

3.1 Introduction

There are many efforts underway relating to biomass energy at all levels of government and in the private sector. These include, but are not limited to, state and federal incentives programs and policy initiatives, research programs, as well as non-governmental organization and industry-sponsored development efforts.

The purpose of this chapter is to document these efforts, assess their effectiveness and applicability to forest-based biomass energy and biofuels, and identify existing gaps and opportunities to increase focused effort on forest biomass use alternatives that will likely result in direct biomass energy use, liquid fuels and biomass-derived chemical manufacturing in Oregon. We also summarize forest biomass energy development projects underway in Oregon and review incentives available in other states. This information will be used to help identify opportunities that impact all areas of biomass development, and identify criteria for prioritizing action.

A developer interested in identifying technologies and funding opportunities for a biomass project can find significant information on the internet. The trouble can often be too much information. Many of the funding agencies outlined in this report maintain files on current and former grant recipients. There is non-proprietary information on specific projects available from these agencies. In addition, funding recipients are often willing to share their experiences of developing a new project.

3.2 State Efforts

Within Oregon state government, there are several efforts underway promoting renewable energy in general as well as forest biomass utilization specifically. Many of these efforts have been initiated only within the last one or two years. Although many of these activities are related, we have organized them under the following framework for discussion purposes:

- Policy and legislation
- Working Groups and Initiatives
- Agency Activities
- Incentives
- Research and Development

3.2.1 Policy and Legislation

Recent state policy direction in regards to renewable energy and forest biomass come from the Renewable Energy Action Plan, the Oregon Business Plan and Senate Bill 1072.

3.2.1.1 <u>Renewable Energy Action Plan</u>

In April, 2005, after public review and comment, Governor Kulongoski issued the Oregon Renewable Energy Action Plan with an ambitious goal of placing Oregon at the forefront of the cause for clean energy. The plan adopts several goals related to renewable energy development to meet the overall goal of ensuring that renewable resources meet 25% of Oregon's energy needs by 2025.

Key components of the plan include:

- **<u>Renewable Portfolio Standard</u>** – the ODOE Renewable Energy Working Group has been charged with developing a renewable portfolio standard which the Governor will propose to the legislature in 2007.

- **<u>Biofuels</u>** – legislation will be developed to create policies and incentives which promote production of biofuels, particularly biodiesel and ethanol, in Oregon.

- **<u>Conservation</u>** – promotion of innovative technologies to maximize savings to consumers and create economic opportunities in this new industry.

- **<u>Tax credits to support new investment in renewable energy</u>** – the Governor will work to promote new state tax incentives to encourage development of renewable energy projects and ensure development is cost competitive. He will also promote long-term extension of the federal production tax credit for renewable energy.

Governor Kulongoski also proposed a legislative fix for provisions in statute that create a conflict between Oregon's Business Energy Tax Credit and the federal Production Tax Credit. If successful, this would result in a net increase in tax incentives for renewable energy projects in Oregon. However, a recent IRS ruling has clarified the issue and as a result, legislation is not needed. The Oregon Dept. of Energy in 2004 petitioned the IRS for published guidance that the production credit under section 45 of the Internal Revenue Code would not be reduced for a wind-powered or other type of electric generation facility, which also receives the State's Business Energy Tax Credit. The IRS ruled recently that the Section 45 production credit's reduction applies only to other federal business credits and not to state credits.

The plan also identifies biomass from fuel reduction efforts in Oregon's forests as a source of feedstock for electricity generation and ethanol production. The plan lays out investments in forest and other biomass conversion to energy that will lead to multiple environmental, economic, and social benefits. These include:

- Reduced wildfire risks to communities and wildfire suppression costs to taxpayers,

- Increased timber supplies,

- Improved forest health, water quality, wildlife habitat, and recreation areas,

- Reduced air pollution from wildfire and prescribed forest burning smoke,

- Extended landfill life with recovery of biomass,

- Reduced and avoided carbon dioxide emissions, and

- Maintenance of family-wage jobs and a forest industry infrastructure in rural Oregon.

The plan lays out a number of actions by state agencies to encourage the development of biomass to energy projects in Oregon (see following section). For more information, the entire plan can be found at: http://egov.oregon.gov/ENERGY/RENEW/docs/FinalREAP.pdf

3.2.1.2 Governor's Mandate for State Government

Governor Ted Kulongoski announced on March 10, 2006 that he has raised the bar in pursuit of using new renewable energy in Oregon, and that he has set a higher goal for electricity use by state government. By 2010, the Governor wants new renewable electricity to account for 100% of state government's electrical needs.

To achieve his goal the Governor directed his staff, the Department of Administrative Services and Department of Energy to deliver a roadmap by July 2006 that includes the exploration of the following options:

- Developing one or more state renewable energy facilities – or partnering with a private developer to purchase the output of renewable energy.
- Participating in utility-renewable-energy purchase programs.
- Expanding the use of cost-effective solar energy in state buildings.
- Passing legislation that authorizes state agencies to develop renewable energy on state forests, state lands, state campuses and other state property.

Oregon state government is on track to meeting the target of reducing energy consumption by 20% by 2010 (based on energy consumption in 2000) and meeting 25% of state government's total electricity consumption from renewable energy sources by 2010. The plan calls for 100% by 2025, but the Governor's wants to accelerate that timeline to 2010. The state is also making progress on meeting the Governor's target of increasing the use of biodiesel in state cars by 25% and ethanol by 10% by 2010. Over the past three years, the state has purchased or scheduled the purchase of more than 230 hybrids and more than 400 vehicles that run on ethanol, providing environmental benefits and thousands of dollars in savings to the state. That is the highest per capita rate of any state in the country.

3.2.1.3 Oregon Business Plan

Since it was launched in 2002, the Oregon Business Plan has provided the strategic framework for Oregon's business and elected leaders, working together, to build a stronger, more competitive state economy. The Oregon Business Plan envisions the growth and success of leading-edge, traded sector industries – clusters of allied businesses that ring up sales outside Oregon and create well paying jobs that buoy local communities.

Nine initiatives were established by the Business Plan, one of which deals specifically with Oregon's forests. The goal of the 2005 OBP forestry initiative, "Enhance Oregon's Forest Resource Benefits," is to build economic strategies based on Oregon's strong environmental performance, resulting in market advantages for Oregon wood products, landowner rewards for environmental contributions, encouragement of new forestry investments, reduced risk of catastrophic wildfire, and public-private collaboration on conservation solutions.

Among the six current agenda items under the initiative, four directly or indirectly relate to forest biomass utilization:

- **Forest Sector Economic Strategy**. Develop and promote a state-wide forest sector economic strategy in cooperation with the Oregon Board of Forestry and the Oregon Economic and Community Development Department to leverage current and future investments in forestland ownership and manufacturing base.

- **Federal Forest Management**. Under Board of Forestry leadership, develop and implement an aggressive action plan for active federal forest management to address forest health and fire risks on federal land.

- **Forest Sector Cluster Expansion.** Aggressively expand and integrate the forest cluster with the development of biomass energy that includes combined heat and energy (in manufacturing processes) and hogged-fuel electric power from small-diameter trees.

- **Innovation.** Invest aggressively in Oregon's forest sector by developing the Wood Innovation Center at Oregon State University.

Many of the activities discussed later in this report have evolved from the Business Plan's forestry initiative, including the Forest Cluster Initiative and Wood Innovation Center.

3.2.1.4 Forestry Program for Oregon

The 2003 Forestry Program for Oregon is the state's strategic plan for forest resources and represents policy choices that provide overall direction for the Department of Forestry. It established the mission statement for the Board of Forestry (BOF) and identifies seven strategies that the BOF wants to pursue over the eight years of the plan. Several of the strategies are relevant in the context of forest biomass utilization. The seven strategies are:

- Strategy A. Promote a sound legal system, effective and adequately funded government, leading-edge research, and sound economic policies.

- Strategy B. Ensure that Oregon's forests provide diverse social and economic outputs and benefits valued by the public in a fair, balanced, and efficient manner.

- Strategy C. Maintain and enhance the productive capacity of Oregon's forests to improve the economic well-being of Oregon's communities.

- Strategy D. Protect, maintain, and enhance the soil and water resources of Oregon's forests.

- Strategy E. Contribute to the conservation of diverse native plant and animal populations and their habitats in Oregon's forests.

- Strategy F. Protect, maintain, and enhance the health of Oregon's forest ecosystems, watersheds, and airsheds within a context of natural disturbance and active management.

- Strategy G. Enhance carbon storage in Oregon's forests and forest products.

3.2.1.5 Senate Bill 1072

Senate Bill 1072, which was signed into law by Governor Kulongoski in 2005 and took effect January 1, 2006, provides direction for greater state government involvement in federal forest planning and management and encourages greater use of forest waste material for bio-energy facilities on federal and state lands, and development of other forest products. The legislation directs the Oregon Department of Forestry to work with the Department of Energy and other state agencies to look for opportunities to develop bio-energy facilities while preserving forest health. The bill includes a legislative finding that "a biomass based industry may provide a renewable source of energy, reduce net greenhouse gas emissions, reduce air pollution from wildfires, improve fish and wildlife habitat, create jobs and provide economic benefits to rural communities." The Legislature declared state policy support for biomass-fueled energy production facilities.

Section 2 of the law provides for the State Forester to become involved, to a greater extent, in the management of federal forest lands in Oregon. Several means of accomplishing this are listed, including facilitation of the development of stewardship contracts; creating a forum for interagency cooperation and collaborative public involvement; participation in the development of federal forest policies and in the land management planning processes of the federal agencies; and coordinating with the State Department of Fish and Wildlife, OSU, OFRI, the Department of Environmental Quality and other agencies.

Legislative findings are incorporated into Section 3. Several are particularly important in regards to biomass utilization:

- Forestlands in federal, state and private ownership comprise some of the most important environmental, economic and recreational resources in the State of Oregon. However, federal lands, and to a lesser extent state and private lands, are increasingly jeopardized by the risk of drought-induced mortality, severe insect and disease outbreaks and catastrophic wildfires.

- The development of new market-based solutions to reduce the risk of severe insect and disease outbreaks and catastrophic wildfires may reduce the requirement for public funding. The development of biomass markets, including energy markets, that use forest biomass unsuitable for lumber, pulp and paper products as a primary source of raw material may assist in the creation of a sustainable, market-based model for restoring complexity and structure to Oregon's forests.

- A biomass-based industry may provide a renewable source of energy, reduce net greenhouse gas emissions, reduce air pollution from wildfires, improve fish and wildlife habitat, create jobs and provide economic benefits to rural communities. Through the collection and conversion of forest biomass, ancillary benefits may be realized through the improvement in forest health, the protection of infrastructure and the stabilization of soils within critical watersheds.

- The collection and conversion of forest biomass diminishes fuel loads and is an ecologically and economically sustainable practice where the reintroduction of fire is not appropriate.

- The policy of this state is to support efforts to build, and place in service, biomass fueled energy production facilities that utilize biomass collected from forests or derived from other sources such as agricultural crop residue when:

  - The facilities utilize sustainable supplies of biomass from cost-effective sources;

  - The use of woody biomass for energy maintains or enhances the biological productivity of the land, taking into consideration transportation costs, existing forest conditions, management objectives, vegetation growth rates and the need to sustain water quality and fish and wildlife habitat; and

  - The set of forest values to be sustained, in addition to wood and biomass for energy, is considered. Forest values include forest products, water, wildlife and recreation.

Section 4 directs the State Forester to take a number of actions including establishing a policy of active and inclusive communication with federal government and the public regarding utilization of woody biomass; promotion of public involvement in a number of related areas; conducting inventories and providing information on woody biomass availability; providing public education on the role of biomass utilization in forest restoration; ensuring the use of best available science and technologies pertaining to forest restoration and biomass use; and seeking opportunities to provide biomass from federal, tribal, state and private forests. The State Forester is also directed to prepare a report on woody biomass use every three years.

In sum, SB 1072 is an important legislative milestone in establishing state policy towards forest health on federal and non-federal lands as well as establishing state policy support for biomass-fueled energy production facilities.

3.2.1.6 House Bill 3481

HB 3481 was introduced in 2005 to promote the development of a biofuels industry in Oregon. The bill would have created or expanded tax incentives for production facilities producing ethanol, biofuel or certain fuel additives, for agricultural production of biofuel raw materials or biomass used for energy production, for research and development related to biofuel production, and for bus tailpipe emission reduction devices. Among the provisions was one that provided a $10 per green ton producer tax credit for forest or rangeland vegetative biomass delivered to produce electric energy, direct application heat, or transportation fuel. Versions of the bill also included a Renewable Fuels Standard for ethanol and biodiesel. This was removed during House debate.

An amended version was approved by the Oregon Senate in July, 2005 but died in conference committee. It is likely that this bill will come up again in the next session. Two interim legislative committees are working on it and held hearings in January, 2006. The committees are the House Agriculture and Natural Resources Committee's Subcommittee on Biomass and Alternative Fuels and the Interim Senate Task Force on Alternative Fuels.

3.2.2 Working Groups and Initiatives

The State has formed a hierarchy of interagency working groups under the Governor's Sustainability Office to coordinate renewable energy development activities. The organizational structure and reporting relationships are shown in Figure 1.

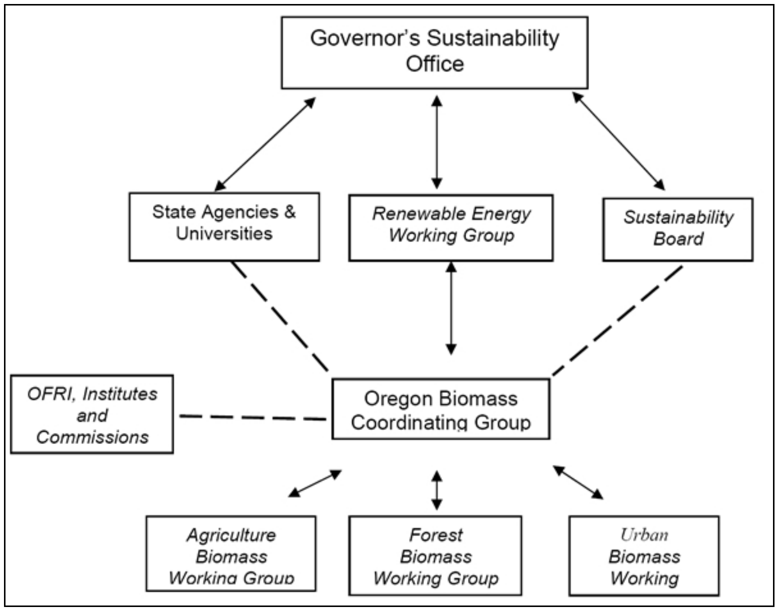

Figure 1 – Oregon's interagency biomass energy working groups.

Three groups, the Renewable Energy Working Group, Oregon Biomass Coordinating Group and Forest Biomass Work Group are described in the following sections.

3.2.2.1 Renewable Energy Working Group

One result of the Renewable Energy Action Plan was the formation of the Renewable Energy Working Group, formed through a collaborative process involving the Oregon Department of Energy and the Governor's Office. The primary mission of the Renewable Energy Working Group (REWG) is to guide implementation of the Renewable Energy Action Plan. To accomplish this goal the Renewable Energy Working Group will play an advocacy and an advisory role. Group members will work to find and implement solutions - in the legislative arena, in the private sector, and elsewhere - that encourage the growth of renewable energy and accompanying economic development in Oregon.

The Renewable Energy Working Group will be briefed on renewable energy development in Oregon and submit regular status reports on the implementation of the REAP to the Governor's Office for public dissemination. The REWG will also be considering a list of more than fifty action items identified for its consideration in the REAP. Many of the tasks assigned to the Renewable Energy Working Group can be delegated to technology-specific working groups already in place (such as the wind, biomass and geothermal working groups). However, at least four key areas will need to be addressed by the Renewable Energy Working Group directly:

- Prioritization of the numerous tasks in the REAP, and monitoring of those tasks.

- Discussion of and action taken on crosscutting issues affecting multiple technologies with a focus on issues like transmission constraints, interconnection, and Bonneville Power Administration policies.

- Renewable energy production policy and the potential role of production incentives, a renewable portfolio standard, and/or the public purpose charge to achieve REAP goals.

- Identification, coordination, and packaging of legislative concepts as appropriate.

3.2.2.2 Oregon Biomass Coordinating Group

The Oregon Biomass Coordinating Group (OBCG) is an interagency group formed in July 2005 to coordinate agency roles in biomass market development and electricity generation.

Members of the OBCG include staff from the Governor's Office, the Oregon Departments of Agriculture, Economic and Community Development, Energy, Environmental Quality, and Forestry; Oregon State University; Oregon Forest Resources Institute; and the Public Utility Commission.

The Oregon Biomass Coordinating Group provides support and oversight for the Agriculture, Forest, and Urban Biomass Working Groups. These three separate groups focus on specific opportunities, barriers and solutions in the three sectors. The OBCG also will keep the Governor's Renewable Energy Working Group informed of the status of activities and needs related to biomass development; will provide recommendations for policy-makers; and will identify legislation to increase beneficial biomass use in Oregon. The OBCG will provide a report to the 2007 Oregon Legislature identifying the status of biomass in Oregon including accomplishments, strengths and opportunities.

3.2.2.3 Oregon Forest Biomass Working Group

The Forest Biomass Working Group is exploring how utilizing biomass can improve forest health and create a viable biomass industry using previously un-merchantable raw material from Oregon's forests. The 35+ member Group represents diverse interests: forest and energy industries, resource agencies, environmental organizations, elected officials, tribes, labor representatives and local communities.

The 2005 Legislature, through Senate Bill 1072, directed the State Forester and ODF to take specific actions to increase the use of forest biomass, particularly on federal lands. The work group will identify existing barriers of utilizing biomass in Oregon and discuss ways to overcome them. The Oregon Departments of Forestry and Energy are overseeing these collaborative efforts. The work group will also address the renewable energy goals articulated in Governor Ted Kulongoski's April 2005 Renewable Energy Action Plan, which notes that new forest biomass energy markets could stimulate environmental, social and economic benefits.

The Forest Biomass Work Group has six issue areas they are addressing by identifying barriers, determining key outcomes, and committing to specific actions. These six areas are:

- Predictable supply
- Stakeholder and public consensus

- Supportive regulatory environment
- Research and development
- Extraction (of biomass), production and infrastructure development
- Economic and market development

3.2.2.4 Governor's Blue Ribbon Work Group

With Governor Kulongoski's support, the Oregon Business Council is coordinating a Blue Ribbon Work Group that includes partners from the forest products, non-profit and energy sectors. This group will make recommendations to the Governor and the Legislature about how to move this industry forward. By June 1, the Group will provide a Biomass Strategic Plan and Action Agenda including the following items:

- Current status of forest health of federal, state and private lands and barriers to cleanup
- Economics of timber production from various types of forests
- Review or electricity purchasing strategy
- Review of technology

3.2.2.5 Oregon Business Plan, Forest Cluster Initiative

The Forest Cluster's priority initiative for the 2006 Oregon Business Plan is an integrated strategy to restore forest health and habitat, increase Oregon's supply of renewable energy, and improve rural economic vitality – a triple win for Oregonians. The cluster strategy has three components: 1) Generate renewable electric energy and transportation bio-fuels from woody biomass to help meet Oregon's renewable energy and carbon emission reduction goals; 2) Increase sustainable timber harvest from public forestland; and 3) Promote forest research and wood innovation. This strategy can increase jobs and boost the forest cluster's contribution to the economy, reduce dependence on fossil fuels and hydropower and reduce the risk of large, severe fires that threaten our federal forests.

This initiative is supported by Governor Kulongoski and Oregon Senators Smith and Wyden. Actions that have been identified in support of this initiative are:

- Promote federal policies that improve forest health, improve rural economic vitality, improve habitat, reduce fire-risk and support the sustainable utilization of woody biomass from federal forests (e.g. full funding of the National Fire Plan; full funding and implementation of the Healthy Forest Restoration Act; full achievement of the timber harvest and environmental enhancement objectives of the Northwest Forest Plan; development of federal supply contracts for a predictable woody biomass supply; and the thinning of 12.2 million acres of Condition Class II & III federal forestlands over 20 years by treating 600,000 – 800,000 acres per year).

- Bring together the Federal forestland managers, the private/public utilities, Oregon Public Utility Commission and the Bonneville Power Administration with the Forest Cluster to develop an action plan for sustainable production/use of woody biomass for electrical energy.

- Educate policy makers about the need for active management and the benefits of thinning for biomass production, fire resiliency, rural jobs and habitat improvement by sponsoring tours of demonstration areas such as the Lake County Pilot Project.

- Ensure full and continued recognition of electric bio-energy and transportation bio-fuels from woody biomass as "renewable" in the state and federal Renewable Energy Action Plans and policies including those that provide for purchase of biomass energy by utilities at [avoided cost] market rates; full implementation of SB 1072; and creation of biomass recovery business incentives (e.g., transportation, energy or other subsidy).

- Promote aggressive use by Oregon of the new opportunities created by the President's Energy Bill and full federal funding of biomass credits.

- Increase funding for start-up and expansion of the Oregon Wood Innovation Center at OSU.

3.2.3 Agency Activities

3.2.3.1 Oregon Department of Energy

The Oregon Department of Energy (ODOE) is the principle staff for the Governor's renewable energy strategy efforts and works closely with the Department of Forestry on the forest biomass energy issues through the Biomass Working Group. ODOE manages the Oregon portion of USDOE's Regional Biomass Program. This program maintains state-wide information on biomass resources, funds small study or R & D grants and publishes periodic reports.

The ODOE manages two incentives programs, the Oregon Business Energy tax Credit and Small-Scale Energy Loan Program.

Oregon's Business Energy Tax Credit program offers a 35% credit against Oregon taxes for up to a $10 million qualifying project. Should a developer not have sufficient Oregon tax liability or be a tax exempt organization, the Oregon tax credit can be passed through to a partner with adequate tax liability and the developer can receive the net present value of the credit up front.

The Subsidized Small Scale Energy Loan Program (SELP) is an incentive targeted for energy efficiency and renewable energy projects. Unlike private finance companies, SELP has experience with the specifics of energy project development, and have engineering expertise as well. SELP requires a credit evaluation, and a reasonable amount of equity in the project by the developer to qualify for the loan.

3.2.3.2 Oregon Department of Forestry

The ODF's strategic plan, the 2003 Forestry Program for Oregon, outlines a number of Board of Forestry policy objectives, strategies and actions that touch on aspects of forest biomass energy (see Forestry Program for Oregon, page 6). Two are related to the Plan's strategy to "ensure that Oregon's forests provide diverse social and economic outputs and benefits valued by the public in a fair, balanced, and efficient manner." These are:

- B.5. The board will promote environmentally sound, active forest management policies that encourage long-term investments, sustainable timber supplies, recreation and cultural opportunities, special forest products, fish and wildlife habitat, clean air and water, *renewable energy*, other forest outputs and benefits, and high levels of employment and income.

- B.8. The board will promote new employment opportunities by encouraging an assessment of what and where wood could be removed from federal forests to improve forest health, consistent with other management objectives, and encouraging the development of the infrastructure needed to accomplish the desired future condition for these forests.

In addition, two actions related to the Plan's forest health strategy relate to biomass energy by promoting treatments to manage fuel conditions and protect from wildfire:

- F.1. The board will promote active fuels and vegetation management, along with aggressive wildfire suppression, as key tools to manage forest health on public and private forestlands.

- F.2. The board will promote forest landscape conditions that are resilient to natural disturbances, reducing the adverse environmental impacts and losses of forest resources to wildfire, insects, diseases and other agents in a cost-effective, environmentally, and socially acceptable manner.

The Board of Forestry's 2005 Forest Vitality Work Plan includes a Forest Health Restoration/Biomass Energy objective:

- Promote incentives for sound sustainable forest health restoration practices, including the development of market-based solutions to reduce the risk of catastrophic wildfires and insect and disease outbreaks.

Under this work plan, the Board and agency staff will undertake the following actions:

- Collaboratively work with other groups to improve the contributions to Oregon's state and local economies from utilization of small diameter forest biomass.

- Produce a State of Oregon Guidance Document for federal land management. The sustainable supply of raw materials for biomass energy production will be included in the issues section of this document with the intent of ensuring that planning of forest health restoration practices includes consideration of opportunities to provide a sustainable and predictable supply of biomass.

- Develop position statements supporting federal legislation and policies which advance the development of a biomass energy industry in Oregon.

- Work with the OSU College of Forestry and PNW Research Station to assess the current state of knowledge regarding the environmental impacts of large-scale biomass removal on sensitive forest resources.

- Department field personnel will participate in the federal planning process at the local level to identify opportunities for biomass recovery and utilization concurrent with proposed forest health restoration projects.

- Department staff will participate on the Forest Biomass Working Group, a subgroup of the state Biomass Coordinating Group.

- Department staff, independently and through participation on the state Forest Biomass Workgroup, will collect and present information on the current status of biomass energy in Oregon and other parts of the country.

- Department staff will continue to monitor developments in federal energy legislation and impacts on biomass energy development in Oregon.

The Forest Biomass Working Group, which is co-led by ODF, is a central part of the agency's efforts to promote forest biomass energy development.

3.2.3.3 Oregon Department of Agriculture

The Oregon Department of Agriculture also plays a role in the implementation of the state's Renewable Energy Action Plan. The Department's responsibilities related to biomass energy under the Plan include the following:

- Assist, jointly with ODOE, in planning and conducting workshops and other educational activities to inform agricultural producers about renewable energy information, technologies, resources, and programs.

- Assist, jointly with ODOE, agricultural producers in evaluating project feasibility and eligibility for federal energy grants, ODOE tax credits, and other resources for renewable energy projects. Assist growers in applying for these resources as appropriate to the project.

- Assist growers and cooperatives, in coordination with Oregon State University research and extension programs and agricultural organizations, in the development of biofuel crops for ethanol production, including varietal development, growing and harvesting practices, development of business plans, facilities for processing, siting, market development and promotion.

3.2.4 Research & Development

State research and development efforts relating to biomass energy and forest biomass utilization are centered at Oregon State University College of Agricultural Sciences and College of Forestry.

3.2.4.1 Oregon State University - Sun Grant Center

The federal government has tapped OSU as one of the country's five initial Sun Grant centers of excellence - regional hubs charged with leading research, education and outreach programs largely focused on the evolving field of bio-energy. The R&D initiative is intended to reduce reliance on imported fossil fuels, add diversity to American agriculture and revitalize rural economies. The mission of the Sun Grant Initiative is to:

- Enhance national energy security through development, distribution and implementation of biobased energy technologies,

- Promote diversification in and the environmental sustainability of, agricultural production in the United States through biobased energy and products technologies;

- Promote economic diversification in rural areas of the United States through biobased energy and product technologies; and

- Enhance the efficiency of bio-energy and biomass research and development programs through improved coordination and collaboration between the Department of Agriculture, the Department of Energy, and the land-grant colleges and universities.

OSU will be the lead university representing nine western states, plus the Pacific Territories and associated Pacific island nations. The network of five land-grant universities serving as regional Sun Grant centers also includes South Dakota State University, Oklahoma State University, the University of Tennessee - Knoxville, and Cornell University.

In August, 2005, President George Bush signed federal legislation providing more than $8 million in funding for the Sun Grant Center at OSU. The Sun Grant Initiative funding will be spread over four years and will largely go to university researchers and extension agents, governmental agency employees, private entrepreneurs and others in the West, including OSU faculty members, who submit successful competitive grant proposals.

More information about the OSU Sun Grant Center is available at:
http://agsci.oregonstate.edu/research/grants_sun_2002.html .

3.2.4.2 Oregon State University - Wood Innovation Center

The College of Forestry at Oregon State University has created a new Oregon Wood Innovation Center to work more closely with private industry, improve the competitiveness of Oregon's forest sector, help the state preserve jobs and better adapt to a challenging global environment.

Innovation may take many forms, such as new specialty products, improved marketing, sophisticated processing technologies, enhanced mechanisms for networking with other firms, and access to continuing education. The Oregon Wood Innovation Center will play a key role in bringing groups together, providing technical and business assistance, doing targeted research, and making sure that Oregon wood products are competitive in the world arena.

The Oregon Wood Innovation Center is a joint initiative of the OSU College of Forestry and the OSU Extension Service. Based on campus, it will take its activities to industries and locations around the state. On a long term basis funds will be sought from industry, other state and federal partnerships, user fees and research grants.

The effort responds to a call by the Oregon Business Plan for more innovation in various areas. It is consistent with the emphasis on innovation in OSU's strategic plan, would contribute to the development of the OSU Innovation Campus, and has been supported by Oregon Business Magazine.

More information can be obtained at: http://owic.oregonstate.edu/index.php.

3.3 Federal Efforts

Most of the federal government's woody biomass utilization efforts are undertaken by the Agriculture, Energy and Interior Departments. Some activities are performed jointly. For example, the USDA, DOE and Interior signed a Memorandum of Understanding on Policy Principles for Woody Biomass Utilization for Restoration and Fuel Treatments on Forests, Woodlands, and Rangelands in 2003. The USDA and DOE also conduct a joint grants program.

3.3.1 Key Federal Policies and Initiatives

3.3.1.1 National Energy Policy

The recently enacted National Energy Policy is of course the foundational energy policy of the federal government. The policy calls for a number of initiatives to reduce the nation's dependency on oil and promote use of renewable energy including biomass. A comprehensive analysis of the Policy is beyond the scope of this report. Among the most relevant elements of the policy from the woody biomass perspective are:

- Re-evaluation of access limitations to federal lands to expand renewable energy production, including biomass;
- Expansion of the existing 1.7 cents per kWh tax credit for electricity to include forest-related biomass sources (see Energy Policy Act 2005 Incentive Programs);
- Increased funding for research and development of renewable energy sources;
- A Biorefinery Initiative directed at perfecting advanced technologies to make fuel ethanol from cellulosic biomass including wood chips – accelerating research to make it cost competitive by 2012.

In his 2006 State Of The Union Address, President Bush Outlined The Advanced Energy Initiative To Help Break America's Dependence On Foreign Sources Of Energy. The President has set a national goal of replacing more than 75% of our oil imports from the Middle East by 2025. In the speech, the President announced the Advanced Energy Initiative, which provides for a 22% increase in clean-energy research at the Department of Energy. The Initiative will accelerate breakthroughs in two vital areas; how we power our homes and businesses; and how we power our automobiles.

The following quote from the speech is particularly notable in its reference to ethanol production from woody biomass: "We'll also fund additional research in cutting-edge methods of producing ethanol, not just from corn, but from wood chips and stalks, or switch grass. Our goal is to make this new kind of ethanol practical and competitive within six years."

3.3.1.2 National Fire Plan

Utilization of woody biomass is emphasized in the federal government's National Fire Plan (NFP), a strategy for planning and implementing agency activities related to wildland fire management. For example, a NFP document cites biomass utilization as one if its guiding principles and recommends that the agencies employ all appropriate means to stimulate industries that will use small-diameter, woody material resulting from fuel reduction activities. Current information on the National Fire Plan can be found at: http://www.fireplan.gov/.

3.3.1.3 BLM Biomass Utilization Strategy

The BLM is implementing a strategy for increasing the utilization of biomass from BLM lands consistent with the National Fire Plan and using the tools of the Healthy Forests Initiative, including the new authorities for stewardship contracting projects and the Healthy Forests Restoration Act. This strategy will help achieve the goals of the National Fire Plan, the National Energy Policy, the DOI Strategic Plan, and the commitments made by the Secretary of the Interior at the Bio-energy and Wood Products Conference held in January 2004.

Short-term efforts will focus on developing tools, increasing field office expertise, and increasing in acres treated and biomass offered. Longer-term efforts will expand to working with partners and looking at barriers to biomass utilization. Nationally BLM will also seek out methods to stimulate supply and demand for biobased products. Efforts will be coordinated with the Forest Service, the Bureau of Indian Affairs, other federal, State and local agencies, and with private timber companies.

3.3.1.4 Federal Land Stewardship Contracting

The USDA Forest Service and the Interior Department's Bureau of Land Management (BLM) received new authority to implement stewardship contracting and agreements in the 2003 Appropriations Act (P.L. 108-7). Stewardship contracting will improve the health of the land, ensure thriving landscapes and contribute to the development of dynamic economies by assisting land managers to enhance and restore forest and rangeland health while strengthening the role of communities and others who contribute to such efforts.

Land Stewardship contracts bundle together a variety of land management tasks within a single contract. Values from recoverable forest products will be used to offset the cost of stewardship services. Contracts are awarded on the basis of best value as opposed to high bid as in the case of timber sales or low bid as in the case of service contracts. Land Stewardship projects will be developed in collaboration with local communities, cooperating agencies (including tribal governments) and other interested parties. Healthy ecosystems, sustainable rural communities and local employment are complimentary goals of stewardship contracting.

Stewardship contracting allows federal land managers to achieve land management goals, including fuels reduction activities, for public lands at high risk to catastrophic wildfire while meeting local and rural community needs. Stewardship contracting will help the agencies achieve key land-management goals to:

- Improve, maintain, and restore forest and rangeland health;
- Restore and maintain water quality;
- Improve fish and wildlife habitat;

- Reestablish native plant species and increase their resilience to insects, disease and other natural disturbances; and
- Reduce hazardous fuels that pose risks to communities and ecosystem values through an open, collaborative process.

Long-term contracts foster a public/private partnership to restore forest and rangeland health by giving those who undertake the contract the ability to invest in equipment and infrastructure. This equipment and infrastructure are needed to productively use material generated from forest thinning, such as brush and other woody biomass, to make wood products or to produce biomass energy, all at a savings to taxpayers.

In Oregon, 36 Forest Service and 14 BLM stewardship contracting projects have been initiated thus far.[1] Many of these are directed at fuels treatments and fire risk reduction.

Forest Stewardship contracting may provide an avenue through which long-term biomass supply agreements can be reached to foster private investment in biomass energy facilities. Under the MOU between the Forest Service, BLM and Confederated Tribes of the Warm Springs Reservation, the agencies committed to offering residual woody biomass from approximately 8,000 acres per year to the open market, utilizing competitive stewardship contracts, traditional service and timber sale contracts, and other contracting vehicles. This would yield approximately 80,000 BDT per year of biomass supply.

3.3.1.5 Coordinated Resource Offering Protocol (CROP) Pilots

The need for coordination of small diameter biomass supply across administrative boundaries and agencies has given rise to an initiative called the Coordinated Resource Offering Protocol, or CROP. The goal of the initiative is to establish a procedure by which various agencies and potentially other landowners could coordinate plans to provide a "levelized" supply of material over time. This would assure developers and investors of a stable feedstock supply. Seven CROP pilot projects have been established across the country including two in Oregon, in the central Oregon and Lakeview areas.

3.3.2 Incentive and Grants Programs

3.3.2.1 Energy Policy Act 2005 Incentive Programs

Section 202, the Renewable Energy Production Incentive (REPI), part of the Energy Policy Act of 2005 (Public Law 109-190 or EPAct 2005), modifies EPAct 1992 to extend the federal renewable energy production tax credit to "open loop biomass." Previously, only "closed loop biomass" i.e. dedicated energy crops were eligible, and the credit was extended through 2007. Open loop biomass and some other sources receive only half the credit. The amount of the tax credit is adjusted for inflation. The 2005 full credit is 1.9¢/kWh for wind, closed loop biomass, and geothermal. The credit for open loop biomass is 0.9¢/kWh. The duration of the credit is 10 years for facilities commissioned after enactment.

[1] US Forest Service Region 6 stewardship contracts are documented at:
http://www.fs.fed.us/r6/nr/fp/FPWebPage/FP70104A/FP70104A.htm
BLM: Pers. comm. with Jim Hallberg, BLM stewardship contracting coordinator, 5/16/2006.

Section 210, of EPAct 2005 is titled, "Grants to Improve the Commercial Value of Forest Biomass for Electric Energy, Useful Heat, Transportation Fuels, and Other Commercial Purposes." It requires the Secretary of the Interior to:

- Establish a USDA-Interior grant program to offset the cost of biomass feedstocks
- Authorize Value-added R & D Research grants
- Make awards of up to $500K with $50M authorized between 2006 and 2026
- Report to Congress by 10/01/2010 on the progress of the program

Section 1303, of EPAct 2005 is titled, "Clean Renewable Energy Bonds" or CERBs. EPAct 2005 created a new category of tax credit bonds that can be issued by governmental bodies, i.e. state and municipal electric utilities, Indian Tribes and rural electric cooperatives, to finance the construction of renewable energy facilities.

CREBs are authorized for two years (January 1, 2006-December 31, 2007) and are interest-free debt instruments to build qualified renewable energy projects. Instead of interest paid by an issuer, purchasers can receive a federal tax deduction in an amount equal to the value of the interest a similar tax-exempt bond might have paid.

CREBs provide the issuer with a guaranteed benefit, once the project is designated as qualified by the Treasury Department ("Treasury"). CREBs offer a significant benefit to public power systems because they provide a non-appropriated mechanism to secure an interest-free loan to build renewable resources. Renewable technologies eligible for CREBs are similar to those eligible for the federal Production Tax Credit and include closed- and open-loop biomass.

In December 2005, Treasury issued a notice providing background information, interim procedures for requesting bond limitation, a deadline of April 26, 2006 for a request for limitation, and contact names for additional information. Because of the short notice for requests for bond limitation, Pacific Energy Systems notified OFRI of this funding opportunity prior to the completion of the study.

3.3.2.2 Joint Biomass Research and Development Initiative

The Biomass R&D Initiative is the multi-agency effort to coordinate and accelerate all Federal bio-based products and bio-energy research and development. Participating agencies include the U.S. Departments of Energy, Agriculture and Interior, The National Science Foundation, Office of Science and Technology Policy, and Office of the Federal Environmental Executive. The Initiative is intended to promote greater innovation and development related to biomass, and to support the Biomass Research Development Act of 2000, the Healthy Forest Restoration Act of 2003, and the Energy Policy Act of 2005. It also supports Federal policy calling for greater use of biomass-based products, feedstock production, and processing and conversion.

The program promotes all forms of biomass. No projects directly related to woody biomass were funded in the first two years of the program[2]. However, woody biomass was an area of emphasis

[2] A list of projects from FY02-04 is available at:

in FY2004, when 10 projected related to woody biomass were funded for a total of $7.7 million. Included in this were two projects in California. The Hayfork Biomass Utilization Project supported the design and early implementation phases of a biomass utilization facility including log sort yard, small log processor and wood-fired electrical plant. Another California project received funding to evaluate the economic benefits of using forestry residues for generating power in small-scale power plants. None of the woody biomass projects have been in Oregon.

FY2006 awards have not been made as of the date of this writing. Up to $14 million of USDA and DOE funds are expected to be available. Approximately ten to 20 awards are anticipated. Awards may range from $250,000 to $2 million per award.

Information on the Biomass Research and Development Initiative can be found at: http://www.bioproducts-bioenergy.gov/default.asp.

A number of federal grant programs specific to biomass energy and forest biomass utilization are described in the sections below. There may be other federal grants available that are more general in nature, for example small business or innovation programs, that have potential relevance to forest biomass. A one-stop on-line information source for all federal grant programs can be found at: http://www.grants.gov/.

3.3.2.3 Fuels Utilization and Marketing Program

Under the NFP, the USDA Forest Service collaborates with the Interior Department in awarding and funding grants under the Fuels Utilization and Marketing Program (FU&M), a jointly funded program targeting woody biomass utilization efforts in the Pacific Northwest.

Eligible Projects under the FU&M Program include transfer and commercialization of new technology that develops or expands uses and markets for low-value woody material, including small diameter trees removed in fuels treatments projects. Proposals must have the potential to reduce fire hazards by providing incentives for economic use of small diameter and underutilized forest products, including efforts to help offset the costs of forest restoration. Funds can be used to provide training and technical assistance to identify and develop new markets for underutilized wood products; create marketing tools such as product catalogs, trade shows and producer directories; prepare market assessments and feasibility studies; provide direct marketing assistance; and develop business plans. A maximum of 20 per cent of the funds available for this program will be allocated to market assessments and feasibility studies.

Grants under the FU&M Program are bundled and reported under the Wildland-Urban Interface Grants Program of the NFP along with grants for hazardous fuel reduction, community wildfire protection planning and monitoring, and prevention and education grants. The vast majority of grants are for fuel treatment projects. No FU&M grants were awarded in Oregon and Washington in 2005. In FY2006, three FU&M projects are listed as tentatively funded for Oregon, totaling $300,800 or 6% of the $4.7 million to be awarded. These include projects in Deschutes, Jackson and Josephine counties.

Information on the Wildland-Urban Interface Grants Program, including FU&M grants, can be found at: http://199.134.225.81/CommunityAsst.htm.

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http://www.bioproducts-bioenergy.gov/pdfs/USDA-DOEJointSolicitationR&DMatrix.pdf.

3.3.2.4 Woody Biomass Grants

Another biomass-related grants program is managed by the USDA Forest Service, Forest Products Laboratory in Madison, WI as part of the Healthy Forest Restoration Initiative (PL 108-148) and EPAct 2005 (PL 109-190). The State and Private Forestry Technology and Marketing Unit administers the program.

The Woody Biomass Grants Program is intended to encourage forest restoration activities focusing on creating markets for small-diameter material and low-valued trees removed from fuel reduction activities. These funds are targeted to help communities by offering grants to state, local, and Tribal governments, school districts, non-profit organizations, businesses, public utility districts, fire districts, conservation districts and ports. Projects should turn residues from fuel reduction activities into marketable forest products or energy products. The program aims to:

- Increase the value of biomass and other forest products produced by fuel reduction treatments.
- Create incentives and reduce business risk for use of biomass from or near national forestlands.
- Fund projects that help remove economic and market barriers to using small-diameter trees and woody biomass.

In 2005, Oregon was well-represented in the grants program. Five of the 20 grants awarded were to projects in Oregon. These projects totaled 27% of the $4,333,000 awarded (Table 1). Two of the five projects (COIC, Warm Springs) were related to biomass energy.

In the FY2006, at least $4 million will be made available for grants to increase the use of woody biomass from or near National Forest System lands. The Forest Service announced the request for proposals September 26, 2005 in the federal register. Applications were due in December, 2005 for the current grant cycle. Grants will be not less than $50,000 or more than $250,000 each.

Information on the Woody Biomass Grants Program through the Forest Products Laboratory can be found at: http://www.fpl.fs.fed.us/tmu/ grant/biomass-grant.html.

Table 1 – USDA Forest Service Woody Biomass Grants awarded in Oregon, FY2005.

Project Name **Applicant**	**Location**	**Biomass Use(s)**	**FS Award**	**Total Project**
Coordinated Resource Offering Protocol *Central Oregon Intergovernmental Council (COIC)*	Redmond	Develop and implement scheduling protocols for FS, BLM units to predict 5-year programs of work, coordinate annual programs to stabilize outputs, enable private investment in local cogeneration and small log facilities; implement independent monitoring and evaluation of results.	$220,000	$271,920
Small Log Sort and Merchandizer Center *Dodge Logging, Inc.*	Boardman	Improve lumber recovery from small logs that would otherwise be burned on site during fuel reduction projects	$222,000	$377,400
Mill Upgrade Project *M&L Enterprises*	Sun River	Purchase equipment and upgrade mill to more efficiently utilize and process small trees down to 1-inch diameter.	$236,500	$300,355
Wallowa Integrated Wood Utilization Center *Wallowa Resources*	Wallowa	Expand plant to include production of chips and hog fuel	$250,000	$352,500
Extraction Turbine Project *Warm Springs Forest Products Industries*	Warm Springs	The grant will partially pay for an engineering plan, installation, and operation of extraction turbine.	$250,000	> $7.5 million
Total			$1,178,000	

3.3.2.5 Economic Action Programs

In the past, the USDA Forest Service provided grants through its Economic Action Programs (EAP). However, EAP funding has recently been eliminated in order to help balance the federal budget. The goal of EAP was to facilitate and foster sustainable community development by linking rural community assistance with natural resource management. EAP helped rural communities and businesses dependent on natural resources to become sustainable and self-sufficient. EAP:

- Focused on the themes of healthy communities, appropriately diverse economies, and sustainable ecosystems;
- Emphasized community-based and community-led efforts in rural areas;
- Implemented forest products technologies that increased commercial use of small diameter and woody biomass resulting from the removal of hazardous fuels;
- Acted for the long-term solution versus the "quick fix" approach;
- Accomplished objectives through collaborative partnerships; and

- Built community capacity, leadership and social infrastructure.

Before its demise, EAP was focusing grants to communities (particularly western states) needing assistance in their efforts to reduce hazardous fuels via market-based solutions for the use of small diameter woody material.

Grants awarded in Oregon between FY1994-2004 funded 721 projects for nearly $56 million. Including leveraged funds, project funding totaled $131 million. Seven of the projects in Oregon have been directly related to biomass supply in general or specifically to biomass use for energy (Table 2). Related projects considering biomass for other uses (e.g. composting and miscellaneous small diameter wood products) have not been included in the table.

Table 2 – USDA Forest Service Economic Action Program grants for biomass energy-related projects in Oregon, 1994-2004.

Project Name **Applicant**	***Type of Study***	***Biomass Use(s)***	***FS Award***	Total Project
Prineville Collaboration for Fuel Wood Removal *Central Oregon Partnership*	Fuel reduction methods and costs	Not specified	$62,400	$84,300
Biomass Feasibility Study/Business Plan *Central Oregon Intergovernmental Council*	Supply assessment and risk analysis	Expansion of cogen facility using multiple fuels	$31,000	$39,301
COPWRR Phase III *Central Oregon Intergovernmental Council*	Product dev. And market research leading to expanded use	Any	$62,842	$80,842
Harney County Fuels Utilization and Byproduct Feasibility *Harney County*	Feasibility	Steam, juniper oil, or value-added	$25,000	$32,000
Biomass Power Plant Feasibility Study *Klamath County Economic Dev. Assn.*	Feasibility of locating energy plant in Klamath Co.	Energy	$25,000	$32,000
Biomass Resource Assessment *Oregon Office of Energy*	3-county biomass resource assessment	Energy	$99,998	$126,785
Wood Biomass to Energy Analysis *Union County Economic Development Corp.*	Study/identify all existing applications	Energy	$40,000	$77,300
Total			$346,240	$472,528

Unfortunately, funding for EAP has been severely curtailed since FY2004 and grant funding, except for earmarks, has been eliminated. More information about the Economic Action Program can be found on the following web-site: http://www.fs.fed.us/spf/coop/programs/eap/index.shtml.

3.3.2.6 USDA Rural Development

USDA Rural Development administers several relevant incentive programs including grants and guaranteed loans under Sections 9006 and 6401 and Rural Business Enterprise Grants.

Section 9006 is titled "Renewable Energy and Energy Efficiency / Rural Development". Eligible projects include renewable energy derived from biomass, or for which hydrogen is derived from biomass using a renewable energy source. The term "biomass" includes any organic material that is available on a renewable basis and includes trees grown for energy production, wood waste and wood residues, fibers and other waste materials. All eligible projects must be located in a rural area (population less than 50,000) and use a pre-commercial or commercially available technology. The applicant must be a small business or agricultural producer that is owner of the project and controls the operation and maintenance. Eligible costs include:

- Post-application purchase and installation of equipment;
- Post-application construction or project improvements;
- Energy audits or assessments;
- Permit fees;
- Professional service fees, except for application preparation;
- Feasibility studies;
- Business plans; and
- Retrofitting.

Eligible renewable energy system projects include biomass, geo-thermal, hydrogen, solar and wind generating systems. Eligible energy efficiency improvement projects include purchase and installation of non-residential energy efficiency improvements to a facility, building or process resulting in reduced energy consumption or reduced energy required per unit of production.

In FY2006, over $11 million in grants will be awarded via a national competition. Grants may be up to $250,000 per project and cannot exceed 25% of the project cost.

Section 9006 also includes a guaranteed loan program to support "gap" financing for renewable energy systems and energy efficiency improvements by rural small businesses and agricultural producers. The program is lender-driven; the USDA guarantees the loan rather than lending directly. The guaranteed loan and grant can finance up to 50% of total project costs and loan guarantees have a maximum limit of $10 million. In FY2006, up to $200 million in funds are available under this program.

The Section 6401 program is titled: "Value-Added Agricultural Product Market Development Grants (VAPG)". The current fiscal year notice of grant availability was published December 21, 2005, with applications due March 31, 2006. This grant program was reauthorized and modified in the 2002 farm bill and slated to receive $40 million annually. The purpose of the grants is to facilitate greater participation in emerging markets for value-added products. Grants can fund planning activities to design a value-added marketing opportunity or be used to acquire capital to run an established value-added business. The grantee will be expected to provide proof of the availability of matching funds that must be equal to or greater than the awarded grant. The maximum award per grant is $500,000 with no minimum grant requirement.

The VAPG program provides an important investment in the U.S. agricultural and forest sector, and is paving the way for the development of a more robust bio-based product industry. It provides incentives for production of energy from a wide variety of feedstocks. These two grant programs have been eliminated from the president's budget in recent years, only to be rescued in conference committee in budget reconciliation efforts.

The USDA Rural Development Oregon state office in Portland reports that the 9006 and 6401 programs have not yet been utilized in Oregon for woody biomass and small diameter forest products projects. However, they are very interested in changing that and are anxious to work with potential applicants.

Rural Business Enterprise Grants, administered by USDA Rural Development, provide grants to non-profit groups, towns, and counties to support small business development and economic growth. Four of 31 Oregon projects awarded funding in May, 2006, were biomass-related. Funding for these projects totaled $29,000 out of $356,000 awarded. Biomass-related projects included:

- Blue Mountain Community College, Biodiesel demonstration project ($3,000)
- Central Oregon Intergovernmental Council, Western juniper commercialization feasibility study ($,10,000)
- Harney County, Pre-feasibility study for biomass energy systems ($6,000)
- Wallowa Resources, Woody biomass utilization preliminary feasibility study ($10,000)

For additional Information: http://www.rurdev.usda.gov/rbs/coops/vadg.htm
http://www.rurdev.usda.gov/rbs/farmbill/what_is.html

3.3.2.7 US DOE/USDA Coordinated Biomass R & D Grants

In cooperation with USDA, USDOE announced on November 2, 2005, a grant program opportunity geared to research and development efforts with biomass. DOE has regular R & D grant offerings, and a partnership between Oregon State University, a private firm with an interest in expanding its work in biomass to energy and perhaps the Oregon Department of Energy would be a consortium eligible for funding if the proposed project was in an area described in the current DOE notice.

While most companies do not engage in R & D, such an effort could help move the bar forward in creating new markets, and gaining experience in this area. R & D grants are fairly small, but if done in cooperation with a long-term research effort, would be eligible for continued funding as the project developed.

Additional information can be found at:
www.eere.energy.gov/biomass/biomass_basics_faqs.html

In addition, the USDOE's State Energy Program (SEP), has periodic announcements of projects that require state energy office participation. The advantage of teaming with the Oregon Department of Energy (ODOE) on a project is gaining access to staff technical expertise, as well as their knowledge of state incentive programs to put together a coordinated funding proposal. These opportunities can easily be found at Grant.gov, and search for such key words as biomass, distributed energy generation or others. If interested, it is useful to be placed on ODOE's mailing list for such opportunities as well.

3.3.2.8 Other U.S. Department of Energy Grants

Although DOE maintains some grant programs and provides technical assistance to assist federal, state, and tribal agencies in switching to renewable energy, most of its activities focus on research and development. Most of DOE's woody biomass activities are overseen by its Office of the Biomass Program, although some activities also are conducted within the Federal Energy Management Program and the Tribal Energy Program.

DOE maintains several grant programs that emphasize renewable energy, potentially including woody biomass. The National Biomass State and Regional Partnership provides grants for biomass-related activities through five regional partners: the Coalition of Northeastern Governors Policy Research Center, the Council of Great Lakes Governors, the Southern States Energy Board, the Western Governors' Association, and DOE's Western Regional Office. DOE provides funds to each regional partner; the partners, in turn, provide grants to states. Although the overall DOE partnership does not emphasize woody biomass over other types of biomass, the Western Governors' Association is directing its DOE funds toward projects involving woody biomass.

Another DOE grant program that potentially involves woody biomass is the State Energy Program, which provides grants to states to design and carry out their own renewable energy and energy efficiency programs. States manage the funds and are required to match 20% of the DOE grants. In 2004, about $44 million was directed in grants to the states, and another $16 million was directed to special state projects. While the grant program does not emphasize woody biomass over other energy sources, woody biomass projects may be included among those funded, depending on state priorities.

3.3.3 Research & Development

3.3.3.1 U.S. Forest Service

Forest Service researchers are conducting research into a variety of woody biomass issues. The Pacific Northwest Research Station in Portland has been the source of much of this work. Often working collaboratively with the agency's Forest Products Laboratory and other research stations, PNW researchers have conducted assessments of the woody biomass potentially available through fuel reduction treatment projects. Researchers also have developed several computer models including the Fuel Treatment Evaluator and My Fuel Treatment Planner. These models are useful for analyzing the effects of fuel treatments, assessing the economics of biomass harvesting, and planning treatment of specific stands. At the PNW Station, Forest Service scientists also are studying the economics of woody biomass use in other ways; including an assessment of the economic, environmental, and energy-related impacts of using woody biomass for power generation.

The Forest Service also conducts extensive research into uses for woody biomass, primarily at its Forest Products Laboratory. The laboratory's strategic plan includes the goal of developing new and improved technologies to use low-value, underutilized forest resources, including less expensive ways of converting woody biomass to liquid fuels.

3.3.3.2 U.S. Department of Energy

DOE's woody biomass research and development activities are managed by its Office of the Biomass Program, which has overall responsibility for managing DOE's research activities relating to the use of biomass for fuels, chemicals, and power. Many woody biomass research and development activities within DOE are carried out by the National Bioenergy Center, a "virtual center" intended to unify DOE's efforts to advance technology for producing fuels, chemicals, materials, and power from biomass. These activities generally encompass research into the conversion of biomass, including woody biomass, to liquid fuels, power, chemicals, or heat. In addition, a new biomass laboratory—the Biomass Surface Characterization Laboratory—was dedicated at NREL in January 2005. DOE also supports research into woody biomass through partnerships with industry and academia.

3.4 Private Sector Efforts

3.4.1 Energy Trust of Oregon

The Energy Trust of Oregon, a nonprofit organization created to invest public purpose funding for energy efficiency and renewable energy in Oregon, has several programs to encourage renewable energy sources including biomass.

The **Open Solicitations** program is designed to support renewable energy projects that do not already have an established incentive program developed and launched by the Energy Trust of Oregon. They expect to reserve 10% of the Renewable Energy program budget, or about $1 million annually, for open solicitation incentives. Eligible projects include biomass. There is no funding cap for projects, but the projected program budget is expected to fund 4-6 projects each year.

The program does not fund R&D or pre-commercial activities. It is likely to fund projects that follow certain guidelines, including:

- New commercial technologies in established applications
- Established technologies in new applications
- Projects that can be implemented quickly
- Market defining demonstrations

The Energy Trust may fund all or a portion of the above-market costs of a project, defined generally as the difference between current wholesale or retail electricity prices and the cost of electricity generated by the project. There is no fixed percentage for the amount of the above-market costs the Energy Trust will pay. The Trust will also fund feasibility work to help a potential project plan for their open market solicitation funding request.

Eligible projects must either be located in the Oregon service territory of Pacific Power or Portland General Electric, or have a power purchase agreement with one of those utilities. Off-grid projects are not eligible for Energy Trust support.

The Energy Trust's Biopower Program provides grants to eligible projects to encourage the use of renewable biomass fuels in Oregon for generating electricity. Grants may fund all or a portion of the above-market costs of a project, defined generally as the difference between wholesale or retail electricity prices, and the cost of electricity generated by the project. There is no fixed percentage for the amount of the above-market costs the Energy Trust will pay. The Energy Trust Board of Directors approved $5.3 million for 2005 projects and an additional $2.11 million for the in 2006.

In December, 2005, the Trust announced five finalists for funding, including four projects focused on utilizing woody mill waste and forest thinnings. These projects are listed in Table 3.

Table 3– Woody biomass project finalists for Energy Trust Biopower Program 2005 funding.

Name	***Resource***	***Location***	Nameplate capacity (MW)
Freres Lumber	Mill waste	Lyons	10.00
Rough & Ready Lumber	Mill waste	Cave Junction	1.28
Sun Studs	Mill waste	Roseburg	3.30
Warm Springs Forest Products Industry	Mill waste and forest thinnings	Warm Springs	7.50

The Energy Trust Utility-scale Generation Program supports the development of large-scale energy projects through cash incentives that buy down the higher costs usually associated with producing renewable energy. Each year, Energy Trust sets aside several million dollars for this purpose, and works with PacifiCorp and Portland General Electric to select projects that have been proposed as part of those utilities' integrated resource planning.

Utility-scale energy projects produce at least 10 MW of electric power. Projects that produce that much energy can include large-scale wind, geothermal, biopower or hydropower resources.

Energy Trust also collaborated with Pacific Power and PGE on their RFPs for new energy resources. PGE's selection of the 75 MW expansion to the Klondike Wind Farm near Wasco, Oregon is a result of one of the collaborations. The project, consisting of 50 1.5 MW GE turbines, came on line at the end of 2005. It produces enough energy to supply electricity to more than 18,000 homes. Energy Trust is working with PGE and Pacific Power to select more large-scale renewable projects in 2006 and 2007.

The Energy Trust website is: http://www.energytrust.org/.

3.4.2 Climate Trust

For a project that satisfies a detailed set of criteria, including additionality, monitoring and verification, guarantees of performance and others, the Climate Trust may invest in a renewable generation project and take title to the carbon offset credits. The Trust is not currently accepting RFPs, but at various times they are in a position to do so. If the criteria can be met, and it can be shown that the project would not have happened but for Climate Trust funding, this may be a way to secure partial project funding.

The Climate Trust website is: http://www.climatetrust.org/.

3.4.3 Bonneville Environmental Foundation

The Bonneville Environmental Foundation (BEF) was founded in 1998 to support watershed restoration programs and develop new sources of renewable energy. Funding for these efforts has been provided in a way that would be called unusual for most foundations. BEF, a non-profit organization, markets green power products to public utilities, businesses, government agencies and individuals. BEF strives to promote innovation in project finance and design, and to increase the visibility of clean, renewable, distributed energy generation technologies through education and community outreach. BEF's assistance may take the form of a grant, an equity position, or project management.

Projects that generate electricity (or thermal energy) are the focus of BEF's renewable program. The Foundation's priority is to fund new environmentally low-impact wind, geothermal, solar (including solar hot water heating), hydroelectric and certain biomass and waste to energy projects. To date, BEF has funded 15 projects in Oregon. Of these, 14 have been solar energy projects and one was an animal waste to energy project. Ten of the solar projects were at school facilities.

More information is available at: http://www.b-e-f.org/index.shtm.

3.5 Forest Biomass Energy Development Projects Underway in Oregon

3.5.1 Lakeview

The Lakeview Biomass Project supports forest health with a management plan for ecological restoration of the forest while also creating an opportunity for economic growth in the area. The project is a 15MW biomass power plant that would supply energy to Collins Company mill in Lakeview, and additional power to the grid. In addition, the project includes financial assistance/incentives and long term agreements for fuel supply.

Key partners include Collins, USDA Forest Service, Friends of the Winema/Fremont, and Defenders of Wildlife. By collaborating with public and private partners using the Oregon Solutions process, the Lakeview Biomass Project has the potential to become a model for other communities across the state. Lake County Resources Initiative is the project sponsor.

In 2002, CH2MHill completed a feasibility study and business plan for the Lakeview Biomass Project. The business plan identified three areas that had to be addressed to make a biomass energy plant in Lakeview viable:

- Open loop biomass had to receive the same federal renewable energy production credits as wind, solar and closed loop biomass;
- Goods for service under new federal stewardship contracts had to substantially reduce fuel costs to the plant;
- Establish a forest carbon credit system to assist in paying for fuel reduction treatments.

EPAct 2005 provided the federal renewable energy production credits for open loop biomass. The University of Washington and Yale University developed a system using the Fremont National Forest for calculating forest carbon credits based on reduction of catastrophic fire events. The West Coast Carbon Sequestration Partnership has contracted with Winrock International, Oregon State University, LCRI and Oregon Department of Forestry to begin field tests to verify the models developed by the Universities.

Mater Engineering has been hired to develop a Coordinated Resource Offering Protocol (CROP) within a 100 mile radius of Lakeview. This agreement will provide a levelized and reliable supply from Federal, State, private and tribal wood sources including juniper. The CROP analysis is projected to be completed by the end of March 2006. The Governor declared the Lakeview Biomass Project an Oregon Solutions Project with Hal Salwasser, Dean of the College Forestry, OSU and J.R. Stewart, Lake County Commissioner, as co-conveners of the project.

In December 2005, the Lakeview Stewardship Group, comprised of environmental groups, The Collins Company and local leaders completed the Long-range Strategy for the Federal Lakeview Stewardship Unit (http://www.lcri.org). The strategy outlines treatments agreed to for the Unit and how a biomass plant can be a tool to achieve the goals of the Unit.

In January 2006, State and Federal agencies, private businesses, and key environmental groups signed the Declaration of Cooperation, identifying what they could do to move the project forward (see http://www.orsolutions.org).

3.5.2 Central and SW Oregon

Recently, the Oregon Governor's Office, USDA Forest Service, BLM, Oregon Economic & Community Development Department, Sustainable Northwest and many others signed a commitment to support the Central Oregon Coordinated Resource Offering Protocol (CROP). Discussions are focusing on specific geographic areas, in particular central and southwest Oregon. Other options include establishing a focal point for tracking contracts, labor resources and skills available for biomass recovery, and aligning efforts with the PNW Research Station and others to incorporate R&D efforts into regional activities.

3.5.3 Warm Springs

The Confederated Tribes of Warm Springs are working toward establishing a renewable energy project on the Tribe's Reservation. This proposed cogeneration project would supply steam and power for use on site at the Tribes' sawmill enterprise – Warm Springs Forest Products Industries (WSFPI). Power generated in excess of the sawmill's needs would be sold under a long-term contract to a utility purchaser. WSFPI's long term economic viability would benefit from the diversified revenue generated as a result of this renewable energy project. This sawmill enterprise currently employs 135 persons.

WSFPI seeks to develop a new 15.5 MW (net generation) cogeneration facility requiring 150,000 bone dry tons (BDT) of biomass fuel per year to operate (12,500 truckloads per year).

- About half the fuel would come from Reservation controlled sources (mill waste and forest fuels reduction activities on CTWS Reservation) and urban wood transported on a backhaul from Portland area. The other half will have to come from off-Reservation sources. The project needs about 8,000 acres per year of off Reservation material assuming 10 BDT per acre.

- The total estimated capital cost to construct on-site at WSFPI is $25 million. The project will add a minimum of 50 – 70 jobs, mostly in the forest – harvesting, collecting, processing and transporting biomass fuel.

- Phase 1 of the project was the construction of a new boiler. This unit became operational at the end of 2005. Phase 2 and 3 is a second new boiler and new power generation equipment, planned for start-up in October 2007.

- The project needs an unsubsidized power rate of between 8 to 9 cents per kilowatt hour (kWh) to be profitable.

- Small logs will be removed as part of hazardous fuels reduction projects. WSFPI will modify current sawmill configuration to efficiently and cost effectively process small logs (5" to 7" diameter inside bark). The current mill does not process 5" to 7" DIB logs efficiently. $4 million investment required to modify sawmill for small log utilization, and the modifications will add 20 jobs per shift.

- The project will need a sustainable supply of small logs of 11 million bd. ft. per shift per year to consider capital investment to modify current saw mill. Thinning stands of up to 16 inches can partially offset cost of biomass thinning. The cost to accomplish forest fuels reduction without sawlog removals may be between $300 to $600/acre.

The Warm Springs Tribe recently signed an MOU with the Forest Service and BLM for access to 8,000 acres of off-reservation land for fuel reduction treatment and juniper removal adding up to about 80,000 BDT per year. In addition, the Tribe is in contact with wholesale power purchasers about buying the output of the co-gen plant.

3.5.4 LaPine

The LaPine project is a proposed stand-alone 24 MW biomass fueled power plant. Vulcan Power, the project developer, is negotiating for stewardship contracts with the federal land management agencies. Located in an industrial park in LaPine, the developers are also looking for manufacturers that could use small diameter trees to co-locate with their proposed facility to help defray shipping costs for fuel.

3.5.5 Sisters

One project looking to take advantage of the CROP agreement is possible biomass to heat and electricity proposal in Sisters. Originally a "Fuels for School" style effort, project proponents have recently applied for a Healthy Forests, Healthy Communities (HFHC) grant to look at project feasibility. The biomass plant would use material government agencies are already taking out of forests as part of fire prevention efforts to provide heat and electricity for the local Middle and High Schools, and possibly other public buildings in the future. Cindy Glick, assistant silviculturist for the Ochoco and Deschutes National Forests is a contact.

3.5.6 Prineville

The Woodard Co. is looking to relocate an existing mill from Yakima and use it for small diameter trees. The development would include wood-fired kilns, and is expected to be completed in the next 12 months.

3.5.7 Wallowa

Wallowa Resources is in the exploratory stages of developing a biomass project. The two main goals of the project are:

- Improved use of available biomass, creating jobs and opportunities, and
- Reaching agreements on forest land use policies to improve the value of existing assets.

Wallowa Resources recently applied for a USDA Rural Business Enterprise Grant (RBEG) to look at the feasibility of expanding beyond current operations to products made from small diameter logs, and perhaps a renewable fuels or co-gen facility. The company is discussing strategies for future development with the National Renewable Energy Lab, the Biomass Energy Resource Center in Vermont and others.

3.6 Forest Biomass Efforts in Other States

An exhaustive analysis of all of the various efforts related to biomass energy in other states is beyond the scope of this report. Fortunately, there are two readily available and continually updated sources of information available on the web. The Database of State Incentives for Renewable Energy and Alternative Fuels Data Center provide much information on efforts to promote alternative energy and transportation fuels at the state level. We also briefly describe recent biofuels legislative initiatives across the country, with emphasis on the northwestern states and California.

3.6.1 Database of State Incentives for Renewable Energy

The Database of State Incentives for Renewable Energy (DSIRE) is a comprehensive source of information on state, local, utility, and selected federal incentives that promote renewable energy. Established in 1995, the Database of State Incentives for Renewable Energy (DSIRE) is an ongoing project of the Interstate Renewable Energy Council (IREC), funded by the U.S. Department of Energy and managed by the North Carolina Solar Center.

DSIRE categorizes incentives for renewable energy into two main types: (1) Financial Incentives and (2) Rules, Regulations, and Policies. The following section provides a description of each incentive type in these two categories. Following these descriptions, Table 4 summarizes the incentives available in each state. Table 5 summarizes the rules, regulations and policies in place by state.

Financial Incentives

Corporate Tax Incentives – allow corporations to receive credits or deductions ranging from 10% to 35% against the cost of equipment or installation to promote renewable energy equipment. In some cases, the incentive decreases over time. Some states allow the tax credit only if a corporation has invested a certain dollar amount into a given renewable energy project. In most cases, there is no maximum limit imposed on the amount of the deductible or credit.

Direct Equipment Sales – A few utilities sell renewable energy equipment to their customers as part of a buy-down, low-income assistance, lease, or remote power program.

Grant Programs – States offer a variety of grant programs to encourage the use and development of renewable energy technologies. Most programs offer support for a broad range of renewable energy technologies, while some states focus on promoting one particular type of renewable energy such as wind technology or alternative fuels.

Grants are available primarily to the commercial, industrial, utility, education, and government sectors. Some grant programs focus on research and development, while others are designed to help a project achieve commercialization. Programs vary in the amount offered--from $500 to $1,000,000--with some states not setting a limit.

Industrial Recruitment Incentives – This category focuses on special efforts and programs designed to attract renewable energy equipment manufacturers to locate within a state or city. Renewable energy industrial recruitment usually consists of financial incentives like tax credits, grants, or a commitment to purchase a specific amount of the product for use by a government agency.

The recruitment incentives are designed to attract industries that will benefit the environment and create jobs. In most cases, the financial incentives are temporary measures that will help support the industries in their early years but include a sunset provision to encourage the industries to become self-sufficient within a number of years.

Leasing/Lease Purchase Programs – Utility leasing programs target remote power customers for which line extension would be very costly. The customers can lease the technology, e.g., photovoltaics, from the utility, and in some cases, the customer can opt to purchase the system after a specified number of years.

Loan Programs – offer financing for the purchase of renewable energy equipment. Low-interest or no-interest loans for energy efficiency are a very common strategy for demand-side management by utilities. State governments also offer loans to assist in the purchase of renewable energy equipment. A broad range of renewable energy technologies are eligible. In many states, loans are available to residential, commercial, industrial, transportation, public, and nonprofit sectors. Repayment schedules vary; while most are determined on an individual project basis, some offer a 7-10 year loan term.

Personal Income Tax Incentives – Many states offer personal income tax credits or deductions to cover the expense of purchasing and installing renewable energy equipment. Some states offer personal income tax credits up to a certain percentage or predetermined dollar amount for the cost or installation or renewable energy equipment. Allowable credit may be limited to a certain number of years following the purchase or installation or renewable energy equipment. Eligible technologies may include solar and photovoltaic energy systems, geothermal energy, wind energy, biomass, hydroelectric, and alternative fuel technologies.

Production Incentives – Production incentives provide project owners with cash payments based on electricity production on a $/kWh basis, as is the case with the Federal Renewable Energy Production Incentive, or based on the volume of renewable fuels produced on a $/gallon basis, as is the case with a number of state ethanol production incentives. Payments based on performance rather than capital investments can often be a more effective mechanism for ensuring quality projects.

Property Tax Incentives – typically follow one of three basic structures: exemptions, exclusions, and credits. The majority of the property tax provisions for renewable energy follow a simple model that provides the added value of the renewable device is not included in the valuation of the property for taxation purposes. That is, if a renewable energy heating system costs $1,500 to install versus $1000 for a conventional heating system, the renewable energy system is assessed at $1000.

Property taxes are collected locally, so some states allow the local authorities the option of providing a property tax incentive for renewable energy devices. Six states have such provisions: Connecticut, Iowa, Maryland, New Hampshire, Vermont, and Virginia.

Rebate Programs – are offered at the state, local, and utility levels to promote the installation of renewable energy equipment. The majority of programs are available from state agencies and municipally-owned utilities and support solar water heating and/or photovoltaic systems. Eligible sectors usually include residents and businesses, although some programs are available to industry, institutions, and government agencies as well. Rebates typically range from $150 to $4000. In some cases, rebate programs are combined with low or no-interest loans.

Sales Tax Incentives – typically provide an exemption from the state sales tax for the cost of renewable energy equipment.

Rules, Regulations & Policies

Construction and Design Policies – include state construction policies, green building programs, and energy codes. State construction policies are typically legislative mandates requiring an evaluation of the cost and performance benefits of incorporating renewable energy technologies into state construction projects such as schools and office buildings. Many cities are developing "Green Building" guidelines that require or encourage consideration of renewable energy technologies.

Some guidelines are voluntary measures for all building types, while others are requirements for municipal building projects or residential construction. Local energy codes are used to achieve energy efficiency in new construction and renovations by requiring that certain building projects surpass state requirements for resource conservation. Incorporating renewables is one way to meet code requirements.

Contractor Licensing – Many states have rules regarding the licensing of renewable energy contractors. Contractor licensing requirements can be enacted for solar water heat, active and passive solar space heat, solar industrial process heat, solar thermal electricity, and photovoltaics. These requirements--where they do exist--are designed to ensure that contractors have the necessary experience and knowledge to properly install systems.

Equipment Certifications – Statutes requiring renewable energy equipment to meet certain standards are generally seen as a tool for reducing the chance that consumers will be sold inferior equipment. Beyond being a consumer protecting measure, equipment certification benefits renewables by reducing the number of problem systems and the resulting bad publicity.

Generation Disclosure Rules – "Disclosure" typically refers to the requirement that utilities provide their customers with additional information about the energy they are supplying. This information often includes fuel mix percentages and emissions statistics. Fuel mix information, for example, can be presented as a pie chart on customers' monthly bills. "Certification" is a related issue which refers to the assessment of green power offerings to assure that they are indeed utilizing the type and amount of renewable energy as advertised. One example of green power certification is the Green-e stamp.

Both disclosure and certification are designed to help consumers make informed decisions about the energy and supplier they choose. It is worth noting, though, that two states that have not moved ahead with restructure--Florida and Colorado--have enacted disclosure provisions. Indeed, disclosure is often thought of as a good policy to help educate customers about electricity and thereby to prepare markets in advance of retail competition.

Green Power Purchasing/Aggregation Policies – Municipalities, state governments, businesses, and other non-residential customers can play a critical role in supporting renewable energy technologies by buying electricity from renewable resources. At the local level, green power purchasing can mean buying green power for municipal facilities, streetlights, water pumping stations and the like. Several states require that a certain percentage of electricity purchased for state government buildings come from renewable resources. A few states allow local governments to aggregate the electricity loads of the entire community to purchase green power and even to join with other communities to form an even larger green power purchasing block. This is often referred to as "Community Choice". Green power purchasing can be achieved via utility green pricing programs, green power marketers (in states with retail competition), special contracts, or community aggregation.

Line Extension Analysis – When an electric customer requests service for a location not currently serviced by the electric grid, they are charged a distance-based fee for the cost of extending power lines to their load. In many cases it is cheaper to have an on-site renewable energy system to meet their electricity needs. Certain states require utilities to provide their customers with information on renewable energy options when a line extension is requested.

Net Metering Rules – For those consumers who have their own electricity generating units, net metering allows for the flow of electricity both to and from the customer through a single, bi-directional meter. With net metering, during times when the customer's generation exceeds his or her use, electricity from the customer to the utility offsets electricity consumed at another time. In effect, the customer is using the excess generation to offset electricity that would have been purchased at the retail rate. Under most state rules, residential, commercial, and industrial customers are eligible for net metering, but some states restrict eligibility to particular customer classes.

Public Benefit Funds – Public Benefit Funds (PBF) are typically state-level programs developed through the electric utility restructuring process as a measure to assure continued support for renewable energy resources, energy efficiency initiatives, and low-income support programs. (These funds are also frequently referred to as a system benefits charge, or SBC). Such a fund is most commonly supported through a charge to all customers on electricity consumption, e.g., 0.2

cents/kWh. Examples of how the funds are used include: rebates on renewable energy systems; funding for renewable energy R&D; and development of renewable energy education programs.

Renewable Portfolio Standards/Set Asides – Renewable Portfolio Standards (RPS) require that a certain percentage of a utility's overall or new generating capacity or energy sales must be derived from renewable resources, i.e., 1% of electric sales must be from renewable energy in the year 200x. Portfolio Standards most commonly refer to electric sales measured in megawatt-hours (MWh), as opposed to electric capacity measured in megawatts(MW). The term "set asides" is frequently used to refer to programs where a utility is required to include a certain amount of renewables capacity in new installations.

Required Utility Green Power Option – A handful of states require certain classes of utilities to offer customers the option to purchase power generated from renewable sources. Typically, utilities may provide green power using renewable resources they own or for which they contract; or they may purchase credits from a renewable energy provider certified by the state's Public Utilities Commission.

Solar and Wind Access Laws – These statutes provide for solar or wind easements or access rights. Easements allow for the rights to existing access to a renewable resource on the part of one property owner to be secured from an owner whose property could be developed in such a way as to restrict that resource. This easement is transferred with the property title. Access rights, conversely, automatically provide for the right to continued access to a renewable resource. Solar easements are the most common type of state solar access rule. Furthermore, some states prohibit neighborhood covenants that preclude the use of renewables.

At the local level, communities use many different mechanisms to protect solar access, including solar access ordinances, development guidelines requiring proper street orientation, zoning ordinances that contain building height restrictions, and solar permits.

Table 4 – Available financial incentives for renewable energy by State (Source: DSIRE Database 2/23/2006)

State/Territory	Personal Tax	Corporate Tax	Sales Tax	Property Tax	Rebates	Grants	Loans	Industry Recruit.	Leasing/ Sales	Production Incentive*
Alabama	1-S					1-S				
Alaska							1-S			1-U
Arizona	2-S		1-S		4-U					
Arkansas										
California	1-S			1-S	2-S,15-U,2-L	1-L	1-U		1-U	1-S
Colorado					3-U, 1-L		1-U, 1-L			1-L
Connecticut				1-S	1-S	4-S	3-S			
Delaware					1-S	2-S				
Florida			1-S		2-U					
Georgia										1-U
Hawaii	1-S	1-S			2-U		1-U, 2-L	1-S		
Idaho	1-S		1-S			2-P	1-S			
Illinois				1-S		1-P				
Indiana				1-S		4-S				
Iowa	1-S	1-S	1-S	3-S		1-S	2-S			
Kansas				1-S		1-S				
Kentucky							1-P			
Louisiana				1-S						
Maine					1-S	1-S				
Maryland	1-S	1-S	1-S	2-S	1-S, 1-L		2-S			
Massachusetts	2-S	3-S	1-S	1-S	1-S	2-S	1-S			1-S, 1-P
Michigan				1-S		4-S	1-S	3-S		
Minnesota			2-S	1-S	1-S, 2-U	1-U	3-S			1-S, 3-U
Mississippi							1-S			1-U
Missouri		1-S				1-S	1-S			
Montana	2-S	1-S		3-S		2-P, 1-U	1-S			
Nebraska							1-S			
Nevada			1-S	3-S	1-S					1-S
New Hampshire				1-S						
New Jersey			1-S		1-S	2-S	1-S			1-S
New Mexico		1-S	1-S			2-S				1-U
New York	2-S	1-S	1-S	1-S	3-S, 1-U	1-S	2-S	2-S		
North Carolina	1-S	1-S		1-S			1-S	1-S		1-U, 1-P
North Dakota	1-S	1-S	1-S	2-S						
Ohio		1-S	1-S	1-S		1-S	1-S	2-S		
Oklahoma		1-S						1-S		
Oregon	1-S	1-S		1-S	2-S , 6-U	2-P, 1-S	1-S, 4-U			1-P
Pennsylvania					1-L	2-S, 5-L	1-S, 5-L			1-U
Rhode Island	1-S		1-S	1-S	2-S	1-S				1-S, 1-P
South Carolina					1-S					
South Dakota				2-S						
Tennessee				1-S			1-S			1-U
Texas		1-S		1-S	2-U			1-S	1-U	
Utah	1-S	1-S	1-S							
Vermont			1-S		1-S	1-U				1-U
Virginia				1-S		1-S		1-S		
Washington			1-S		7-U	2-P	5-U	1-S		2-U, 1-P, 1-S
West Virginia		1-S		1-S						
Wisconsin				1-S	1-S, 1-U	2-S	1-S, 1-U			1-U
Wyoming			1-S		1-S				1-U	
District of Columbia						1-S				
Puerto Rico	1-S		1-S							
Totals	20	18	20	35	71	53	49	13	3	27

= Number of programs S = State, , L = Local, U = Utility, P = Non-profit
* In addition to these incentives, some private renewable energy credit (REC) (also know as green tag) marketers provide production-based incentives to renewable energy project owners. See http://www.eere.energy.gov/greenpower/markets/certificates.shtml?page=2 for more information about REC marketers.
Note: This table does not include incentives for renewable fuels and vehicles. For these incentives, go to http://www.eere.energy.gov/afdc/laws/incen_laws.html

Table 5 – Rules, regulations and policies for renewable energy by State (Source: DSIRE Database 2/23/2006)

State/ Territory	PBF	Dis-closure	RPS	Net Meter-ing	Inter-connection	Exten-sion Analysis	Contract-or License	Equip-ment Certifi-cation	Access Laws	Construction & Design Standards	Green Power Purchase	Required Green Power
Alabama												
Alaska									1-S			
Arizona		1-S	1-S	2-U	1-U	1-S	1-S	1-S	1-S	2-S, 2-L	1-L	
Arkansas				1-S	1-S			1-S				
California	1-S	1-S	1-S	1-S	1-S		1-S		2-S, 8-L	1-S, 9-L	5-L	
Colorado		1-S	1-S, 1-L	1-S, 4-U	1-S, 2-U	1-S	1-L		1-S, 2-L	3-L	2-L	
Connecticut	1-S	1-S	1-S	1-S	1-S		1-S				1-S	
Delaware	1-S	1-S	1-S	1-S	1-S							
Florida		1-S	1-U	2-U	1-S		1-S	1-S	1-S, 1-L	1-S		
Georgia				1-S	1-S				1-S			
Hawaii			1-S	1-S	1-S		1-S		1-S	1-S		
Idaho				3-U	2-U				1-S			
Illinois	1-S	1-S	1-S	1-U	1-U					1-L	1-S, 1-L	
Indiana				1-S	1-S				1-S			
Iowa		1-S	1-S	1-S	1-S				1-S		1-S	1-S
Kansas					1-S				1-S			
Kentucky				1-S	1-U				1-S			
Louisiana				1-S	1-S			1-S				
Maine	1-S	1-S	1-S	1-S				1-S	1-S		1-S	
Maryland		1-S	1-S	1-S	1-S				1-S	1-S	1-S, 2-L	
Mass.	1-S	1-S	1-S	1-S	1-S				1-S		1-L	
Michigan		1-S		1-S	1-S		1-S					
Minnesota	1-S	1-S	2-S	1-S	1-S			1-S	1-S	1-S		1-S
Mississippi												
Missouri			1-L		1-S				1-S			
Montana	1-S	1-S	1-S	1-S, 1-U	1-S				1-S			1-S
Nebraska									1-S			
Nevada		1-S	1-S	1-S	1-S		1-S		1-S	2-S		
New Hamp.				1-S	1-S				1-S			
New Jersey	1-S	1-S	1-S	1-S	1-S				1-S		1-S	
New Mexico			1-S	1-S	1-S	1-S			1-S			1-S
New York	1-S	1-S	1-S	1-S	1-S				1-S		1-S, 1-L	
N. Carolina				1-S	1-S				1-L	1-L		
N. Dakota				1-S					1-S			
Ohio	1-S	1-S		1-S, 1-U	1-S				1-S			
Oklahoma				1-S								
Oregon	1-S	1-S		1-S, 1-L	1-S				1-S, 2-L	2-L	1-L	
Penna.	1-S	1-S	1-S	1-S	1-S						1-S	
Rhode Island	1-S	1-S	1-S	1-U	1-S				1-S			
S. Carolina											3-L	
S. Dakota												
Tennessee									1-S			
Texas		1-S	1-S, 1-L	1-S, 2-U	1-S	1-S				1-S		
Utah				1-S	1-S		1-S		1-S		1-L	
Vermont		1-S	1-S	1-S	1-S							
Virginia		1-S		1-S	1-S				1-S, 1-L			
Washington		1-S		1-S, 1-U	1-S				1-S	1-L	2-L	1-S
W. Virginia												
Wisconsin	1-S		1-S	1-S	1-S		1-L	1-L	1-S, 1-L	1-L	1-L	
Wyoming				1-S	1-S							
D.C	1-S	1-S	1-S	1-S	1-S							
Guam										1-S		
Puerto Rico								1-S				
Totals	16	26	28	55	43	4	10	8	50	31	29	5

= number of rules, policies S = State, L = Local, U = Utility

3.6.2 Alternative Fuels Data Center

An on-line database similar to DSIRE is also available for alternative transportation fuels. The Alternative Fuels Data Center (AFDC) is an online collection of data, including more than 3000 documents and several interactive tools covering the topics of alternative transportation fuels, alternative fuel vehicles, hybrid electric vehicles, idle reduction technologies, fuel blends, and fuel economy. The AFDC is sponsored by the U. S. Department of Energy's Clean Cities and Energy Policy Act of 1992 (EPAct) fleet programs. Because this data is both very extensive and rapidly changing we have not attempted to summarize it here.

The AFDC web site is located at: http://www.eere.energy.gov/afdc/.

3.6.3 Recent State Biofuels Legislation

A number of state legislatures have taken up measures relating to biomass energy and biofuels. Key among these has been proposals for Renewable Fuels Standards (RFS). RFS legislation has been proposed recently in a number of states including Oregon, Washington, Idaho, Colorado, New Mexico, Iowa, Illinois and Missouri. RFS are similar in concept to Renewable Portfolio Standards for production of electricity but apply instead to transportation fuels. The goal of an RFS is to create a market for alternative fuels by mandating use within the state. Minnesota, Montana, Hawaii, and – most recently – Washington, are the only states that have successfully enacted a Renewable Fuels Standard. Oregon considered an RFS in HB 3481 during the 2005 legislative session but it was subsequently removed from the bill. Idaho's senate passed an ethanol fuel standard which was killed in the House. Recent state RFS legislation is summarized in Table 6.

Washington Governor Christine Gregoire signed legislation creating an RFS there on March 30, 2006. Senate Bill 6508 establishes an alternative fuels market in Washington by requiring an increasing percentage of the state's fuel supply to be renewable biofuels. The law is expected to spur the development of an alternative fuels production industry in the State.

The Washington Legislature intends that consumers have a choice of fuels ranging from zero renewable content to completely renewable fuel. At least 2% of total annual diesel fuel sales must be biodiesel fuel sales whenever the earlier of two events occur: (1) The Dept. of Agriculture (DOA) determines that feedstock grown in Washington can satisfy the 2% requirement; or (2) on November 30, 2008. The reporting level rises to 5% of biodiesel sales when the state determines that both in-state oil seed crushing capacity and feedstock grown in Washington can satisfy 3% of total annual diesel fuel sales. Beginning December 1, 2008, at least 2% of all gasoline sold in Washington must be denatured ethanol. All gasoline sold in Washington must contain higher percentages of denatured ethanol if the Department of Ecology determines that ethanol content greater than 2% will not jeopardize continued attainment of federal Clean Air Act standards, and the DOA determines that sufficient raw materials are available within Washington to support economical production of ethanol at higher levels.

Table 6 – Recent state legislative initiatives on renewable fuels standards.

State	***Level***	***Date***	Enacted
Minnesota	E10 E20	Current 2013	Yes
Hawaii	E10	2006	Yes
Montana	E10	When state achieves min. production level	Yes
Washington	Ethanol: 10% total sales Biodiesel: 5% total sales	When state demonstrates sufficient in-state production	Yes
Colorado	E10 E20	2009 2013	No
Illinois	Ethanol: 10% total sales Ethanol: 15% total sales	2008 2012	No
Idaho	E10 (S.B. 1364) B2 (S.B. 1393)	When state is producing 30 million gallons of ethanol and 4 million gallons of biodiesel annually	No
Iowa	25% of total sales	2015	No
Kansas	E10 B2	2010	No
Missouri	E10	2010	No
New Mexico	E10 B2	2009	No
Oregon	E10 B2	When state is producing 90 million gallons of ethanol and 5 million gallons of biodiesel annually	No

Source: www.greencarcongress.com (4/11/2006), updated from various legislative sources.

Many are surprised to learn that California does not have a RFS despite its long promotion of ethanol fuel. However, state agencies, through the Bioenergy Interagency Working Group, are working to develop a state policy on biomass and biofuels, including a recommended RFS. A draft report issued in March, 2006 recommends that California establish a RFS targeting consumption of 2 billion gallons of biofuels by 2020 with a minimum of 40% produced in California[3].

[3] *Recommendations for a Bioenergy Action Plan for California.* Draft Consultant Report prepared for the Bioenergy Interagency Working Group by Navigant Consulting. CEC-600-2006-004-D. March, 2006.

3.7 Summary

Clearly, there is a significant and growing effort behind the promotion and development of renewable energy in general in Oregon. This includes opportunities to convert woody biomass from Oregon's forest resources to both power and transportation fuels. Within Oregon, these efforts are rising from the ground up – in communities like Lakeview, Klamath Falls, Wallowa and Bend – and from the top down from the Governor's office, state legislators, and from key agencies. Motivations include environmental benefits like clean air and water, healthy forests and economic and social benefits such as rural development and job creation, energy independence and even national security.

At the state level, we have reviewed the current status of:

- Policy and legislation
- Working Groups and initiatives
- Agency activities
- Research and Development efforts

These are supported at the federal level by federal policies, a variety of incentive and grants programs as well as research and development, and also by various private sector efforts.

How effective will these efforts be and what are the existing gaps that need to be filled?

3.7.1 Effectiveness of Efforts, Gaps and Opportunities

A comprehensive review of the effectiveness of every program and policy listed here is well beyond the capabilities of this project; however, we offer these general observations based on our experiences researching the information presented here, feedback from stakeholders and others we have talked to, and a few other published reports.

3.7.1.1 State Programs

- Our first observation is that there is an impressive array of activity at the state level and we believe that Oregon is on the right track. It is evident that renewable energy is a top priority of the Governor's Office and agencies are responding. This includes woody biomass.

- Oregon has many of the policies in place to promote renewable energy and is actively working on developing missing components such as a Renewable Portfolio Standard. Oregon's Business Energy Tax Credit is among the most generous of its kind.

- It is too early to evaluate the effectiveness of the hierarchy of Working Groups outlined in Section 3.2.2. The groups have been in place a relatively short time.

    - The Forest Biomass Working Group seems to be progressing faster than the Agricultural Biomass and Urban Biomass Working Groups, as well as the Biomass Coordinating Group. It is important to make progress on the agriculture and urban waste fronts because all sources of biomass will be needed and the combined synergies will strengthen the entire biomass energy industry.

- Representation on the Working Groups by agencies that should be involved appears to be generally good. However, we suggest that an executive level representative from the Oregon Department of Fish & Wildlife (ODFW) be added to the Renewable Energy Working Group or Oregon Biomass Coordinating Group. These groups are formulating policy that may have a significant effect on fish and wildlife habitat; ODFW needs to be represented at the table.

- Long term effectiveness will require continued communication and coordination between groups and on-going support and attention from agency heads. Otherwise, efforts may receive too little attention and could possibly founder.

- It is important that all State agencies recognize the priority placed on renewable energy. All agencies, including regulatory agencies, should make this a long term priority. Each agency's direction ought to be to figure out the right way to use biomass and recognize the broader environmental and economic benefits.

- We suggest that Oregon Progress Board benchmarks are needed to measure progress on:

    - Forest restoration and health
    - Renewable energy development
    - Biomass use

  This provides the agency heads with an important incentive to make these issues a priority within their agencies and allows the state to consistently measure progress toward these goals.

3.7.1.2 <u>Federal Programs</u>

- With regard to federal programs, we observed that there is a bewildering array of grant and incentives programs available, but they can be quite confusing and intimidating to the potential user and, perhaps as a result, not all have been utilized in Oregon. Arising from a variety of legislation over time, the various grant programs are housed and managed by many different agencies and offices. While information is available on the internet, it can be difficult to find and confusing to sort through for the uninitiated. There is no single source of information available on alternative programs, their uses and goals, and conditions. Sometimes, the same program is referred to by multiple different names. A major need is to develop a "one stop" information center that organizes and explains each program. More visibility is also needed; the programs should be more actively promoted to potential applicants.

- We have attempted to document the use of federal grant programs in Oregon where we could get information. The most heavily used grants programs are the USFS Woody Biomass Grants (Section 3.3.2.4) and Economic Action Program (Section 3.3.2.5). Grant programs that have not been tapped in Oregon for woody biomass projects, as best we can determine, include the Joint Biomass R&D Initiative (Section 3.3.2.2), Fuels Utilization & Marketing Program (Section 3.3.2.3) and USDA Section 9006 and 6401 grants (Section 3.3.2.6).

- A recent GAO report assessed the effectiveness of federal efforts aimed at promoting the use of woody biomass, from the perspective of user's experiences (GAO 2006). Some of the key findings of that report include the following:

  - Users cited insufficient biomass supply, increased equipment and maintenance costs, and other factors that limited their use of woody biomass or made it more expensive or difficult to use.

  - Users in locations close to federal lands reported difficulty obtaining biomass from federal lands. Users with this problem expressed concern about the Forest Service's ability to conduct projects generating woody biomass, and two expressed skepticism that the large amounts of woody biomass expected from widespread thinning activities will ever materialize.

  - Because one goal of federal efforts to stimulate woody biomass use is to defray the cost to the government of thinning millions of acres of land at risk of wildfire, government efforts must focus on finding uses specifically for these small diameter trees. Otherwise, efforts to stimulate biomass use may simply increase the use of other woody biomass, such as mill residues, rather than biomass from thinning.

  - Government efforts may be more effective if they take into account the extent to which a logging and milling infrastructure is in place in potential user's locations.

  - Government activities may be more effective if they are tailored to the scale and nature of the users being targeted.

    Federal agencies must take care that their efforts are appropriately aligned with the agencies' own interests and that they do not create unintended consequences. The agencies risk adverse ecological consequences if their efforts to develop markets for woody biomass result in these markets inappropriately influencing land management decisions. Efforts to supply woody biomass in response to market demand rather than ecological necessity might result in inappropriate or excessive thinning.

- Forest Stewardship contracting is another major program area within the federal land management agencies. The application of the contracting authority by the agencies is rapidly changing as they gain experience. Two reviews of stewardship contracting are GAO (2004) and National Forest Foundation (2005). Our major comments are as follows:

  - The findings of the GAO reports (GAO 2004; GAO2006) are applicable to forest stewardship contracting by the USFS and BLM.

  - Previous stewardship contracts in Oregon have generally not been of the size and scope that would be required to attract investments in biomass energy development.

  - Some means of offering supply assurance, either through performance bonds or loan guarantees, need to be considered to reduce the risk to investors.

- Performance goals regarding forest restoration within the USFS are based on acreage treated and cost. As a result, the agency is incented to treat the lowest cost acreage rather than the areas most needing treatment from an ecological or fire management perspective. Prescribed fire is a lower cost option than mechanical treatment and so is favored under current performance measures.

  Better targets would look at how many acres are improved (e.g., condition class 3 to condition class 1) and at how much product (biomass, small diameter thinning, etc.) is being productively used. The BLM has recently begun reporting biomass volume offered to the market as a performance measure, which should encourage increased utilization. Agency performance measures should be modified to ensure that the right acres, as determined through collaborative efforts, are treated and biomass is utilized when appropriate and possible.

- Finally, research and development activities are critically important.

  - Federal research spending on renewable energy has been only a fraction of that spent on traditional, fossil fuels and nuclear energy over the last 30 years, as we outline in Section 5.5.2. Although spending now is moving in the right direction, renewables still received less than 20% of the DOE spending in FY2004. Breakthroughs in cellulosic ethanol production are critical and should be funded appropriately.

  - The USFS Forest Products Lab and Research Stations play an important role, specifically in research on woody biomass and related subjects such as harvesting technologies, alternative small diameter products, economics and supply modeling. These are important programs that should receive priority.

  - The Sun Grant Center and Wood Innovation Center at OSU are key R&D assets in Oregon and should be leveraged to the maximum extent possible to solve problems related to woody biomass energy conversion technology and biomass harvesting. OSU College of Forestry researchers should continue to focus attention on forest restoration and fuel treatment research questions.

Literature Cited

General Accountability Office. 2004. Additional guidance on community involvement could enhance effectiveness of stewardship contracting. GAO-04-652. June.

General Accountability Office. 2006. Woody biomass users' experiences offer insights for government efforts aimed at promoting its use. GAO-06-366. March.

National Forest Foundation. 2005. 2005 Stewardship contracting roundtable: USFS Region 6. Prepared by National Forest Foundation in partnership with Sustainable Northwest. December 30.

Chapter 4
Stakeholder Opinions

4.1 Introduction

Recently there has been growing momentum behind the idea of using the byproducts of forest restoration thinning projects as a source of renewable energy. Because it incorporates forest health objectives, renewable energy, and potential revitalization of rural economies, the idea has been characterized by some as a win-win-win policy direction. While a variety of studies have examined the technical feasibility of converting forest biomass to energy in Oregon, few have asked stakeholders[1] their opinions on this policy direction. This study had two purposes: first, to understand stakeholders' views on converting forest biomass to energy in Oregon. Second, to identify, from the perspectives of stakeholders, the barriers to and opportunities for converting forest biomass to energy, potential strategies that could be employed to overcome the barriers, and guidelines that should be in place if this policy direction continues to move forward.

4.2 Methods

Forty stakeholder interviews were conducted between March 3 and April 26, 2006. Individuals who were known by the researchers to have an interest or expertise in forests, forest biomass, renewable energy and/or rural economic development were intentionally selected from nine stakeholder groups (Table 1). The sample of individuals who participated in the study was not intended to be representative of any of the groups, but rather to provide an introduction to the range of opinions that exist on the subject of converting forest biomass to energy in Oregon. The goal was to obtain as many different viewpoints as possible in one study. Further research would be required to determine how widespread each viewpoint is within the entire stakeholder group.

Table 1 - Stakeholder Groups

Stakeholder Group	Number of Participants
Community Organizations	4
Conservation Community	5
Elected Officials*	2
Energy Utilities	6
Federal Agencies	6
Forest Industry Sector	6
Informed Energy Participants	6
State Agencies	3
Tribal Organization	2

*Interviews were conducted with staff members of the elected officials and not the elected officials themselves

Interviews followed a semi-structured format with an interview guide, rather than a fixed set of questions. No two interviews were identical in questions asked or information obtained as

[1] Stakeholders are defined here as individuals or groups that have a vested interest in an issue where they or their constituents are likely to be directly impacted by a decision or a policy.

interviews largely followed the participant's lead. The advantage to this format is that it is flexible enough to allow the participant to guide the interview to focus on what is important to them as it pertains to the research topic. The disadvantages are that comparisons between individuals are difficult, and statistical analysis is not practical.

Interviews lasted an average of 1 hour, 15 minutes. Over half of the interviews (23) took place in person (generally at the participant's office), the rest were conducted over the telephone. Most interviews were digitally recorded for accuracy. Notes taken during the interview were typed as soon as possible following the interview; a summary of key points from the interview was simultaneously made. The summaries were sent as soon as possible to most participants for their review (summaries were not sent to some participants at their request). This report was developed using the summaries. Participants were also sent a draft of the report with the introductory material and the section relevant to them. Comments and edits of both the summaries and draft were incorporated into the final report.

4.3 Report Format

This report presents the author's best representation of the participants' opinions in four key areas: (1) opportunities for and (2) barriers to converting forest biomass to energy, (3) strategies for overcoming the barriers, and (4) guidelines that should be in place if this policy (converting forest biomass to energy) were to move forward. Where possible, similar pieces of information have been consolidated into categories; however this was not always possible due to a risk of losing subtleties among different viewpoints. The order of categories presented in each stakeholder group was selected based on number of responses appropriate to the category (before comments were consolidated): the category with the most responses is listed first in each of the four topic areas. A brief summary of the most common viewpoints is provided at the beginning of each stakeholder section.

It should be noted that each bullet point represents the author's understanding of an opinion held by a participant at the time of the interview. It is not the purpose of this research to verify opinions for factual accuracy. During the review process some minor disagreements over opinions within stakeholder groups arose; these have been noted with a footnote.

The purpose of this chapter is to present the range of opinions within and between stakeholder groups. Further analysis of the information collected will be the subject of a thesis that will be produced at a later date.

4.4 Summary of Results

Most participants held the general opinion that converting forest biomass to energy in Oregon is a beneficial policy direction, and almost all of the participants saw this as a possibility in eastside and southwestern forests where fire suppression has altered the fire regime of the forest. However, it is important to note that there were a wide range of opinions on whether this is a good idea or not expressed within the conservation organizations. On one end of the spectrum were organizations actively promoting projects and research that would convert forest biomass to energy. On the other end were organizations that are highly skeptical of, and in some cases opposed to, the idea, particularly if the majority of material would come from federal forests.

Opportunities for converting forest biomass to energy most commonly fell under the headings of forest restoration, rural economic development, and renewable energy. Forest restoration was generally seen as the most important driver of the momentum to convert forest biomass to energy in Oregon.

Barriers to converting forest biomass to energy typically fell into eight categories: supply issues, general lack of supportive public policies, public perceptions and trust, institutional issues within the federal agencies, market access, technical issues, costs, and potential negative environmental impacts. Additional barrier categories are listed under the stakeholder group in which they came up. The most common barriers were under the general categories of obtaining supply, public policies, and public perceptions and trust.

Strategies to overcome the barriers are presented under the heading most descriptive of their topic area, and where possible under the same category as the barriers. Proposed strategies tended to be specific to an individual's experiences and knowledge, and are not included in the brief summaries of participants' viewpoints at the beginning of each stakeholder group. While there are a number of individual strategies, there were two that came up frequently: at a broad scale, most participants indicated that a collaborative approach would be essential to overcoming the barriers. More specific to biomass conversion to energy, many participants felt a renewable portfolio standard would help ensure competitive prices for biomass-generated power.

Guidelines that should be in place if this policy were to go forward were strongly emphasized in all interviews with members of conservation organizations, thus they are presented first for that stakeholder group. In interviews with other stakeholder groups, guidelines were mentioned sporadically, but were usually not a focal point. Almost all guidelines suggested by participants were concerned with sustainable forest management and scaling the facility to ensure that the projects were driven by local forest restoration needs and not the needs of an energy industry.

4.4.1 Stakeholder Group: Community Organizations

The participants from community organizations were in favor of converting forest biomass to energy, but not at the exclusion of other value added products. There were two primary motivations: improving forest health and reducing fire risk, and opportunities for rural economic development. Creating a market for small diameter timber, energy or otherwise[2], was seen as an important step in accomplishing the above goals.

The most significant barriers reported concerned the federal agencies, mostly the Forest Service. Institutional issues ranged from the agency's accounting systems to regulatory requirements to internal culture. Participants also saw obtaining long-term supply, public perceptions and trust, and public policies as being significant barriers.

[2] One participant strongly recommended that energy production be the very last use of forest biomass as communities would benefit more from value added products.

Opportunities for converting forest biomass to energy in Oregon

<u>Forests / Forest Restoration</u>

- Increase forest management
    - Less risk for catastrophic fire and epidemics of disease and insect outbreaks
    - Improved water quality and quantity—less water is available today due to all the trees that have grown up as a result of fire exclusion
- Ecosystem will be better equipped to handle impacts caused by global climate change
- Utilizing material that is normally a hassle to the timber industry
- Forest aesthetics improved, especially when compared to what forests look like after a catastrophic fire

<u>Rural Economic Development</u>

- Regional economic benefit through supplying regional mills
- Manufacturing sector would create a middle class through high paying, skilled jobs; would encourage families and youth to stay in the community
- Could provide additional revenues besides taxes to fund services that communities provide

<u>Renewable Energy</u>

- It is a good idea to produce energy from material left over from value added products.
- Could use biomass to provide energy to schools—the local school uses 250 gallons of oil a day in their boiler during the winter. Using biomass instead would be cheaper (since the material would be what was left over after value added products had been made, it truly would be waste and available to the school for low cost). Low-cost energy for other community buildings is also an attractive idea.

Barriers to converting forest biomass to energy in Oregon

<u>Institutional Issues (Forest Service)</u>

- FS targets are based on number of acres treated at the cheapest cost, which encourages underburning. Underburning isn't possible in the areas most at risk for fire, and it doesn't produce any usable product.
- Agency capacity
- Agency funding
    - The FS has money allocated to it, but people question how that money is distributed amongst forests and projects
        - Money that is spent on fire fighting could instead be spent on restoration and fire prevention
    - FS is reluctant to enter into a 10 year contract when they get appropriated funds on a year to year basis
- Institutional culture
    - Large institution with generational families employed—they long for the way things were

    - FS has become marginalized by conflict and has become unwilling to take risks
    - Loss of hope
    - Change is hard
    - Lack of collaborative effort
- Management Direction
    - Very little management is taking place on federal lands
    - No continuity in project management
        - Constant movement of personnel within the agencies
        - Changes in management direction with administration changes
    - The investment is not being made by the Washington Office to forests for these types of projects. Seems like they are still hoping for the timber sales program to go back to the size it was. But that is way too costly now with appeals and litigation—it is just a bad idea.
    - No incentives within the FS to work through the change and make these new types of projects work

<u>Supply</u>

- Long-term, secure supply
    - Supply needs to be consistent and secure for expected life of the facility ~ 10-20 yrs
    - Long-term contracts (10 year minimum, 20 year preferred) are needed
- Much of the supply will have to come from federal forests as there isn't enough private timberland and other sources to support the facility
    - Supply from the agencies needs to be continuous and certain
    - Changes needed in federal policy
- Industry infrastructure to handle all the material

<u>Public Perceptions and Trust</u>

- Lingering lack of trust between the FS, the environmental community and the county over battles in the late 80's and early 90's
- Social acceptance; there needs to be intellectual buy-in from citizens, rather than emotional reactions
- The community is still in the mindset of the old timber industry—things would be better if the timber industry would just come back. But, it will never be like the old days. The community needs to move on and build a new industry.[3]
- Widespread misunderstanding on forest management, partially due to special interests on both sides continually providing misleading information

<u>Public Policies</u>

- National renewable production credit of 1.8 cents/kwh is only available to closed biomass plants (feedstock is grown specifically for the plant); credit for open biomass plants (feedstock comes from the forest or other sources) is 0.9 cents/kwh.
- National renewable production credit only applies to plants in operation by the end of 2007

[3] One reviewer felt it important to point out that some forest dependent communities have already developed a new vision and are actively pursuing a new industry based on forest restoration.

- Oregon doesn't have a renewable portfolio standard
- Congress is driven by crises—when it was Biscuit there were a lot of resources, but when it was Katrina the resources were diverted there. Need consistent funds to prevent the next crisis. Lightning strikes should not be a crisis.

Market Access

- Market to sell the material
    - Either local uses for power and steam, or power sold entirely to grid
- Market needs to be strong enough to offer assurances investment costs will be recovered

Strategies to overcome the barriers

Institutional Issues

- Agency funding should be consistent and long-term, rather than based on target production
- FS should exercise their authority to issue 10 year contracts
- Targets should be based on something that would encourage the highest risk acres treated
- Work on ways to reduce the cost of putting together a timber sale
    - Designation by prescription
    - Sales by weight
- Long-term management plans are needed that aren't subject to changing personnel and administrations

Public Involvement

- Collaboration with all stakeholders involved is essential
- Public education and outreach

Public Policies

- Extend full amount of the national renewable production tax credit to open biomass systems and reauthorize the credit to go beyond 2007
- Develop a renewable portfolio standard in Oregon; the European model, one that is being considered by the Governor, would favor smaller sized facilities that are community based, which would be more favorable for biomass

Funding Projects

- Carbon credits. University of Washington developed a model to demonstrate the carbon benefit from treating the forest vs. having a catastrophic fire
    - They are now involved in a 4 year study to test the accuracy of the model
    - If the model is accurate, credits may be able to be sold to generate revenue for treatments
- There is strong desire within the community to participate in projects that will revitalize the community (developing new businesses, using local materials and expertise); it is not out of the question that communities may provide some of the capital for the new businesses

  - The advantage to community members investing, rather than private or government investors, is that they don't care about as much about the rate of return; societal (community) benefits are given much more consideration.[4]

<u>Supply</u>

- Senate bill 1072 allows the Department of Forestry to hold long-term contracts with the federal government. The State could enter into agreements with the FS and BLM on behalf of community projects as a government to government interaction. The federal government can only have long term supply memorandums of understanding with other government entities.

<u>Pilot Projects</u>

- Use the Adaptive Management Units that are in fire prone areas with a lot of biomass as giant labs to see if this will work out and be socially acceptable, ecologically beneficial, and provide economic returns. If it doesn't work, we could learn why. If it does, it could provide a model for other areas.

<u>Environmental Issues</u>

- 3rd party monitoring for the length of the contract

Guidelines

<u>Small diameter timber utilization</u>

- Energy production is the very last choice for what to do with small diameter timber
  - Rural communities need a manufacturing sector which value added production would develop, whereas straight energy production won't
  - There are less jobs related to biomass energy production than when biomass is used to make value added products

<u>Forest Practices</u>

- Management can't be one-size fits all—has to be site specific
- Management decisions should be driven by ecological decisions rather than economic ones
  - It is okay to make a profit, but the tail shouldn't wag the dog

<u>Scale</u>

- Size of facility needs to be scaled to the realistic estimate of current and future supply

<u>Collaboration</u>

- A true collaborative group with all stakeholders at the table is extremely important

<u>Projections</u>

- Don't be overly optimistic about supply or rate of return—be realistic

[4] One reviewer noted that there are also advantages to having a privately owned facility; communities could negotiate with a privately held company to provide some of the community benefits that would come with a publicly owned facility.

4.4.2 Stakeholder Group: Conservation Organizations

There were a wide range of opinions expressed within the conservation organizations regarding converting forest biomass to energy, particularly when material from public lands will be used. On one end of the spectrum are individuals who are actively pursuing forest restoration projects on eastside forests with a biomass utilization component, and who see inaction as the biggest risk to these forests. On the other end are individuals who see this as generally a bad idea; they question what the true motivations behind the proposed projects are and if biomass can be considered renewable energy.

Despite the wide range of opinions, there were some common principles that came up in every interview.

- These projects must be science-based all the way from determining what the historic range of variability for particular stands is, to project planning, implementation, monitoring and adaptation.
- The underlying motivations for the projects must be ecological and not economic.
- Facilities (both individually and regionally) must be scaled to fit the supply available so as to not create an unsustainable, industrial demand on the forests, with the understanding that there will be less supply available in the future once forest conditions are within the natural range of variability.

Guidelines (primarily refers to projects on public land)

<u>Project Planning</u>

- Very clear sidebars are needed on what will be done
- No projects in old growth, roadless areas or wilderness
- Be realistic about what is available and what will happen
- Don't try to get around regulatory "hurdles" like public input
- Don't couple biomass projects with the existing timber sale program
- Any models that are used to determine fire return intervals (or anything) need to be ground truthed before we rely on them for management
- Don't plan projects under the guise of fire danger when the motivation really is something else
- Big need for transparency and multiple parties involved in planning and monitoring
- Have separation between the planners/monitors and the person/organization that will make money off of it

<u>Forest Practices</u>

- Establish parameters based on ecological principles
- No new roads
- No high environmental impacts
- Mechanical removal of forest material can not be seen as a replacement for fire
    - Fire is a part of the natural system and provides a number of ecological benefits that can't be replicated
- Some biomass needs to stay on site to provide nutrients and ecological benefits
- National forests don't need to bear the brunt of needs for energy and wood products
- Do the right things in the right places

<u>Biomass to Energy Projects in General</u>

- Start with small projects in non-controversial, priority (WUI and/or plantations depending on where they are on the landscape) areas, with everyone at the table, to see what happens and what the impacts are
- Motivation needs to be ecologically and not commercially based
- Projects and related policies must be grounded in science and have the flexibility to practice adaptive management as new science becomes available
    - Motivations behind the science itself must be ecological and not economical
- Decisions will need to be very site specific on what the forest looked like and what, if any, treatments are needed
- Arrangement can't be permanent; have to be able to reassess with no commitments after 10-15 years to see what effect there has been on the forest
    - The reassessment doesn't preclude continuous monitoring
- These projects should not replace efforts to conserve energy and increase efficiency

<u>Scale</u>

- When determining supply, agencies should only guarantee about 1/2 to 1/3 of that supply so that an unsustainable industry isn't created. This will offer flexibility to managers if it is later realized that removing a lot of material has worse ecological impacts than leaving it.
- Ensure that facilities economic haul radius' don't overlap to the point that there isn't enough supply for everyone and an unsustainable industrial demand is put on the forests
- Life expectancy and size of energy facility/facilities shouldn't exceed the carrying capacity of the forest
- There will be less material available in the future since we are trying to get the forests back to a normal ecosystem function with fire playing an integral role

<u>Education</u>

- Any education efforts need to be more than just messaging
- Any pilot projects can't be poster children, they have to be the norm

Opportunities for converting forest biomass to energy in Oregon

<u>Forest Restoration</u>

- Improved forest conditions with concurrent improvements in the quality of our rivers, lakes and streams
    - Fisheries would be positively impacted
- Have all the societal benefits of a green forest if treating before the fire, and side benefits to the restoration work (jobs, energy potentially, products)
- Opportunity for multiple goals to be met with forest restoration
- More cost effective to treat proactively than wait for a fire
- Not wasting the material generated during thinning operations that is currently being burnt on site

<u>Rural Economic Development</u>

- Rural economic health

    - Lots of jobs are associated with restoration work; jobs created with the bioenergy facility too
    - A stable work force keeps people in the community as they know they can educate their kids and raise a family
    - Kids would have jobs when they grew up, so they could stay in the community
- If you treat hazardous fuels before a catastrophic fire, you can create markets for the products, and you aren't working on a 3 year countdown before the material loses value

<u>Environment</u>

- Potential for less particulate matter to be released compared to an open burn
    - These clean air benefits should not outweigh fire's natural role in the forest
- Addresses global warming

<u>Renewable Energy</u>

- Some energy produced
- Could reduce our dependence on foreign oil; keep more money in the U.S. rather than exporting it

Barriers to converting forest biomass to energy in Oregon

<u>Public Perceptions and Trust</u>

- Trust between parties
    - Bush administration won't follow whatever parameters are agreed upon
    - Motives behind projects—important to call it what it is
    - Lack of trust paralyzes us into inaction
    - Seeing the same entities involved with biomass projects as were responsible for the past 50 years of treatment of the public forests is a reason for concern and suspicion
- Agreement on how much material there is and over what time period it will be available for
- Agreeing on what the historic conditions were (pre-settlement) so we know where we're going
- Lack of certainty about the desired future conditions (pre-settlement or otherwise)
- Concerns about the ability to change strategies if it turns out the treatments are harmful for the forest
- Lack of education of citizens in E. OR on ecological principles—denial and deep ignorance of new (since 1940's) science and ways of thinking

<u>Supply</u>

- Transportation of material
    - Long distances require more use of diesel and resultant negative impacts on air quality
    - New roads, even "temporary" increase sedimentation in streams, which impacts fish
    - Costs to haul the material

- Supply needs to be continuous, steady, and certain—agencies have capacity to levelize supply
- Cost of removal is high

Research
- Need more research to determine what would be good for the environment—how much should be taken and how much should be left. It isn't just about biomass and fire potential. Animals need plant material and humans need to make sure we aren't taking out the nutrients the animals and forests will need in the future.
- Scientific integrity needs to be re-built into the Forest Service system
- Too much information

Institutional Issues
- Method of distributing funds for projects in FS—get money for logging, building roads, spraying herbicide, but not for restoration projects
- FS culture

Market Access
- Securing power contracts
- Investors need to be able to see that they will get a return on their investment

Public Policies
- Congress doesn't understand the forests—they don't come out to the forests to learn about the ecosystems

Technical Issues
- Need an available, skilled work force to bring the material out of the forest

Society
- Dissonance between what we want and our behaviors

Strategies to overcome the barriers

Public Perceptions and Trust
- All parties agree upon parameters to the project that will ensure that the projects are driven by ecological benefits, and that there are environmental safeguards. With protective parameters, the environmental community won't be afraid to support these projects.
- Keep focus on small and left over material—demonstrates this isn't a grab for money
- FS can't come around later (after the project has been agreed upon) to add more large logs to "help pay for the project"—that would cause some trust issues
- Use a diverse group to plan and monitor projects
- Implement pilot studies all over the state to show people what the forests will look like after the treatments
- Diameter limit might help to keep focus in the right spot
- Educate citizens who don't understand ecological principles

<u>Institutional Issues</u>

- Redistribute FS budget to focus on restoration; shift how forests compete with one another
- Both FS and BLM employment base need to be increased to provide the long-term, extensive knowledge and expertise that is needed. Probably would need to change the culture in the agencies of moving people around so much—this movement just when someone really gets to know a place is bad for the resource
- 5 year review of EIS, rather than annual, if contract were long-term
- Regional Environmental Impact Statements
    - Break state into regions of arid EISs to deal with most severe category condition class 2 & 3 forests.
        - For example, may have the Klamath Mountain Ecoregion assessment, Klamath Basin to the Idaho border assessment, and the rest of the arid regions as the Blue Mountain assessment. Might need a Willamette Valley assessment too since there are a lot of forests in classes 2 & 3.
    - EIS's would be developed by a group of top scientists, conservation leaders, and members of the forest industry that would be contracted to work together with the FS and BLM; group would develop the EIS in consultation with the community
    - Once EIS was complete it would be presented back to the FS and BLM, and then the FS and BLM would go through their process
    - Majority of work could be done through stewardship contracts
    - Small part of the work would be done by a smaller group of the consortium of people that were responsible for the EIS
    - Projects would have annual audits, also done by a small subset of the larger group responsible for the EIS
    - FS or BLM would have broad oversight to make sure the group is in compliance with the contract being let
    - This would be a way to build trust back into public forest management

<u>Public Policies</u>

- Subsidies, either on haul side or power side, or maybe a combination
- Government subsidy
    - If we as a society decide that there are societal benefits to getting excess biomass out of the forest and use it for energy, then we as a society could pay for it through subsidies
    - Subsidy would likely be at the federal level rather than the state level
    - In the past we have subsidized other forest activities, such as fire suppression and cutting old growth—we can subsidize this too if needed
- Need to build a centrist approach, grounded in good science from universities both within and outside of Oregon. This broad based group needs to create a bold new vision of both forest and community health.

<u>Determining Historic Range of Variability</u>

- Openly share the information being used to determine the historic range of variability

- Use scientific methods such as counting tree rings and mapping fires, rather than historic anecdotal info or data collected just after an area was logged. Historic range of variability must be determined on the ground.

Project Planning

- Plan on a scale that is based on precise information rather than modeling. We have the technology for site specific information and it is worth the extra time.
- Prioritize areas to be treated
    - If priority areas (e.g. near communities) are agreed upon and that is where the efforts are focused, then a bit of trust could be built

Environmental Issues

- True natural resource sustainability would solve many of the world's conflicts, which are often about natural resources

Market Access

- Facility could be collectively owned

4.4.3 Stakeholder Group: Elected Officials

Both of the offices of the elected officials that were surveyed think that converting forest biomass to energy is a good idea in Oregon, both for forest health reasons and to generate renewable energy, as well as to generate revenue for rural communities. They talked most about barriers relating to supply availability, and a general lack of funding to plan and implement the projects.

Opportunities for converting forest biomass to energy in Oregon

Forests/ Forest Restoration

- Improve forest health in the West; reduce risk of catastrophic fires
- Provides a use for material that would otherwise be wasted, like the slash from timber sales, or thinnings from restoration projects

Renewable Energy

- Develop renewable energy sources
- Opportunity for small providers of energy; distributed generation as alternative to mega energy system we have today
- New source of energy—less dependence on foreign sources

Rural Economic Development

- Expand local tax base

Social

- Since the drivers are equally forestry, energy and rural economic development, there is an opportunity to eliminate polarization

Financial

- People in Oregon have demonstrated that they are willing to pay more for things that are valuable to them, like renewable energy

Technology

- Technology is already available, and it is cleaner than it used to be

Barriers to converting forest biomass to energy in Oregon

Supply

- Supply needs to be close to minimize transportation costs and use of fossil fuels in transport
- Guaranteed supply
    - Investors need to believe in the supply—they need to believe that the federal government will get the sales out
    - Necessary to get a loan for equipment
    - Potential litigation could prevent supply availability

Public Policies

- Tax structure in general doesn't reflect an advantage for new investments in biomass facilities (small subsidy in the energy bill, but overall it isn't advantageous)
- Leadership is not pushing renewable energy enough

Environmental Issues

- If multiple biomass facilities are built would need to look at the aggregate for the impacts on clean air
- Greenhouse gasses need to be looked at

Public Perceptions and Trust

- Mistrust created by how the federal government managed the land in the past. People are worried big trees will be cut.

Technical Issues

- Antiquated transmission grid system
    - There are competing energy sources (including competing renewables), and the grid can only handle so much
    - This could be both a barrier and an opportunity

Financial Issues

- Costs a lot of money to build facility

Strategies to overcome the barriers

Public Perceptions and Trust

- If the agencies said they weren't going to cut in old growth and weren't going to go into controversial areas, but instead were going to focus on taking care of the lands

most in need, their projects wouldn't be so controversial. This has been demonstrated on the Siuslaw NF.
- Get some projects going as demonstration projects to show people what these projects do
- Public education on what options are available and what the impacts are to the land

<u>Public Policies</u>
- Restructure tax code; provide incentives to make it more affordable
- Strong leadership on development of renewable energy sources

<u>Institutional Issues</u>
- Ensure FS has funding it needs to make the material available
    - If treat proactively, then less money needs to be spent on fire suppression
- Ensure the Community Wildfire Protection Plan in HFRA has enough funds to do what it is supposed to

Guidelines

<u>Forest Practices</u>
- Forest controversies would lessen if agencies proclaimed they wouldn't be cutting in old growth or other contentious areas
- Agencies would gain public support by focusing their efforts on the areas that need it the most, such as in the wildland urban interface

4.4.4 Stakeholder Group: Energy Utilities

For the participants from energy utilities in Oregon this was primarily an issue of cost. Oregon's energy marketplace is currently dominated by hydro, coal and natural gas fired generation, which makes it difficult for more expensive sources of generation to compete. However, all of the utilities have expressed interest in renewable energy, and recognize that it may cost more than traditional sources. Biomass that could compete with wind in terms of cost would be very attractive to them. Biomass does have a distinct advantage over wind in that it can serve as a base load power source, whereas wind is only an intermittent resource. This advantage for biomass might allow them to pay a bit more for biomass power than wind, but only after issues of supply reliability have been addressed (supply needs to be technically available, and the fuel source needs to be politically and socially acceptable).

Opportunities for converting forest biomass to energy in Oregon

<u>Renewable Energy</u>
- Biomass could serve as base load power, unlike wind which is only an intermittent resource
- Clean source of energy
- Large interest in the state in renewable energy and citizens have demonstrated willingness to pay more for it (both investor owned utilities in Oregon are national leaders in voluntary green power sales)

- The rural co-ops will need additional sources of electricity in the future, and they would prefer economically sound Oregon sources, particularly rural Oregon sources where the communities need an economic boost
- If biodiesel or ethanol could be made from woody biomass, then there would be less need of foreign imports for fuel
  - Oregon may be particularly well suited for the manufacture of bio-fuels since it has abundant forest lands

<u>Forest Restoration / Supply</u>

- Minimize fire danger
- There appears to be a large supply of material from forest trimmings and forest fuel-reduction strategies

<u>Facility Siting</u>

- Siting a biomass facility may be less controversial than that of traditional energy generation resources
  - Many biomass facilities could be sited in existing mill sites where there is already community support for forestry related practices
  - Recent wind facilities didn't have siting difficulties due to public opposition (indicating support for renewable energy facilities)

<u>Rural Economic Development</u>

- Biomass may provide a potential economic boost for rural economies

Barriers to converting forest biomass to energy in Oregon

<u>Cost</u>

- Biomass will only be attractive if it is cost effective. Even if a utility needs new renewable resources due to growth demands, or to satisfy a state or federal Renewable Portfolio Standard (RPS), it will go with the most cost effective resource.
- Capital costs to produce energy (competing against other renewables if there is an RPS, and competing against all energy sources if there is no RPS requirement)
- Economies of scale—bigger energy projects are more attractive to major utilities
  - Costs of developing a 10 and 1000 MW plant are about the same, except the 1000 MW plant will get a faster return on the investment
- Transporting the feedstock is expensive, especially when compared to wind

<u>Supply Issues</u>

- To be a reliable source of energy there has to be a reliable source of forest material
  - Forestry appears controversial right now, how reliable is that supply?
  - Do people in Oregon want their forests thinned and the product used for energy?
    - How deep is the support for those that say they want to see forest biomass converted to energy?
- Policies aren't in place to direct forest thinnings for energy (instead of burning or other uses)—policies/incentives would come from national level since the state doesn't have the finances to do it

<u>Public Policies</u>

- Biomass not treated equally with other renewables, such as wind
  - Woody biomass doesn't qualify for the full production tax credit
- Biomass (and wind) needs to be able to get fully compensated for its other environmental benefits, such as CO2 reduction and fewer emissions
- Too many options and strategies to work from leads to debate between the options and no action. There needs to be leadership to pick a couple of options and move forward before the opportunity is gone.

<u>Transmission</u>

- How and where do the projects interconnect into the existing system
- Siting and land use issues with new transmission lines (NIMBY)
- The NW transmission system is in need of significant upgrades
  - Transmission bottlenecks (want to move power from East to West, but only a few spots you can get it over the mountain)
- If the biomass facility is built in an area without much energy infrastructure, building transmission lines is very expensive—approximately 1 million dollars/mile of line

Strategies to overcome the barriers

<u>Public Policies</u>

- Could have a production incentive, such as is used in Europe. This model allows purchasers of the energy to buy it at avoided cost rate. The producer would get a subsidy to cover the extra cost in the production. Market can decide how much of the renewable energy will be sold instead of a true RPS where utility is told how much renewable energy to produce. Market is kept fair by the subsidy covering the extra costs for the renewable energy.
- State could provide targeted economic assistance for developers
- Incentives should be on the forestry side rather than energy side if primary goal is to thin the forest
  - Some look to the utility to solve the problem of the forest by providing the needed money since the government doesn't have the money to offer incentives, but this isn't the right way to go about it as utilities will invest in least cost renewable energy, which may or may not be forest biomass
- Provide an economic stimulus (subsidy) for biomass to be burned in a energy facility rather than in a wildfire.
  - This was done in CA for agricultural fields—a subsidy was provided to farmers to decrease their emissions from field burning; subsidy indirectly resulted in some biomass being used for energy
- If the state passed an RPS with a portion of it specific to biomass, and the PUC allowed the utility to include this cost in their rates, this would pass on the costs of the social benefits of using biomass energy to the recipients of these benefits, the citizens of Oregon

    - RPS needs teeth to be a real mandate. The CA RPS is aggressive in its targets, but there is no penalty for the state or utilities if the targets aren't met; it is more like a suggestion than a mandate[5].
- Federal RPS has been talked about, but hasn't been passed. Also has to have teeth, and could be modeled after the UK system.
    - The federal RPS could be put in place if the production tax credit isn't extended. Lots of questions on what will happen with renewables at the end of 2007 if the credit isn't extended.
- Development of a mature renewable energy credit market would benefit all renewables

Market Access

- The customers in the voluntary renewable energy market would be most interested in sustainably produced biomass energy
    - Forest thinnings from certified forests
    - Efficient gathering and transport of fuel to an energy facility—carbon neutral (using biodiesel or cellulosic ethanol)
    - Jobs that pay family wages
- In order to have their power purchased by the voluntary renewable energy program, biomass projects need to be of a scale that is beneficial to the program and not too small to be more administrative work than it is worth, given the number of renewable certificates they need every year
    - The scale could be met by having biomass facilities larger than 10 MW, or several smaller facilities that are administered in the project together
    - Facilities operating all year could be attractive even if they are smaller than 10 MW

Technical Issues

- Transmission complications could be partially solved if all the parties acted together as a single transmission utility
- If power is sold locally, transmission access isn't as much of an issue

Guidelines

Forest Practices

- Make policies that ensure sustainable forest management

4.4.5 Stakeholder Group: Federal Agencies

Participants from the federal agencies (Forest Service and Bureau of Land Management) were very interested in the idea that converting forest biomass to energy could help provide needed funds to help them with their forest restoration projects. They saw this as primarily a forest restoration opportunity with an important side benefit of providing an economic boost to rural communities. It is important to note that with this support came the caveat that energy production would be a byproduct of forest restoration activities, and not the other way around.

[5] One reviewer pointed out that there are penalties for utilities not meeting the requirement, although there are total penalty caps for each utility.

Concerns over the "tail wagging the dog" came up in over half of the interviews. By far the biggest barriers were institutional and supply oriented in nature. Other frequently mentioned barriers were public perceptions and trust, and project costs.

Opportunities for converting forest biomass to energy in Oregon

Forests / Forest Restoration

- Fire risk is reduced through removal of excess material; forest becomes more resilient to fire
- Potential for lower costs of treating forests when compared to fire suppression costs
- Generate a useful product with former hazardous fuels
- Create fire safe communities—protect life, property and watershed quality in that order (order in their mandate)
- Move ahead of insects so not relying on salvage
    - Missing the point with salvage, need to move ahead
    - There are epidemic proportions of insects in some states. Affects the aesthetic values of the forests, and puts them at risk for fire

Rural Economic Development

- Employment in rural communities is an important part of their state and private program, and biomass is an opportunity to provide family wage employment
- Jobs keep people in the communities; need talent and skill to manage public lands in perpetuity
- Value in the products and improved forest aesthetics can help the communities

Environment

- A range of ecological services provided from these treatments, including carbon sequestration, increased water quantity, improved wildlife habitat
- Improved air quality if alternative is to burn the material in the forest
- Chance to recycle and reuse
- Society is more sustainable if we can produce and consume locally

Renewable Energy

- Alternative source of energy to oil (liquid technology should be up and running in next five years)
    - Becomes more important with the rising price of oil
- Biomass provides renewable energy

Forest Service

- To work collaboratively with the community and other stakeholders
- Perhaps could be a backdoor way for the FS to become certified
- The FS leadership is on board, national office is 188% behind the idea; the agency is coming around

Collaboration

- We are at a juncture where people realize that we have to work together—no one can do it alone
- If collaboration efforts are successful, it could mean no litigation for the agencies

Timing

- High oil prices at the same time there is an abundant supply of material in the forests due to fire suppression

Research

- CROP—coordinated supply for prudent utilization

Technology

- Technology is used in Europe for low-impact removal; we don't have to reinvent the technology

Barriers to converting forest biomass to energy in Oregon

Institutional Issues – Internal Culture

- Inertia in doing things the same way rather than thinking outside the box
- Needs a change in the mindset of people on the ground
    - Burning biomass is so standardized that most people don't even think about removing it for some other purpose
    - Strong impressions that removing biomass is more costly than burning it, when it could be that the costs are comparable, if not cheaper to remove it
- National Forest System is slow to recognize the opportunities of biomass removal, despite direction from the national office
    - They are so resistant that they are creating barriers through stewardship contracting complications that are unnecessary
        - Direction to not "ruin a perfectly good timber sale"
        - Timber accountability standards require extensive presale and cruising work
        - Non-support of weight scaling of timber products
        - All of these impediments cause great frustration on the ground

Institutional Issues - Funding

- Method of appropriating money—have to meet targets of timber production rather than targets focused on restoration (number of acres treated, or some other benchmark)
- In the past, the FS got its revenue through selling a commodity (timber) to the public. Now there is less merchantable timber being put up for sale, and consequently there is less revenue
- For service stewardship contracts that are designed to be multi-year, there is great confusion on if they can be awarded since there is no money, or a guarantee the money will be there
    - Seems much easier from the BLM side

- Capacity (financial and otherwise) is needed to take care of the supply

Institutional Issues – Regulatory Policies
- Government employees can't talk to Congress about what is needed and what the situation is (unless involved in some formal procedure or in Washington Office)
- No way to appraise less merchantable material, yet NFMA requires fair market value for the material
- Internal barriers that are in the form of rules set by Congress—they have to work within that framework to assess low value products
- NEPA documentation

Institutional Issues – Accounting
- Need a whole-cost accounting for how they are treating the land
- The current reporting system is based on target acres, rather than a reporting system based on doing what is right for the land
    - Change needs to come from Congress
    - Would need to change the way that Ranger Districts compete and show they are doing a good job

Institutional Issues – Leadership
- Lack of clear direction from management saying this will go forward on all appropriate ranger districts
- Despite changes occurring in national leadership in FS, change needs to take place on the ground, which is harder

Supply
- From an investment standpoint, have to have reliable, consistent, sustainable supply
- As the cost of fuel goes up, the cost of transporting material goes up and the radius from which material can be taken shrinks
- FS doesn't have enough money to deliver the material to a facility, and the facility doesn't have enough money to pay for the material—big gap in what each side is able to do
- Access
    - Lots of biomass is roadless
    - Citizens want fire proof communities, but they don't want to provide the access to reduce the fire danger
- Competition of a biomass facility with other uses for small diameter timber
    - For example, some people worry that a biomass facility would take the material from the firewood program
- FS has a large inventory of material that could be used, but no way to supply it

Public Perceptions and Trust
- All sides locked in arguments over previous management practices; have to move forward
- Trust within the environmental community on what is driving these projects—is it really forest restoration, or is it an excuse to harvest more timber?
- Sometimes the lack of trust argument seems to be used to promote a political agenda
- Lack of public understanding on the benefits to converting forest biomass to energy

- Lack of trust between different disciplines within the agency can also be problematic

Project Costs

- Projects cost a lot of money—costs money to cut down material, to transport material off the forests
    - Projects will have to be cost-effective for the changes to take place
- If more funds were available, more work could be done
- Won't get money from Congress to treat the forest

Capital Costs

- High capital costs in developing the infrastructure to handle the small diameter timber
- Economic feasibility on the energy side

Public Policies

- Lack of a requirement for renewable energy, or some other incentive to force utilities to purchase more expensive renewable power
    - The supply could be pulled through by a market demand for the energy it would create

Technical Issues

- Lots of forestry infrastructure has been shut down

Strategies to overcome the barriers

Supply

- Stewardship contracts
- CROP—method to levelize the supply from the federal agencies. Looks at what federal agencies could offer over a 5 year period in areas where infrastructure is available, and the community and other biomass stakeholders are in alignment. Beneficial since no bank would loan without a steady supply.
- SPOT—strategic placement of treatments. Used for hazardous fuel treatments in watersheds. Focuses on WUI and ecological principles
- Use a combination of CROP and SPOT to make sure they aren't offering too much material
- Administrative Free Use clause will work in some places, but not everywhere
- Need to complete enough NEPA documents in advance so that investors would feel more confident about the supply

Public Perceptions and Trust

- Management has to be done in a collaborative manner, not just a cooperative one, but one in which the government gives up some of its power
- The FS needs to be at the table with the stakeholders to manage the land, even if the stakeholders don't have specialized training. This is difficult for some people in the FS to do.
- Multi-group monitoring team
    - This has been beneficial on the Deschutes NF

Institutional Issues

- NEPA
    - Get a bunch of documents done in advance
    - Have an attorney be part of the district office staff to help with the documents so they will be defensible in court
    - Categorical exclusion for biomass projects—start with WUI
- Rework some internal processes so that layout costs are lower
- Working on integration between departments and agencies so that they can tap into each other's resources rather than each working on the same thing independently

Education

- Demonstration and pilot projects would be helpful
- Most of the population lives along the I-5 corridor in areas that get a lot of rain. Awareness is needed for the drier parts of the state where there is a historic high frequency of fires.
- Once the Warm Springs project is operational, positive media attention could show people the benefits and increase understanding about biomass projects in general

Revenue for Projects

- FS could potentially get more money from partnerships with endowments or other private entities
- FS would have a lot more money available to work with if they could take all the money spent on litigation and put it towards caring for the land

Appraising

- Hand appraising guide that could be taken into the field
    - A "how to assess" guide with a summary of techniques included
    - The guide should have enough information to allow the appraiser to know what the value of the material is and whether it would be more cost effective to remove the material or burn it
    - If it would be most cost effective to remove, then guide should help determine the most cost effective method of removal
    - Need to be able to compare economics of hazardous fuel treatments vs. wildfire vs. using the material vs. clean air and water and carbon sequestration
        - This is difficult since not all of these factors have known values
    - Need to develop the guide quickly since lots of FS people are retiring and taking their knowledge with them

Community Forests

- Each forest based rural community could get all the interested and relevant stakeholders together to form a non-profit
    - The non-profit could apply for grants
    - FS would be more likely to be able to enter into agreements with them than on an individual basis
    - FS could deliver the supply to the non-profit, and the non-profit could distribute the supply to the different business interests

- This is a way to get around the target acres barrier—still have target acres, but with the community group bringing more money to the FS for projects they need, the target acres wouldn't be as limiting
- This is being done on other national forests
- Everyone has to be at the table for it to work

Public Policies

- Political will in Congress needs to be behind this—that would help with a lot of the barriers
- State renewable portfolio standard could provide the incentive for the utilities to pay more for biomass energy, which could close the monetary gap between source and facility

Communication

- FS is working on a deskguide to help ranger districts be able to offer material where appropriate

Facility Financing

- Biomass facilities can have significant financial gain through tax credits if they know how to get them

Prioritize Areas

- On a national scale, first emphasize areas where there is still a forestry infrastructure in place

Technical Issues

- FS is looking at what is being done in other countries, such as Scandinavia, to learn from them

Guidelines

Forest Practices

- Very important that the tail not wag the dog
- Soil and water quality need to be the first two considerations
  - More acres treated means that there will be more mechanized equipment on the forest. This can be a small impact with new techniques
- Need to protect the different kinds of forests, and not end up with a regulated-looking forest—maximize diversity

Scale

- Uneasy with the idea of large biomass plants—biomass has to be the byproduct of forest management and not the driver of forest management
  - If larger plants are proposed (like Warm Springs 15 MW plant) then alternate sources of material are needed—FS can't be responsible for supplying all the material

Collaboration

- Collaborative groups can't work when all parties aren't at the table willingly

Project Planning
- Don't need the same kind of planning documents as you do for larger tree sales

4.4.6 Stakeholder Group: Forest Industry Sector

The participants in the forest industry sector were largely for converting forest biomass to energy, although there are varying degrees of skepticism about whether or not it will happen in Oregon. Skepticism largely stems from whether federal supplies will actually be made available, and the impossible nature of some of the key barriers. All participants were enthusiastic about the possible benefits if these projects were to go forward, including improved forest health, production of renewable energy, and economic stimulus for rural communities.

Opportunities for converting forest biomass to energy in Oregon

Forests/ Forest Restoration
- Huge opportunity to treat Eastern and Southwestern Oregon forests
    - Reduce fire risk
    - A way to get money back into the stands
    - Forest productivity increased through thinning and restoration work
- Further reduce waste material generated in wood products industry
- Improved pulpwood market would provide a viable outlet for their thinning materials—would allow them to thin forests prior to harvest to grow larger trees
- Light touch techniques are available from Scandinavia—don't need to invent new technology

Renewable Energy
- Produce green, carbon neutral energy
- Reduce fossil fuel use
- Could be used to replace natural gas
- Reduce dependence on foreign energy sources
- With increasing energy prices biomass will become more cost-competitive

Supply
- Area could support more wood burning plants—plenty of supply for all uses
- Mills are normally located right next to biomass sources, and there is excess material generated in the process of making wood products and paper that can be used for generating energy
- Good growing conditions for dedicated energy crops

Rural Economic Development
- Help the local community through good jobs and possibly heat for the schools

Environment
- Air coming out of a biomass facility is far cleaner than either a wood stove or open burning.

    - It is cleaned twice—once through a microcyclonator, and once through electrostatic scrubbers
    - Collected particulate matter is taken to a landfill, or used where possible
- It is a win-win situation with a win in reducing fuels and a win in producing power in a manner that has little risk to the environment

Social

- Bring people together that are generally on opposite sides
    - Issue where everyone can win
- Most people agree something needs to be done in the woods to reduce fire risk

Incentives

- Federal legislation has produced incentives on both forestry and energy side to promote development

Barriers to converting forest biomass to energy in Oregon

Supply

- Supply availability
    - Supply has to be of the right volume and guaranteed to be continuous over a long time period—people won't invest $30 million on someone's word that the supply will be made available.
    - FS may not have the mechanisms to offer certainty of supply
    - FS has long history of having their projects appealed and litigated
- Cost of supply
    - Can't truck material a long way—facility or other use has to be close to the stand
    - Material has to be gathered into large, relatively clean piles to be picked up and taken to a facility
    - Uncertainty about the economics of the forest treatments
- Not all fuels are the same
    - Old growth Douglas-fir bark has the highest heat value at 9300 btu, urban wood waste has around 8000 btu, forest material is typically 8400 btu
- Landings have to be large enough to accommodate the equipment (e.g. tub grinders and chip vans)
- Not much supply available from southwestern Oregon as much of the land is steep and there isn't much biomass/acre
- This is a federal issue since most of the supply is on federal land, but most of the country isn't interested in local fire danger. Need to emphasize drivers that are important to the whole country, like global warming and needs for renewable energy.

Institutional Issues

- Oregon utilities do not like small suppliers, and biomass is a small supplier
- No momentum and direction within the leadership of the FS and BLM to get something done; lack of motivation on the ground to make this happen
- Long history of inactivity on federal lands

- Need agency commitment for 10 yrs of supply or more in order for investors to build a facility
    - Commitment has to be real—agency can't guarantee the supply and after the facility is built decide the supply really can't be offered
- Lack of funding for the agencies to lay out the projects and implement them
- NEPA planning documents
    - Takes 2 years
- FS and BLM look at the micro scale, but need to think about this on landscape level

Public Policies

- A renewable portfolio standard would not ensure more biomass production unless biomass was specifically mandated
- Financial help much more likely from power rate side than a government subsidy
    - There is a subsidy in the current energy bill, but funds haven't been allocated. The subsidy is for $20/green ton. For just the FS class 3 acres this would equate to a subsidy of 40 billion dollars, which is incredibly unlikely
- Uncertainty about federal politics and policies (for instance the growing potential of converting forest biomass to ethanol will likely get the attention of the mid-Western congressional delegation, who will need to protect Midwest ethanol feedstocks)
- Is this the best place to spend our efforts, given the almost impossible nature of the barriers? Is this the right direction for the American public as a whole?

Capital Investment

- Capital costs are high for the facility and associated equipment—measured in millions of dollars. A 10 MW plant could cost 20 million dollars. Savings in energy costs would have to be substantial in order for a business to make that kind of investment.
    - Savings depends on cost of electricity from other sources
    - Green tags and other incentives can help justify the costs
- Businesses have lots of capital investments that could be made, a biomass facility has to be more attractive than the other possible investments. This largely boils down to which investment would be more profitable
- Have to have certainty that mill/business will be operational long enough to cover investment costs (at least) before converting to biomass boilers

Market Access

- Power rates are cheaper in Oregon than in CA, making it more difficult to invest in biomass facilities here
- Long-term market needed before investment can be made
- Uncertainty about how competition between forest biomass produced energy and corn/soybean produced energy will play out

Facility Siting

- Has to be close to the fuel supply and in a convenient location for the electrical transmission infrastructure
- Very difficult to get public approval for any kind of energy facility when it is in their communities

Public Perceptions and Trust

- Polarization between groups, reflected in politicians—need some middle ground
- PR campaign of the environmental movement

Waste Disposal

- Any facility burning wood will have to dispose of the ash. Expensive to take it to a landfill. Cheaper if you can find another use, like supplementing agricultural soil (has to be checked by DEQ to make sure it is beneficial and not harmful to the soil)

Strategies to overcome the barriers

Institutional Issues

- Designation by prescription rather than description
    - Don't have to physically mark everything on the ground
- Stewardship contracts
    - Contracts need to include some larger timber to make the project profitable, or a subsidy for the fuel removal
    - Contracts have been successful in CA, should be successful here too
- NEPA documents could cover the entire 10 year contract, and be expedited for biomass projects
- Change the leadership at local level in FS and BLM to bring new ideas and someone that is motivated to get something done
- Change the appeals process—people have a right to participate and have their say, but the appeals process shouldn't be able to completely stop a project at the last minute when a lot of resources have already gone into preparing it. Plans, once they are determined, should be set in concrete.
- FS and BLM need to realize that there are costs associated with achieving their desired future conditions of a fire resistant forest
- FS and BLM could outsource a lot of their work
    - They have a finite number of employees
    - Could hire a contract firm to complete the NEPA documents
    - Private industry outsources with high success

Public Policies

- Strong leadership and focus from politicians and/or the PUC
- State needs to be willing to pay for some of the extra public values from biomass utilization
- Renewable portfolio standard that has a mandate for a certain percentage of biomass produced power
- Forests should be managed for everyone's benefit and not the benefit of the minority

Public Perceptions and Trust

- Work together for a solution that works for everyone; bring all necessary parties together
- Pilot projects to demonstrate viability, benefits and impacts
    - Maybe a pilot project that gets its supply from State and private lands where supply issues aren't as difficult

- Provide assurances that thinning will be restricted to small trees in high-risk areas

Education and Research

- Public education is needed. Foresters aren't trusted, and neither is the government. But an organization like the Quincy Library Group that has all sides participating would be more believable
- Science should dominate, not emotions
- Demonstration of a successfully implemented 10 year stewardship contract (acres got treated and supply was consistent)
- Demonstrate attractiveness of tree energy vs. competing energy sources (wind, solar, tidal etc.)
    - Comparative attractiveness will be determined by: ramp-up time and costs, R&D uncertainties, cost competitiveness and need for subsidies amid budgetary constraints, environmental side-effects, scale of energy potential
- To successfully make the case that massive thinning is needed on federal lands, federal land managers need to inventory what is there, and research the various land management practices (including inaction)

Communication

- Group convened by the Oregon Business Council is working to bring energy and forestry sides together—two totally different fields that now need to come together
- People and organizations that want to see this go forward (State of Oregon, Oregon Business Council, OFRI, timber industry organizations) should push the agencies to make the projects available

Project Planning

- Plan with the desired future conditions of the stand always in mind—focus more on what should be left than what should be taken
- Focus on larger details of what we want to accomplish rather than the minute details that in the whole scheme of the project don't mean much

Supply

- There has to be long-term supply contracts where the federal government assumes the liability. These contracts need to guarantee the supply at a certain cost—if costs go up then the government needs to cover these costs

Project Funding

- Could potentially get more money through partnerships with the timber industry, electric utilities and/or communities

Biomass energy feasibility

- Biomass facilities need to be connected with wood processing facilities

Guidelines

Forest Practices

- Practice good forestry (both aesthetic and multiple use) and public support will be there
- Important to not over-utilize the material so that there is a long-term supply
- Monitor the stewardship contracts every year—change prescription if end result isn't what was wanted
- Biggest risk is to do nothing at all

Initial Questions that have to be answered before building a facility

1. What is the cost to produce the power?
    a. Cost right now for a facility is 2.5 million dollars per MW
    b. Cost to produce power is around 6.5 cents per kw
2. Who will buy the power?

Public Policy

- Utility can't be penalized for a state standard requiring them to purchase renewable energy—PUC needs to be willing to pass this on to the ratepayers

4.4.7 Stakeholder Group: Informed Energy Participants

The informed energy participants were a diverse group of energy experts that work for non-governmental organizations or as consultants. They saw many potential benefits to converting forest biomass to energy, but cautioned forestry professionals to be cautious in their optimism for the energy sector's ability to solve forest restoration problems. Perhaps not surprisingly, the participants saw the greatest opportunities in renewable energy, rural economic development, and forest restoration, in that order. Primary barriers concerned securing a long-term, cost effective supply that is socially acceptable.

Opportunities for converting forest biomass to energy in Oregon

Renewable Energy

- Clean, renewable source of energy
    - Mitigates greenhouse gasses and contributions to global warming
- Biomass is the largest potential source of renewable energy in Oregon (with exception of solar which could be big later on when technology improves)
- If biomass energy caused people not normally interested in renewable energy to become interested, that would be a good thing
- Renewables are attractive because they aren't a commodity (like oil or coal), and prices are more stable
- If facilities were located where energy demands are expected to grow, they could be a benefit to the utility

Rural Economic Development

- Jobs
    - More jobs are associated with forest biomass energy than other renewable energy sources
- Renewed tax base

- Non-urban areas could get an economic lift—that has caught the attention of rural legislators, who otherwise might not be interested
- All renewables are currently getting attention for both global warming reasons, and as a result of the energy independence movement

<u>Forests/ Forest Restoration</u>
- Forest health improved by removing excess material
- Reduction of risk of catastrophic wildfire
- Defensible communities

<u>Environment</u>
- Improved air quality
- Healthier watersheds
- Improved rangelands (if removing juniper)

<u>Infrastructure</u>
- Oregon has a lot of old mill sites that are strategically located close to the forest, market transportation systems (highway, rail, water etc), and the electrical grid
- Skilled forestry workforce (although this is going away)
- Doesn't require a technological transformation to work out—technology (to burn wood for energy) is already here and has been used for a long time

<u>Supply</u>
- Lots of supply

Barriers to converting forest biomass to energy in Oregon

<u>Supply</u>
- Access to supply that is long-term, guaranteed and reliable
    - Even if there is a 15 year stewardship contract—how secure is that against changes in administration in Washington DC, and other changes in government?
    - Access to supply needs to be on a scale that matters
- Supply is spread out
- Energy density of forest biomass low (compared to fossil fuels)
- High transportation costs
- Multiple ownerships
- Competing uses for the same material (energy vs. value added products)

<u>Public Perceptions and Trust</u>
- Public perceptions that a biomass industry would be harmful for the forest
- Trust between parties, particularly the environmental community trusting that the motivations behind the projects are for the good of the forest and not a ploy to log large trees
- Broad public support for the issue doesn't translate into support for a specific project
    - Run into problems with NIMBY and environmental concerns

- A critical mass of credible stakeholders need to be in agreement over support for the facility and associated land management requirements before an investor or a public interest stakeholder will be comfortable with the project
- Supply agreement needs to be such that the contractor or FS won't decide 5 years down the road that bigger trees are needed to make the project feasible, or 50 people will have to be laid off. Project needs to be ecologically sound, and the game can't be switched later on down the road.

<u>Public Policies</u>

- Lack of state tax incentives[6]
- Lack of emission reduction credits for improved air quality if biomass is burned for energy rather than it burning out in the forest
- Lack of a high level of involvement from leaders at state and federal levels

<u>Market Access</u>

- Relatively low cost of energy in Oregon; avoided costs are lower here than in other places so development of a biomass energy industry isn't as attractive
- Lack of a willing and financially able market on which to sell renewable energy[7]
- Securing long-term purchasing agreements[8]
- Lack of long-term contracts for sale/delivery of renewable energy certificates, resulting in uncertainty of the revenue stream

<u>Technical Issues</u>

- Multiple revenue streams are needed to make the project economically viable
    - The more revenue streams that are needed (electricity, heat, value-added products), the more complicated the project is and the more things that need to come together at once
    - Difficult to site a facility where it can take advantage of all the needed revenue streams
- Water rights for plants need to be secured

<u>Institutional Issues</u>

- Fire potential is a driver, but this hasn't translated into action on the part of the land stewards
- Forest Service—the agency is a barrier to development of the industry in Oregon much more so than in California
    - Agency opinions in California are different, probably from long-term exposure to the industry in California
    - In Oregon a lot of the supply would come from the FS, but in California industry isn't dependent on FS supply
    - Oregon would need long-term stewardship contracts to guarantee supply

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[6] One reviewer disagreed with this statement by pointing out there is a state incentive that will cover 35% of the cost of an energy project.

[7] One reviewer noted that the PURPA regulations released in the summer of 2005 provides a market by mandating that utilities purchase power generated by facilities 80 MW and smaller.

[8] It was also noted that the PURPA regulations provide a standard 20 year contract for facilities 10 MW and less.

Environmental Issues

- The larger the project, the more material is needed—brings up legitimate environmental concerns

Strategies to overcome the barriers

Public Policies

- Implement the renewable energy action plan as endorsed by Governor Kulongoski
- Implement the greenhouse reduction plan as endorsed by Governor Kulongoski
- Establish a renewable portfolio standard through the legislature[9]
- Make federal and state tax credits available
- Determine what share of the economic burden should be borne by different parties
- Public policy needs to offset the market drivers that make larger facilities more attractive so that smaller facilities could compete

Pilot Projects

- Need to be financially secure and not hovering on edge of bankruptcy (on electrical or thermal use end)
- Can't be in ecologically sensitive areas
- Operations need to be clear and transparent so others can learn from them
- Operators need to be committed to do it right so that the model sets a high bar

Public Perceptions and Trust

- Raise visibility of issue
- Monitoring by a diverse group of parties will help maintain/build trust

Institutional Issues

- FS and BLM should "pay" their tipping fee to remove unwanted material in the form of assuming the costs associated with fuel collection in the forests and delivery to the energy conversion facility yard
- Utilities could figure out where they could use distributed generation the most, and value distributed power produced there higher than someplace where they don't need more electricity. Need different incentives to do this, maybe a mandate?

Technical Issues

- Facility needs to optimize the distance to the fuel and the energy needs. Perhaps along Hwy 97
- Projects need to be sited where both electricity and steam can be used

Supply

- Secure long-term supply arrangements with the federal agencies
- Need to determine what the forest health needs are

[9] One reviewer felt that in order for a renewable portfolio standard to stimulate woody biomass energy development, woody biomass would have to have a specific mandate within the standard. Otherwise the utilities would simply purchase the least expensive renewable sources, such as wind.

Market Access

- Securing long-term purchasing agreements with the utilities to guarantee a reliable pricing structure

Guidelines

Project Planning

- People are very excited due to the possible upsides, but they need to set aside their enthusiasm and take a very close look at the barriers. Need to think clearly
- A one size fits all approach won't work—need to look at individual local situations and have local involvement
- Biomass facilities typically only pencil out if steam can be used—cogneration facilities
- Plants typically need to be operational for at least 20 years
- Supply needs to be guaranteed for at least 10 years, and there must be a plan for where the supply will come from after 10 years to even get an investor to the table

Scale

- Look at the issue on a smaller geographic scale. A lot of the studies are Oregon wide, but the forest health, energy issues, and economic benefits are specific to a small area

4.4.8 Stakeholder Group: State Agencies

The participants from the state agencies were generally very supportive of the idea of converting forest biomass to energy. Renewable energy was seen as the greatest opportunity, but it is worth noting that most of the agencies that participated in the study (Department of Energy, Public Utility Commission, and Oregon Economic Community Development Department) are more focused on energy than forestry. The most common barriers mentioned were public perceptions and trust, issues related to fuel supply, and economics. Another significant barrier was seen as the lack of definitive research regarding whether removing biomass and using it for energy would be beneficial for the forest.

Opportunities for converting forest biomass to energy in Oregon

Renewable Energy

- Biomass could help to develop a renewable energy base
- Both Oregon Department of Energy and the PUC are strong proponents of biomass energy
- Biomass plays a prominent role in the Governor's Renewable Energy Action Plan
- Biomass is currently Oregon's largest renewable source of energy
- There are many benefits to Oregonians in using energy produced from a local source

Rural Economic Development

- Potential to revitalize rural economic growth and development in agricultural and timber based communities

Forests / Forest Restoration

- Reduce fire risk
- Improve forest health—this is a key opportunity to those in the forestry community, but is not a key driver for others

Barriers to converting forest biomass to energy in Oregon

Public Perceptions and Trust

- Lack of trust between parties (primarily between federal agencies, the forest industry sector, and conservation organizations)
- Fear that projects are not really about forest health but are actually about the agencies and industry getting big timber out
- Concerns that the projects will result in environmental harm
- Lack of stakeholder consensus
- Threat of litigation is a huge disincentive to invest

Supply

- Determination of available supply from a policy standpoint (not just a technical or economic feasibility standpoint)
- Cost to extract and transport forest products to an energy producing facility
- Lack of a guaranteed long-term supply
- Forestry infrastructure development
    - Workforce training
    - New production targets and auditing capacity
    - Road access and conditions

Environmental Issues / Research Needs

- Consensus within the scientific community on whether or not removal of biomass would be good for the forest—right now there are scientists on both sides of the issue
- Lack of relevant research—public needs to know if this is the right thing to do in the forest

Public Policies

- Inconsistency of federal renewable energy tax credits—they are only available for a short time period, and may or may not get a last minute extension, which makes them less effective as no one can count on them
- Regulatory environment
    - Mixture of federal, state and private lands, all with different regulations and policies—makes it difficult for investors to determine what is available and how to access it
    - Lots of red tape

Technical Issues

- Interconnection is costly, takes time, and requires both expertise and perseverance

Cost

- High capital costs for facilities

- Utilities can get cost recovery from ratepayers only for prudently incurred costs. If forest biomass resources aren't least-cost/least-risk, the utilities won't acquire them.
    - No above-market costs of new renewable generating resources can be passed along to rate payers of Portland General Electric and Pacific Power. (A separate public purpose charge on utility bills goes in part toward the above-market costs of new renewable resources.)

Market Access

- Lack of current market for biomass utilization

Strategies to overcome the barriers

Supply

- Collaborative approach, involving all stakeholders, to determine available supply
- Agricultural community should be included at the table as agricultural related sources will be important too

Public Perceptions and Trust

- Collaborative arrangements with all stakeholders involved; something like the OR Solutions model

Transportation Costs

- To address the transportation side, need to revisit the idea of a subsidy. Not a government subsidy, but a commercial subsidy. Could be to allow a sawlog component to the project so that the company removing the biomass can recover their costs. Could be something like the back haul concept where commodities are transported both ways

Public Policies

- Could consider new legislation that would add a 1 to 2 cent incentive to produce power from biomass

Technical Issues

- PUC will soon be opening a rulemaking on uniform interconnection standards, procedures and agreements for the investor-owned utilities. The consumer-owned utilities have expressed interest in jointly developing standards and procedures, with the understanding that the Oregon PUC and the consumer-owned utilities will each adopt what they deem appropriate.

4.4.9 Stakeholder Group: Tribal Organization

The Tribal organization that participated in this study is in the unique position of being one of the few entities in the state that are currently in the final stages of planning a biomass utilization project using a large quantity of thinning material from federal forest restoration activities. They are clearly very much in support of the idea to convert forest biomass to energy. They have encountered a number of barriers, and have prioritized them based on what needs to be addressed first before the others can be tackled. First a long-term supply must be secured before any power purchaser or lender will be interested in the project. Securing supply involves extensive participation in collaborative groups with open, honest discussion. Once the available supply is determined, then a power purchase agreement must be secured. Once both of those components are in place, project financing must be arranged.

They see the primary opportunities as being two-fold: (1) to be able to protect the Tribal forests from fire, and thus to protect treaty rights (this includes neighboring federal forests). And (2) by protecting the forest they can ensure long-term economic security of the Tribe. By being able to utilize small diameter material, they can provide more jobs to the Tribal community.

Opportunities for converting forest biomass to energy in Oregon

<u>Rural Economic Development</u>

- Long-term revenue for the Tribe. Lumber market has always been volatile, but now it is especially volatile. Producing energy offers another product that is more stable than lumber markets. Revenue from timber funds many tribal government programs—it is very important to maintain that revenue.
- Jobs for tribal members. With the expansion of this facility they can create 60 new jobs on the reservation (based on a 1999 NREL study that projected 4.9 jobs for every MW)

<u>Forests / Forest Restoration</u>

- Reduce fire risk on reservation (by treating both reservation lands and neighboring lands)

<u>Renewable Energy</u>

- In the future technologies will be make it economically feasible to create transportation fuel and bioproducts from woody biomass

Barriers to converting forest biomass to energy in Oregon

<u>Public Perceptions and Trust</u>

- Recognition of the public benefits from utilizing biomass as energy
- Getting conservation groups to support the projects—if that support was there the agency would move forward
  - Lack of trust with the agencies is an issue

<u>Supply</u>

- Long-term economics associated with transportation (rising costs of fuels)
- Some of the supply has to be at no cost or it becomes very difficult financially

<u>Technical Issues</u>

- Lack of understanding on how the equipment works for these types of projects and what their limitations are (example is where a chip truck can and can't go)
- Permits from EPA to meet Clean Air Act and Clean Water Act requirements
  - For them this was a bit easier than it would be for a new facility since they already have a boiler and are just expanding

Market Access

- Power sale agreement
  - Can't even start this until the supply agreements is in place
  - Transmission can be an issue depending on the utility (where they have transmission already and how much it would cost to get to their transmission lines)

Environmental Issues

- Understanding the benefits of converting the material rather than leaving it on the forest

Financing

- Need to be able to utilize tax incentives and other available incentives

Institutional Issues

- Agency expectations that this new market will pay for *all* the forest restoration needs, but that isn't the case—they need to focus on economically feasible projects

Public Policies

- No RPS
  - Investor owned utilities are driven by least cost acquisitions, but renewables aren't typically least cost

Accounting

- The accounting system for the cost of oil—if the cost at the pump reflected its true costs things would move faster in development of alternative sources

Strategies to overcome the barriers

Public Perceptions and Trust

- Work still needs to be done on building trust with conservation organizations
  - Demonstration projects like Glaze Meadows are a good start—need to show the right thing is being done, and then need to keep doing the right thing
- Collaborative arrangements (with agencies and conservation community) to determine supply and feasibility

Financing

- Form partnerships that allow for capital financing
- 15 year power contract is long enough to pay off debts and make a profit

Public Policies

- RPS would help
- Extend the production tax credit reauthorization for 3-5 years instead of 2

Institutional Issues

- Agencies are working on their barriers and those will likely be overcome

Market Access
- Power agreement needs to have an escalator clause

Guidelines

Scale
- Scale facilities appropriately
    - Fuel supply should be much greater than what the plant needs
        - There is a big fear out there that the tail will wag the dog
- Biomass may be a part of the renewable energy solution, but it isn't the whole solution

Collaboration
- Collaboration is essential

Prioritize Goals
- Prioritize ecological and community goals, then look for ways to implement them in the most economical way possible

Location of Facility
- Site so interconnection to the grid is feasible

Chapter 5
Constraints and Challenges

5.1 Introduction

A number of constraints and challenges must be overcome if the potential for woody biomass to energy conversion is to be realized in Oregon. In this Chapter, we identify what we believe are the most important challenges. These have been drawn from a range of sources including the scientific and policy literature (see Chapter 1), an assessment of potential (Chapter 2), an evaluation of current efforts (Chapter 3), stakeholder interviews (Chapter 4), as well as discussions among the project team.

Constraints and challenges have been organized into the following categories:

- **Public Acceptance** – Without a social license from the public, development of a woody biomass energy industry will not proceed very far. Many of the questions the public has are related to the environmental impacts of biomass energy in general and forest biomass harvesting in particular.

- **Biomass Supply** - Assured access to an affordable, long-term supply of suitable woody biomass for fuel or feedstock is often identified as a major challenge in biomass energy projects.

- **Markets** – Market-related issues including the overall competitiveness of biomass energy, project startup and energy market entry barriers, and other issues also rank high terms of importance.

- **Public Policies** – Both the state and federal government have made strides over the last few years in putting into place public policies supporting renewable energy. However, there still remain some challenges in the public policy arena that need to be addressed.

- **Institutional Issues** – Since a large portion of the potential woody biomass supply from Oregon originates from forest restoration treatments on federal lands, the policies and capabilities of the two primary federal land management agencies, the USDA Forest Service and Bureau of Land Management, are critical to building a successful woody biomass energy industry.

- **Technical Issues** - There are technical issues that require research and development attention. These include research on emerging energy technologies, forest restoration and fuel treatments, harvesting technologies, biomass supply, and alternative uses of harvested material.

In the following sections, we discuss each category of constraints and challenges in more detail.

5.2 Public Acceptance

Public attitudes regarding renewable energy, forest biomass opportunities and their economic, social and environmental impacts present a number of challenges that must be addressed if an emerging forest biomass energy industry is to gain a social license, or societal support, to operate. The issues are complex and views and attitudes vary among groups, as would be expected. There is not one public; in fact, there are many. In our democratic, pluralistic society the public rarely speaks with one voice. There are competing views and interests. Elected officials, public interest groups, and even the media claim to represent the public but are often divided on issues.

Who, then, grants the social license? In a general sense, the stakeholder groups most affected by an action have the most leverage in determining whether a social license is granted or withheld for a particular action or policy. Those segments of society that feel less personally affected by an action will seldom raise an objection nor are they likely to actively support it. It is important then, to understand the potential objections of various stakeholder groups so they can be addressed in a constructive and collaborative way.

In the process of this study, we identified the following issues as the most important to various stakeholder groups:

- **Environmental concerns over forest biomass energy development**
  - Impact of harvesting on soils, long term productivity, water quality
  - Unpredicted, unintended environmental consequences
  - Potential for overdevelopment in relation to sustainable capacity
  - Impacts of processing facilities and power plants

- **Lack of trust among stakeholders**
  - Multi-directional distrust
  - Underlying motivations
  - Willingness to live up to commitments

- **Lack of awareness & understanding**
  - Net environmental benefits not recognized
  - Other benefits not well understood - economic and social
  - Perception that wind and solar are cleaner and greener while direct combustion is old technology
  - Need for forest restoration treatments not understood

5.2.1 Environmental concerns over forest biomass energy development

Many people express concern over the potential environmental impacts of a large scale energy industry developed around forest biomass. These concerns center on environmental impacts of biomass harvesting on forest resources and the environmental impact of biomass processing plants.

The concerns over environmental impacts of forest biomass harvesting appear to be the primary factor limiting development of a woody biomass energy industry in Oregon. These concerns resulted in gradual loss of public support for the direction of public land management beginning in the 1970's. Lack of public acceptance of commercial timber harvesting on public lands had by the early 1990's led to calls for limiting or ending commercial timber harvest on public lands. In response to this loss of social license, federal timber sale volumes dropped by as much as 90%.

Today, these concerns extend to proposals to respond to forest health and fire issues by thinning forests and removing excess woody biomass. Among the concerns most often cited are impacts of forest roads, biomass harvesting and extraction on:

- Water quality and fish due to harvesting and increased road use
- Wildlife habitat and biodiversity
- Soil, including compaction and erosion and loss of long-term productivity

There is also concern expressed over the potential for unpredicted, unintended environmental consequences. There is a stated level of anxiety over the effects of forest restoration treatments on ecological processes. Some are concerned that if an energy industry is developed based on forest biomass supply, forest restoration goals will quickly become subservient to supplying the industry. If forest restoration treatments are later found to have unforeseen environmental impacts or to not meet their intended ecological goals, it will be difficult to change directions.

Another strongly expressed concern is that the industry not be overdeveloped in relation to the sustainable capacity of the landbase. Again, the concern is that forest restoration goals could become subservient to supplying energy industry capacity. There is concern that no mechanism is in place to ensure a sustainable level of development.

Those who want to see fire re-introduced into the landscape over the long-term oppose development of an industry that will last after the current backlog of existing biomass is removed. In their view, the industry should be developed to utilize biomass removed during a forest restoration phase of perhaps 20 - 25 years. Following this, the state would move on to other forms of renewable energy and natural fire would replace mechanical removal of biomass in the forest.

Another set of concerns are focused on the harmful environmental impacts of the energy plant itself. The predominant issues that arise in relation to biomass power plants are air pollution and release of carbon into the atmosphere and its effect on climate change.

5.2.2 Lack of trust among stakeholders

Intertwined with the issues stated above is a lack of trust between various stakeholder groups. This represents a tremendous challenge to development of a forest biomass-based energy sector.

Lack of trust is multi-directional. While it is always dangerous to make broad generalizations and there are always exceptions, we note the following commonly heard issues in an attempt to fairly shed light on them:

- Some public interest group stakeholders and some members of the general public distrust federal agencies and suspect that forest industry influence is driving the "biomass movement." They question motivations – is this just another agency/industry attempt to harvest large diameter trees? Is this really about forest restoration or is this just the latest guise to exploit the resource? There is also a suspicion that science and academic institutions could be used to support perceived industry goals.

- Agency employees distrust activists whom they suspect will eventually throw up roadblocks and bring land management activities to a halt, despite their best collaborative efforts. Public interest groups do not speak with one voice. Gaining support from nine groups does not mean a tenth will not appear to bring opposition.

- Project developers and the forest industry in general distrust activists based on past experience. They also suspect that agencies will inevitably fall back into gridlock when opposition arises or administrations change. Money and effort expended to plan projects will be wasted. The overriding concern is the ability of agencies to follow through on long term commitments even when a forest stewardship contract is in place. Lenders share the same concerns.

5.2.3 Lack of awareness

Lack of awareness by the general public of the complex issues surrounding renewable energy and forest restoration and biomass use is often cited as a challenge that must be addressed to gain social acceptance. We are not faulting the public for this lack of awareness; we live in an age of constant bombardment with information on a tremendous variety of issues. Nevertheless, if public acceptance is critical, the current lack of awareness and understanding around these issues is a challenge.

In terms of public recognition, the broader benefits of forest restoration and renewable energy development seem to take a back seat to the more visible site specific costs – from harvesting and road impacts. Nor are all risks, including the risk of inaction, considered. As a result, environmental costs of an action are often not weighed against the full environmental benefits including the avoided costs of the likely result of inaction. By focusing on site-specific impacts rather than the bigger picture, the full environmental benefits are not recognized.

For example, the fact that biomass plants produce air emissions is often expressed as a concern by those opposed to facility development. However, the use of forest biomass for energy production results in lower particulate matter emissions (PM) than either prescribed burning or wildfire. Estimates of emissions from biomass power plants by the EPA equate to 9 to 20% of the emissions from open burning. Emittent pollution levels for ethanol plants are expected to be similar or less than biomass power facilities.

Another challenge is improving the perceptions of biomass energy in relation to other renewables. Wind and solar energy are often viewed as cleaner and greener alternatives than biomass. As evidence, green tags for these alternatives currently have a higher market value. This is due to the lack of recognition of the net environmental benefits of biomass energy.

A final concern is a lack of understanding among the public in general, as well as stakeholder groups, over the need for forest restoration. The overcrowded forest conditions common today developed over a long period of time. To many people, these conditions represent the norm, not a departure from natural conditions. The public has few opportunities to view eastside, dry forests under natural stocking conditions or see the impacts of restoration treatments. Their initiation into the issue, if there is one at all, is through the mass media which often presents confusing and conflicting "sides" with little context for evaluation. As a result, many are suspicious of calls for large scale forest restoration.

5.3 Biomass Supply

Key biomass supply constraints and challenges are as follows:

- **Secure, long-term, affordable feedstock supplies**
  - Uncertainty of supply from federal lands and other sources
  - Cost of supply for forest-based biomass is high relative to value
  - Supply uncertainty creates financing access difficulties, higher risk
  - Supply uncertainty also creates both short and long term operational risks

- **Federal land management agency capacity**
  - Land management agency staffing and resources to plan and implement forest restoration treatments
  - Forest contractors to take on and implement large-scale forest stewardship contracts or other biomass sale agreements

- **Lack of infrastructure for harvesting and delivering biomass**
  - Harvesting and transportation workforce
  - Knowledge and skill-set appropriate for new approaches of forest removals
  - Equipment for logging and hauling biomass material to market

- **Lack of developed marketplace for biomass**
  - No transparent market price, standard supply terms for woody forest biomass fuel
  - Creates credit and operational risk

- **Balancing competing uses for biomass**
  - Competition with small log facilities, paper, and board producers for some of same supply
  - In the future, with expanding liquid fuel and chemical feedstock applications, there will be even greater competition for biomass
  - Need to balance sustainable development of highest value uses in the near term while not foreclosing future development of the transportation fuel industry

5.3.1 Secure, long-term, affordable feedstock supplies

Feedstock supply is the first and most critical issue that must be addressed in the earliest stages of project design. The available supply affects all phases of project development including overall economic feasibility, plant capacity, and capital needs. It is critical to initiating the process of obtaining financing as well as marketing the resulting power. In order to get in the door of financial institutions, project developers must be able to demonstrate an adequate, secure supply for the lifetime of the financing which is usually at least 10 years. This includes identifying a primary and secondary supply to cover contingencies such as poor weather and fire danger. Where fuel supply contracts are negotiated, the problem is to secure supplies which are bankable from an investor's point of view. For operational security, a developer generally looks for a total supply over the expected lifetime of the facility that is three to five times the expected consumption.

Uncertainty of supply from federal lands is the major challenge since the majority source of the potential supply is federal lands in need of fuel reduction treatments as part of ecological restoration. Controversy over management of public lands, litigation (actual or threatened), and the ensuing management gridlock makes reliance on federal supply unstable. Developers and lenders have little confidence that the agencies can follow through on long-term commitments. Institutional challenges, described in Section 5.6, can add to the uncertainty.

For economic reasons, supply is also uncertain on private lands. Because the marginal cost of recovering biomass from private lands is high, there remain questions over whether private landowners will supply biomass to an energy feedstock market. On the other hand, a market for small diameter material provides an opportunity to implement stand treatments that improve growth on residual trees. If treatments yielding biomass and some merchantable small diameter material can break even financially, there may be private supply made available to market.

A major challenge is that the cost of extracting forest biomass is high relative to its value for power production using current technologies. Since commercial applications for converting woody biomass to ethanol are not yet available, the economics of forest biomass for this end-use are uncertain. If the value of woody biomass for transportation fuels is higher than that for power generation, as many expect, high costs of extraction may become less of an issue.

Supply uncertainty creates many problems including difficulties in accessing project financing, higher interest rates to compensate for the risk, and both short and long term operational risks.

5.3.2 Lack of infrastructure for harvesting and delivering biomass

The infrastructure (workforce, equipment and supporting services) required for harvesting and transporting biomass from the forest to a market is not fully in place in all areas of the state. This infrastructure includes:

- Harvesting & transportation workforce
- Equipment
- Support services
- Stewardship contractors

Declining timber harvests from federal lands have contributed to a loss of skilled forest harvesting contractors in some areas. In a recent GAO report, biomass users cited lack of adequate logging infrastructure as a barrier to biomass use. Representatives of one biomass power plant running at less than full capacity said the shortage was due to a lack of local logging infrastructure (GAO 2006).

Perhaps just as importantly, a workforce with new skills and equipment is needed. For contractors to be successful, they must have a different knowledge base and different set of tools. The "new" knowledge base includes a better understanding of ecological restoration, value added markets, use of different types of equipment and extraction techniques for harvesting small trees and biomass, and stronger business management skills. There are some entrepreneurial contractors in eastern and southern Oregon leading the way in this area. More will need to be developed.

One of the major tools of forest restoration is stewardship contracts, under which third party contractors provide land management services to the federal agencies. Forest contractors willing to take on and implement large-scale forest stewardship contracts or other biomass sale agreements will also be needed. As more and larger stewardship contracts are offered, a stewardship contracting force will be required. Under SB1072, the ODF has authority to facilitate the development of stewardship contracts utilizing private contractors and, when appropriate, to seek and enter into a stewardship contract agreement with federal agencies to carry out forest management activities on federal lands. This may provide a means to cultivate a contracting force.

5.3.3 Lack of developed marketplace for biomass feedstock

The market for mill residuals from the production of primary woods products is a mature commodity market in Oregon. Vertically integrated companies transfer residuals between facilities. Non-integrated facilities use residuals for fuel and/or market residuals to pulp mills and solid wood facilities. Among the participants in this market, price levels are generally well-established and known. The network of buyers and sellers is established. Short and long-term contracts are used as well as spot purchases (short term, single sale).

Conversely, forest-based biomass markets – to the extent they exist at all in Oregon – are small and mostly private. Market information is not collected or published. The lack of market information makes identification and coordination of large scale supplies complicated. If developers must enter contract discussions without market reference prices and well understood contract terms, negotiating and contracting costs increase.

The absence of major independent feedstock suppliers results in a credit risk. Financing institutions will be wary of a single source of fuel, even if it is secured with a 10 year stewardship contract. In addition, the lack of significant trading of wood fuels means that supply risks (quality, price or volume) cannot be hedged. This is partially addressed by a long-term fuel supply agreement, but then the developer of a power plant may also have to become a fuel supplier. These are very different businesses and add complexity.

5.3.4 Balancing competing uses for biomass

Some portion of the biomass feedstock supply has alternative uses such as small diameter log products, wood fuel pellets, posts, poles, paper and particleboard and other products. As a matter of economic efficiency the biomass supply should be allocated to end uses with the highest economic value-added. This contributes the most to the economy and is likely to provide the most jobs and highest income. In addition, it will improve the economics of forest restoration treatments by providing additional revenue from higher value end-products.

Small diameter log products, such as small dimension lumber, fence posts, landscape timbers and pelletized fuel are generally higher-value uses and should be encouraged. Markets for these products, however, have historically been limited relative to supply. The challenge is developing new value-added products which can be made from the large supply of small logs from fuel reduction treatments.

Pulp chips are one possible use for small diameter material; however, the northwest paper industry has traditionally relied low-cost residuals while use of whole tree chips has been limited. In general, the northwest paper industry is a high-cost producer and not likely to make use of higher cost fiber sources such as whole tree chips from forest restoration treatments, as long as lower cost residuals are available; the same is true for particleboard producers.

It is more likely that alternative forms of energy production will eventually compete with each other for forest biomass supply. As conversion of cellulosic biomass to ethanol and biochemicals becomes commercial, these uses would compete for biomass used in electrical generation. If supply becomes constrained, the lowest value use (probably power generation) will suffer. To the extent that ethanol and biochemical applications require clean wood chips, small diameter logs (5 – 9") may be directed to this end while smaller, lower quality biomass that cannot be converted to clean chips would be available for power generation.

The challenge for public policy is to encourage sustainable development of woody biomass energy using existing technologies while not foreclosing the possibility of future development of transportation fuel production from the same resource.

5.4 Markets

Markets for a biomass power and fuels industry are not well developed. It will take effort from government and industry, as well as cooperation from NGOs and the public to create the conditions for success.

- **Overall competitiveness of biomass power generation**
  - Power from stand-alone woody biomass plants is more expensive than market prices
  - Electricity consumers demand lowest cost power
  - Distributed nature of forest biomass supply lends itself to smaller-scale projects while economics of plant development push toward larger plant capacities
  - Lack of level playing field compared to other energy alternatives

- **Market entry barriers**
  - Developers have fewer resources than large generation companies or integrated utilities
  - Market preference for conventional technology
  - Access to capital & higher financing costs
  - Early phase development is expensive and risky

- **Uncertainty of future ethanol markets**
  - Historic uncertainty whether ethanol market will grow substantially
  - Recent global energy and political trends are emerging that support ethanol production

5.4.1 Overall competitiveness of biomass power generation

Power from stand-alone biomass power plants is and has been more expensive than other energy sources. In operation, biomass plants must compete based on existing plants' cost of fuel and operations. The cost of electricity produced at stand-alone biomass power plants is greater than the published avoided cost of PGE and PacifiCorp. While some investment in biomass by regulated utilities can be justified through PURPA, or acquisition of long-term contracts that mitigate fossil fuel price volatility, in general utilities cannot acquire higher-cost resources than market. The creation of a renewable resource portfolio requirement in Oregon, if aggressive enough, would go a long way toward erasing acquisition barriers. In addition, if the price of petroleum and natural gas stay high for an extended period of time, which global energy supply and demand trends suggest is likely, biomass may be able to compete directly with these energy sources. However, biomass power will also need to be competitive with other renewable energy sources such as wind and landfill gas, if it is to survive long term without subsidies.

Within regulated utility systems, economic dispatch (ordering plants on-line or off-line based on cost) is being used. Older, conventional power plants usually have a lower dispatch power price. Increasingly, economic dispatch is being used to provide the lowest cost of energy to consumers. This may place biomass-fueled developers at a disadvantage if regulatory policies are not clear, or conflict with renewable portfolio requirements.

Fewer people actually choose to buy green electricity than say they would if they could. One important reason why participation rates are low is that people seem to have a preference for everyone to contribute to renewables. In an October 1998 poll of Texas utilities customers, 88% said they would be willing to pay more for renewables. However, 79% preferred that all utility customers pay at least some of the added costs, whereas only 17% wanted to rely only on green-pricing (Rose 1998).

Developers often find it advantageous to finance large projects with a high level of debt, reducing taxes and increasing return on equity. However, developers who seek to finance commercially small projects may find their debt needs are below the threshold required to gain the interest of lenders. They may also have a problem demonstrating they have access to sufficient equity to qualify for a loan. In these cases, financing may not be available, or required fees and interest rates may put the viability of the project out of reach.

Biomass developments have many secondary project costs that are higher than more conventional technologies per installed megawatt. These expenses could include legal costs, fuel handling, engineering costs and grid connections. Legal costs are particularly high with a biomass project because of the complex contracting obligations. Access to the grid, as with many other renewable power technologies, comes at the end of a lengthy and highly specialized process and can be financially risky.

Small projects may present higher costs at many stages of the development cycle. It costs more for financial institutions to evaluate the credit-worthiness of many small projects than of one large project. It costs marketers more to negotiate contracts with many small projects, and to market to and sign up residential customers, who are the most likely segment to pay more for renewables.

A 1996 study by Resources for the Future found that the total tax burden of natural gas facilities is 0.5¢/kWh (1993 dollars), compared with 1.5¢/kWh for biomass generators. Even with the energy production tax credit, the tax burden is over 50% higher than for a natural gas plant (Burtraw 1996).

The Energy Information Administration found that renewable energy development is further inhibited by a "depletion allowance" for oil, natural gas, and coal suppliers, resulting in a federal tax revenue loss (EIA 1992). The depletion allowance allows companies to deduct the "loss" of fuels that have been mined or drilled. Furthermore, tax law allows fossil fuel producers to write off certain exploration and development costs rather than capitalizing and depreciating them over time. While this has resulted in increased production within the United States and lower oil prices, it may also make competing costs of renewable energy less attractive.

5.4.2 Market entry barriers

A number of barriers exist to entry into the energy market. These barriers may increase the risk of investing in biomass (thereby increasing the cost of capital), and increase operating costs.

Renewable energy projects and companies are generally small. Thus they have fewer resources than large generation companies or integrated utilities. These small companies are less able to communicate directly with large numbers of customers. They will have less clout negotiating favorable terms with larger market players. They may be less able to participate in regulatory or legislative proceedings, or in industry forums defining new electricity market rules.

There is no standard plan for biomass projects. Every plant has unique characteristics, transmission access requirements, complex funding arrangements and market entry difficulties. Environmental benefits of biomass may not be widely appreciated. Barriers at the project initiation stage are typically "go/no-go", possibly preventing viable projects from getting off the ground.

Conventional (fossil-fueled) technology translates into a favorable market position. For biomass developers, this makes even more important the need for a secure and inexpensive fuel supply.

A market preference for conventional technologies leads to high costs of financing for biomass technology because of higher equity requirements, higher interest rates and fees. In addition to having higher transaction costs, financial institutions are generally unfamiliar with newer technologies and are likely to perceive them as risky, so that they may lend money only at higher rates. High financing costs are especially significant to the competitive position of renewables, since renewables generally require higher initial investments than fossil fuel plants, even though they have lower operating costs.

Costs push developers towards finding economies of scale through large-scale development. Large centralized facilities have received most of the past investment in biomass energy while projects that match available local wood supply with local baseload steam production have trouble attracting capital. However, for sustainable development, there is a need to match the production capability of a facility to the available local supply.

Smaller developers may not have a strong credit record. This is important for electricity plants, because the lack of a favorable credit record may prevent a developer from entering into serious discussions with a utility on a Power Purchase Agreement (PPA). And, a PPA is necessary to raise debt financing. A utility will only do business with a generator who can demonstrate a low level of contract risk. A lack of credit is less of a barrier in purely heat applications as no PPA is required, although if the developer is also supplying the fuel, long-term reliability is still an issue for financing.

The financial markets may be wary of investing in traditional biomass power generation facilities because of long-term market uncertainties. Using biomass as fuel for electrical production may in the future prove less attractive than using it in the liquid transportation fuel or chemical feedstock markets. The use of biomass for development of self-sufficient sources of transportation fuel is also clearly in the public interest.

5.4.3 Uncertainty of future ethanol markets

Many of the first cellulose-to-ethanol companies will be small and will require large amounts of financing for their projects. Some estimates of the capital cost of these projects suggest investment of over $100 million for a 20 to 25 million gallons per year plant. The difficulties in financing new technology create a significant challenge and barrier.

Uncertainties in the ethanol market create a challenge. Ethanol is closely tied to federal tax and air quality policies. Investment in new technologies will be limited until there is a strong signal that the ethanol market will grow substantially and securely.

Recently, those signals are emerging. Rising oil prices, global demand for oil in the face of dwindling supply and unsettled global politics are generating considerable interest in alternative transportation fuels in the U.S. Here in Oregon, these signals are being heeded. Two corn-based ethanol plants will begin construction in the summer of 2006 with a combined capacity of 148 million gallons. The plants in Boardman and Clatskanie will be the first ethanol plants in the Northwest. The 113 million gallon per year Clatskanie plant is being built by Cascade Grain Products, LLC and will cost $192 million. It is being supported by a $20 million loan from the ODOE. Pacific Ethanol is building a 35 million gpy plant, estimated at $50 million, in Boardman.[1]

5.5 Public Policies

Current public policies in several areas have constrained development of a biomass energy industry. We have identified the following:

- **Some Oregon policies are in conflict with renewable energy development**
  - Oregon's Renewable Energy Action Plan has the right elements, but existing statutes do not fully align all state agencies towards its accomplishment.
  - A lack of coordinated policies may lead to unintended consequences.

- **R&D playing field is not level**
  - Majority of federal R&D funding goes to non-renewable energy sources

- **Federal policies don't recognize all of the costs of traditional energy sources**
  - Climate change
  - Other environmental costs

[1] "Oregon's next product: ethanol fuel" Oregonian, May 11, 2006, p. A1.

  - Economic costs of foreign energy dependence

- **Permitting and siting processes are considered by developers to be complex, difficult, and sometimes unclear.**
  - Biomass projects are industrial developments, and will require a land use permit, conditional use permit, a zoning or master plan amendment, or perhaps a combination of these.
  - Permits are discretionary, subject to approval by elected bodies such as County Commissions or City Councils, and are not assured at the onset of development.
  - The process can take months or years, is generally very expensive, and is subject to public review, comment, and often, opposition
  - Local permitting staff often have no experience with energy development, and local ordinances are rarely constructed with energy facilities in mind

- **Incentive programs**
  - Programs are available from a variety of agencies and information is difficult to access
  - Recent elimination of Environmental Action Programs funding
  - Short-term incentives don't' match the needs of developers
  - Federal Production Tax Credit is time-limited

5.5.1 Some Oregon policies are in conflict with renewable energy development

Oregon needs a coordinated policy for dealing with all phases of biomass development. While ODOE statutory policy (ORS 469) gives highest priority to renewable energy and energy efficiency measures, other agency and local government direction is not as clear. The PUC is concerned with the lowest short-term impact to ratepayers. Natural resource agencies focus on protection of their resources, often to the exclusion of consideration of others. Regulatory agencies are often constrained by a lack of statutory authority. Legislative proposals in 2005 related to biomass development were unable to gain passage because of conflicting policy priorities.

Agency review often focuses on site and project specific impacts instead of net environmental economic or regional benefits. For example, forest fuel reduction activities may be seen as a loss of habitat and a potential short term risk to water quality. However, in the long term, fuel reduction will result in habitat preservation due to fewer wildfires.

A lack of coordinated policies may lead to unintended consequences. For example, SB 705 in California (2003), eliminating agricultural burning in the San Joaquin Valley, was passed to complement legislation providing subsidies for the use of agricultural biomass in power plants (SB 704). However, the elimination of open burning resulted in emissions that were no longer surplus and therefore could not be counted as offsets to obtain air permits for new sources. The lack of emission offsets is now a significant barrier to further development.

If slash burning on federal forest land is similarly restricted in the future for air quality reasons, air permitting of woody biomass developments could be affected as well. In California, new legislation is needed to overcome this barrier if the original legislative intent is to be realized.

Without the recognition that biomass plants lower overall emissions, permitting of new facilities will be more difficult.

5.5.2 R&D playing field is not level

According to the Congressional Research Service (Sissine 2006), from FY1973 through FY2003, the federal government spent about $101.4 billion (2003 dollars) on energy research and development (Table 1). Nuclear and fossil fuel energy received 75% of this funding. Spending on renewable energy R&D totaled $14.6 billion, 11% of the total and an average of $471 million per year. Renewable energy R&D funding grew from less than $1 million per year in the early 1970s to over $1.4 billion in FY1979 and FY1980, and then declined steadily to $148 million in FY1990. By FY2003, it reached $411 million in 2003 constant dollars.

Table 1 – Federal spending on energy R&D (Sissine 2006).

Research Area	FY1973 – FY2003	
	Billion $'s	*% of Funding*
Nuclear	49.7	50%
Fossil	25.4	25%
Renewable	14.6	14%
Energy Efficiency	11.7	11%

Going back further, total energy R&D spending from FY1948 to FY2003, in 2003 constant dollars, was $131.2 billion, including $74.0 billion, or 56%, for nuclear; $30.9 billion, or 24%, for fossil; $14.6 billion, or 11%, for renewables; and $11.7 billion, or 9%, for energy efficiency.

DOE's FY2004 renewable energy R&D funding totaled $439.4 million, or about 19% of DOE's energy R&D appropriation. Energy conservation received $559.7 million (24%), fossil energy received $672.8 million (29%), and fission and fusion was appropriated $667.4 million (29%). While going in the right direction, these disparities in R&D continue to inhibit adequate preparation for a carbon constrained future.

5.5.3 Federal policies don't recognize all of the costs of traditional energy sources

Renewables will have a harder time competing on a level playing field with conventional energy generation until new policies are adopted to internalize the public costs of fossil fuel sources. Emission fees or caps on total pollution, with tradable emission permits, are examples of ways to internalize the costs of pollution, creating a fairer arena for renewables.

Although the US, in recent years, has placed a heavy emphasis on natural gas for new power generation, it has not yet adopted a policy addressing reduction and sequestration of CO2, as needed to meet goals for sustainable development.

With a few exceptions, such as Oregon's climate change standard for new fossil-fueled power plants, policies do not currently exist to encourage sequestering of this sort at a commercial scale. Biomass conversion can also reduce emission of methane from decomposition, reducing the global warming potential of the emitted carbon. The lack of a national policy to credit the sustainability benefits of biomass or to require a more sustainable use of natural gas and other fossil resources makes the cost of biomass appear high.

5.5.4 Permitting and siting processes are considered by developers to be complex, difficult, and sometimes unclear.

Permitting and siting processes are generally considered by developers to be complex, difficult, and sometimes unclear. Biomass projects are industrial developments, and will require land use permits, conditional use permits, a zoning or master plan amendments, or perhaps a combination of these. Permits are discretionary, subject to approval by elected bodies such as County Commissions or City Councils, and are not assured at the onset of development. The process can take months or years, is generally very expensive, and is subject to public review, comment, and often, opposition.

The streamlining of these processes is possible, but few if any specific actions have yet been taken. Whether or not these processes can be streamlined and still continue to protect health and environmental quality is subject to debate. Ordinances defining technologies and resources can create narrow or technically incorrect definitions that make their application difficult. Performance-based standards in general may prove more effective in achieving environmental objectives without inhibiting technical innovation.

5.5.5 Federal Production Tax Credit

Federal incentives for biomass, though increased over the recent past, are still well short of those that continue to be offered to nuclear, petroleum, coal and gas technologies.

The majority of tax incentives from 1996-2009 have gone or will go to fossil fuels, with 86% of the estimated $16.1 billion total going to fossil during 2005-2009.

The federal Production Tax Credit (PTC) available to existing open loop biomass generators is only 0.9¢/kWh for electricity sold to third parties. This is half of the 1.9¢/kWh available to closed loop biomass and wind generators.

In addition, we have encountered confusion over the issue of how long the tax credit applies. Many have reported that the tax credit is available for 5 years for existing and 10 years for new open loop biomass facilities. For example, the WGA report recommends, "the credit for existing biomass facilities should be extended to 10 years to match that for new facilities" (WGA Biomass Task Force 2006, p. 53) However, our research indicates that the credit does not apply for 10 years even for new facilities. According to IRS Form 3385 for 2005 (page 3), the credit period for various types of renewable energy are as follows:

- 10 years for a wind, poultry waste, closed-loop biomass (not modified for co-fire purposes), or refined coal production facility, beginning on the date the facility was placed in service.

- 10 years for a closed-loop biomass facility modified to co-fire with coal, other biomass (or both), beginning on the date the facility was placed in service, but not earlier than 10/22/04.

- 10 years for a hydropower facility, beginning on the date the efficiency improvements or additions to capacity are placed in service.

- 7 years for an Indian coal production facility, beginning on the date the facility was placed in service, but not before 1/1/2006.

- 5 years for an open-loop biomass facility using agricultural livestock waste, geothermal, solar energy, small irrigation power, landfill gas, or trash combustion facility, beginning on the date the facility placed in service, if placed in service during the period after 10/22/04 and before 8/9/05. If not placed in service during that period, the credit period is 10 years.

- **5 years for an open-loop biomass facility using cellulosic waste, beginning on the date the facility was placed in service, but not earlier than 1/1/05.**

The last bullet point appears to be the classification under which woody (cellulosic) biomass falls. It indicates a 5 year tax credit period and excludes a tax credit for facilities placed in service prior to January 1, 2005. Assuming this is the case, the PTC for woody biomass is only *a quarter* of that for other closed loop biomass, wind, and other renewables. In addition, it treats existing woody biomass plants unfairly in relation to other existing renewable facilities, providing them no tax credit if placed into service prior to 2005.

The federal PTC for open loop biomass should be changed to more closely match the terms of financing and achieve parity with other renewable resources such as wind and geothermal. In addition, the term of the statutory authorization of the FTC itself is usually only two years, then being subject to extension by Congress. This adds a major uncertainty to development planning that with all other uncertainties can easily be five or six years.

The problem with short-term programs is that long-term planning of maintenance and capital expenditures cannot be done efficiently. Financing of repairs, upgrades and infrastructure cannot practically be done within such a short time frame. Investments in new biomass generation facilities cannot be done based on 5-year or shorter programs with a window of assured opportunity of only two years out. Programs involving contracts and support of any type should be at least 15, and preferably 20, years in length. Standard-Offer contracts in California following the enactment of PURPA in 1978 show this. These contracts were offered in a 30-year term, and were solely responsible for the creation of the biomass generation industry in California, home to almost 40% of the current U.S. biomass capacity.

5.6 Institutional Challenges

The federal land management agencies – the USDA Forest Service and Bureau of Land Management – are unavoidably at center stage in the issue of woody biomass energy development in Oregon. More than 70% of acres needing fuel reduction treatments are on public lands managed by these agencies (see Chapter 2). This need provides the largest share of potential woody biomass supply.

To their credit, the agencies have recently initiated efforts to align agency priorities with increased biomass utilization from these lands. Through the National Fire Plan, biomass utilization strategies, grant programs and research and development efforts, the federal agencies have done much to lead the way in national efforts to promote woody biomass use.

Nevertheless, institutional challenges remain for these agencies to overcome. Many of these have been identified by personnel within the agencies, who we have found are often those most anxious for changes to be made. Others were identified by those that work closely with the agencies in various ways. We have grouped the challenges into two general areas:

- **Federal land management agency policies**
  - Woody biomass utilization is not a budgeted agency program in USFS or BLM
  - Biomass utilization policies and plans put in place at national level have not yet filtered down to the field
  - Lack of consistency in policy and actions within and across agencies
  - Performance goals not aligned to maximize biomass utilization
  - Lack of recognition of fuel reduction and biomass utilization issues within land management planning process

- **Federal land management agency capacity**
  - Personnel, skills and resource limitations
  - Lack of coordination within and between agencies with regard to supply
  - Management grid-lock

5.6.1 Federal land management agency policies

The first challenge is fully aligning federal agency policies to facilitate the implementation of needed forest restoration treatments and maximizing utilization of resulting woody biomass removals.

One issue is that woody biomass utilization is not a budgeted agency program in either the Forest Service (USFS) or Bureau of Land Management (BLM). In each case, funding for biomass programs has to be allocated from other programs. This creates unnecessary organizational friction and raises questions about the true priority of the biomass utilization effort.

Second, biomass utilization policies and plans put into place at the national level have not yet filtered down to the field level. This may be a matter of time but is also ultimately involves a question of priorities. Within the USFS, current direction from the top is perceived to be unclear by those in the lower levels of the agency and outside. Involvement in biomass-related work at the forest and ranger district level is often a function of interest by a key staff person and willingness to act as a "champion." At the BLM, the biomass issue has just reached the "radar screen" in the last year or two. As a result of this, there is a lack of consistency in policy and actions both within and across agencies; it is often dependent on personnel involved.

Performance goals regarding forest restoration within the USFS are based on acreage treated and cost. As a result, the agency is incented to treat the lowest cost acreage rather than the areas most needing treatment from an ecological or fire management perspective. Prescribed fire is a lower cost option than mechanical treatment and so is favored under current performance measures. The BLM has recently begun reporting biomass volume offered to the market as a performance measure, which should encourage increased utilization.

The land management planning processes of each agency reportedly sometimes do not address forest restoration and biomass utilization issues. This was mentioned in regards to the ongoing planning efforts of the Oregon BLM.

5.6.2 Federal land management agency capacity

A second set of challenges relates to the on-the-ground implementation of forest restoration and biomass utilization projects. These include agency capacity (resource) challenges, the need for collaborative planning and monitoring efforts to gain public support and the need for coordination of efforts to timely complete planned forest restoration treatments that supply the biomass market.

The agencies face resource limitations that must be overcome to implement landscape-scale forest restoration. Some of the capacity challenges are as follows:

- Forest stewardship program start-up and implementation issues
    - Lack of a planning and development budget
    - Availability of personnel with skills needed to develop, implement and monitor stewardship contracts, meet NEPA/ESA requirements, conduct collaborative planning with community and other stakeholder groups
- Allocation of funding to locations with highest need and for forest restoration projects versus other projects
- Multi-year, up-front funding of stewardship contracts
- Communication of best practices, success stories from other forests and regions to avoid making the same mistakes, re-inventing the wheel

A number of challenges relating to development of forest stewardship contracts are well documented in recent reports by the Pinchot Institute[2] and Forest Service[3]. These reports provide a number of recommendations for improving the implementation of the stewardship contracting concept.

The federal agencies recognize that biomass and small diameter timber markets are needed to accomplish fuel reduction objectives. However, the potential users require that this supply be steady, reliable, and long term. Agencies can help provide this by coordinating efforts across administrative boundaries to provide this sustainable, level supply. The CROP program (see Section 3.3.1.5) is an effort to develop such a coordinated supply and is currently being tested in various parts of the country, including two areas in Oregon. Full implementation of this concept is essential.

Finally, it is well-recognized that the land management agencies (particularly the USFS) have been seriously hampered by years of litigation, appeals, and resulting administrative grid-lock

[2] The Pinchot Institute. 2005. Implementation of Multiparty Monitoring and Evaluation:
Final Perspectives on the USDA Forest Service Stewardship End Results Contracting Demonstration Program. Available at: http://www.fs.fed.us/forestmanagement/projects/stewardship/reports/index.shtml

[3] Forest Service Region 6. 2005. 2005 Stewardship Contracting Roundtable. Available at: http://www.sustainablenorthwest.org/pdf/policy/contract/2006scrrfinal.pdf

caused by the timber wars of the past two decades. To move beyond this, the agencies must seek ways to regain the public trust. Old decision-making approaches within the agencies must be replaced by true collaborative approaches that build trust between the agencies, local communities, other stakeholder groups, and with the general public.

5.7 Technical Constraints

Technical constraints are those that need additional research and development attention.

- **Scientific agreement regarding forest restoration**
    - Need and applicability
    - Treatment design and implementation
    - Monitoring of outcomes

- **Harvesting and transportation technology**
    - Equipment to reduce costs and minimize impacts
        - Forest
        - Juniper
        - Slash recovery
- **Sugar-platform technology**
    - Advances needed to further reduce the cost of production
    - Lacks low-cost cellulase-enzyme combinations
    - Will require further knowledge base to achieve integration of liquid fuels production with production of bio-chemicals and bio-feedstocks

- **Syngas – CO/H2 platform technology**
    - Equipment to remove bark from whole tree chips

- **Alternative markets for small diameter logs**
    - 5 to 9-inch diameter logs
    - 9 to 12-inch diameter sawlogs

- **Biomass supply estimates**

5.7.1 Forest restoration science

While there appears to be general agreement among scientists on the need for forest restoration in Oregon, the science of forest restoration is relatively new. There has been relatively little research on the effects of restoration treatments on environmental values. For example, questions remain around:

- the historic range of variability that describe pre-settlement conditions
- differences between forest types needing restoration treatment (mixed conifer forests in Southwest OR versus inland Ponderosa pine, for example)
- the ability of mechanical treatments to replace the ecological functions of fire
- whether biomass removal is good for the forest

- how to achieve conditions in which forests are resilient to short term disturbances such as fie and long term forces such as climate change

Disagreements also arise over the specifics of treatments. For instance:

- Under what conditions are restoration treatments needed?
- How should treatments be implemented?
- To what extent should larger trees be removed?
- How is effectiveness measured?

The lack of scientific consensus tends to inhibit the development of political support for forest restoration and biomass utilization.

5.7.2 Harvesting and transportation technology

Cost of harvesting, processing, and transporting small diameter material and biomass is a major impediment to utilization. Taxation of fossil fuels and subsidies for renewable energy play a key role in allowing biomass to be competitive in the energy markets of Scandinavia and Finland. Absent these conditions in the U.S., the economics of biomass removal is best when part of an integrated harvesting operation in which the revenue from conventional timber products can subsidize a portion of the overall costs for biomass removal. The full non-market benefits of biomass removal in terms of forest restoration, fire resilience and avoided environmental costs, should also be considered in the economic equation of biomass harvesting.

The literature review on biomass harvesting and transportation in Chapter 1 points to several R&D needs. Equipment designs which reduce costs and minimize environmental impacts, and currently work in Oregon's forests, need to be identified and tested. Research should focus on applying modifications to conventional harvesting equipment that will better allow the integration of harvesting biomass fuel wood along with other value added products. Much of the biomass harvesting operations in central and eastern Oregon will be centered around rural communities without an extensive logging equipment infrastructure Therefore, technologies utilizing more basic equipment such as farm tractors, ATV's and small skyline systems instead of large and expensive equipment should initially be targeted for forest removals. Technology development should include evaluating relationships between important stand and site related variables and the economic decisions that forest managers make in relation to the economics of selecting applicable harvesting equipment. Additionally, the site impacts of forest machinery in a fuels reduction setting is largely absent in the literature. Understanding the operational and environmental effects of forest equipment on the ecosystem will be imperative in developing landscape level forest restoration projects.

Research is also needed on alternative transportation methods since traditional means of hauling forest materials are uneconomical for stem size removals of forest restoration treatments.

Efficient methods of harvesting and processing juniper are needed if this resource is to contribute toward biomass energy development. Technologies for removal of bark from whole tree chips might also improve prospects for use of such material in bio-energy development. Cost-effective methods of recovering and transporting slash are needed if this segment of biomass supply is to be utilized.

5.7.3 Alternative markets for small diameter logs

The economic feasibility of fuel reduction treatments would be significantly improved if there was a stronger value-added market for small diameter logs, especially in the 5-9" size range. In some areas, niche markets for products have developed, but in most of Oregon these are non-existent. Additional research into alternatives such as engineered and composite wood products is needed in Oregon to address this issue. To the extent that ethanol production requires clean wood chips, these small diameter logs may be the preferred feedstock.

Improved markets for somewhat larger logs, up to 12 inches diameter, would also be helpful in improving fuel reduction treatment economics. Large scale restoration efforts, as projected in this report, will generate large volumes of small sawlog material. Ponderosa pine in particular, has lost market share to radiata pine. Prices are already weak and could be further weakened by an increase in supply.

5.7.4 Biomass supply estimates

Estimates of biomass supply are continually being refined and improved. New models such as the Fuel Treatment Evaluator (FTE) and FIA BioSum allow more detailed modeling of supply potential at a landscape scale. Several limitations are apparent, however:

- FTE relies on Oregon FIA data from the early 1990's and has not been updated with the most recent annual inventory data[4].
- Supply estimation efforts to date have not accounted for growth over time or the development of new acres needing treatment. They are static, point in time assessments rather than dynamic.
- Harvest cost analysis has been based on integrated cost of treating the entire acre rather than the marginal cost of biomass harvest and removal. This is especially important in relation to supply from private lands.
- Modeling of transportation costs has been crude; limited by lack of quality road network data.
- Efforts to date do not address ownership objectives (outside federal lands) and generally assume all treatable acreage is available for biomass removal.
- Other sources of biomass supply such as juniper and logging slash have not been rigorously studied and economics have not been evaluated.

Refined supply analyses, especially in support of feasibility studies for specific processing locations, are needed to support financing and operational planning. Additional analyses at the individual forest, regional and state level may help gain stakeholder and public support.

[4] The same has been true until recently for the FIA BioSum model. The Pacific Northwest Station expects to make available to outside users, later this year, a version of the model based on recent FIA data and offering improved analysis capabilities.

There may be opportunities to incorporate data and methodologies from regional landscape analysis efforts including the Interior Northwest Landscape Analysis System (INLAS) and Coastal Landscape Analysis and Modeling Study (CLAMS).

5.7.5 Cellulosic ethanol production technology

Processes for conversion of cellulosic material to ethanol have been developed but are currently prohibitively expensive. A major barrier to commercialization of the sugar-platform technology has been development of low-cost cellulase enzyme combinations. DOE has recently completed cost-shared subcontracts with Genencor International and Novozyme Biotech to reduce the cost of enzymes and improve the economics of production. These enzymes should lead to the first large-scale, cellulose biorefineries.

As production costs for biofuels are reduced, larger and additional markets will open up. The technical challenge is to get biofuels production to a level of maturity comparable to that of the petroleum industry.

Most previous and current research work in the U.S. focused on hardwood species. To our knowledge there are no ethanol pilot research facilities in the U.S. devoted to research on softwood species although there are facilities in western Canada and Scandinavia. There is a need for focused effort on feedstocks important in Oregon.

Literature Cited

Burtraw, D. 1996. Renewable Energy Tax Issues, Resources for the Future, US Department of Energy, Office of Utility Technologies Analysis Workshop, July 23, 1996.

Energy Information Administration. 1992. Federal Energy Subsidies: Direct and Indirect Interventions in Energy Markets, SR/EMEU/92-02. Washington, DC. November.

General Accountability Office. 2006. Woody biomass users' experiences offer insights for government efforts aimed at promoting its use. GAO-06-366. March.

Rose, T. 1998. TU Electric deliberative poll summary results: Residential participants. October 23.

Sissine, F. 2006. Renewable energy: Tax credit, budget, and electricity production issues. CRS Issue brief for Congress, IB10041. March 28.

Chapter 6
Conclusions and Recommendations

6.1 Conclusions

The purpose of this study was to: 1) identify and describe the opportunities for biomass energy and biofuels derived from Oregon's forests, and 2) identify the constraints and challenges that limit woody biomass energy development. To that end, we have conducted an extensive review of the literature on a variety of related topics, interviewed representatives from nine stakeholder groups, catalogued and evaluated numerous ongoing efforts related to woody biomass energy development and conducted our own analysis of the potential. Finally, we have identified the constraints and challenges that have so far limited the development of the woody biomass energy sector.

In summary, we find that an opportunity does exist in Oregon to use woody biomass to produce electrical power and transportation fuels. Heat and power technologies are available that can be applied immediately. In fact, they have been already been applied for decades by the forest products industry to utilize mill wood wastes and generate a significant amount of energy. Technologies to convert cellulosic biomass to ethanol are not yet commercial but could be within the next decade. Production of biochemicals to replace petroleum-derived chemicals is also an opportunity that deserves increased attention.

The largest opportunity in Oregon is creation of an industry that is appropriately scaled to match forest restoration needs primarily on public forests in eastern and southern Oregon. Creating such an industry would provide a market for woody biomass material that could help pay the cost of ecosystem restoration. Public support for this will be built by basing efforts on a scientific understanding of forest restoration needs and careful use of appropriate treatments to achieve restoration goals. Collaboration with affected community and stakeholder groups, careful monitoring of the results of treatments, and use of adaptive management strategies will also be critical to gaining and keeping public support.

A number of other constraints and challenges need to be addressed if biomass energy development is to help achieve forest restoration goals. We classified these as: public acceptance, biomass supply, market constraints, public policies, institutional issues, and technical issues. The state should take a leadership role in addressing these challenges.

The environmental benefits of woody biomass energy development include the opportunity to support forest restoration goals and the realization of a number of environmental benefits of healthier forest ecosystems *and* reduced reliance on fossil fuels. The most significant environmental benefits include reduced carbon and other air emissions from wildfires, long term protection of soil and water resources, and restoration of biodiversity and wildlife habitat.

Economic and social benefits include the potential revitalization of Oregon's rural communities and economies, reduced reliance on imported oil with benefits to the foreign trade deficit and national security.

The following discussion provides additional detail on these general conclusions and observations.

- **<u>An opportunity exists in Oregon to combine a need for forest restoration treatments on large areas of forest land with goals of reducing reliance on fossil fuel energy and strengthening the state's rural economy.</u>**

  The opportunities lie in three areas of bio-energy production:

  - Power generation
  - Biofuels such as ethanol
  - Biochemicals

  Current technology can convert woody biomass from forest thinnings to electrical power either for on-site consumption or transmission to consumers over the electrical grid. This offers the potential to reduce reliance on fossil fuels, particularly natural gas and coal. Combined heat and power applications, which combine electricity production with the use of the steam heat, are the most efficient development alternatives.

  Technology which converts cellulosic (woody) biomass into transportation fuel (ethanol) is on the horizon and promises the opportunity to replace petroleum-based foreign fuel with "home grown," renewable alternatives.

  Finally, bio-refinery technology offers the capability to replace many fossil-fuel derived chemicals and chemical feedstocks with biochemicals produced from woody biomass. This is a particular opportunity for the state's existing pulp and paper industry.

- **<u>The magnitude of this opportunity hinges on the question of to what extent forest restoration treatments are needed and how much biomass material would be removed to support restoration goals.</u>**

  As demonstrated in Chapter 2, most of the potential biomass supply arises from forest thinnings, largely on public lands, designed to reduce fuel loadings in overgrown forest conditions that have arisen as a result of fire suppression and other influences over the last century. Another potential biomass source, although it is less quantifiable at present, is removal of western juniper where it has expanded and encroached on eastern Oregon rangelands. Logging slash from commercial timber harvesting operations could provide an incremental biomass supply but is high cost relative to energy value and its removal has less ecological value.

  Federal forest scientists have identified 12.2 million acres of forestland statewide in Fire Condition Classes 2 or 3. These are forests in which fire regimes are moderately to significantly outside the historic, natural range and the risk of losing key ecosystem components in the event of a wildfire are moderate to high. Treatments such as use of prescribed fire and mechanical thinning could be used to restore these forests to natural conditions.

  The forest health issue is most apparent in the dry conifer forests of southern and eastern Oregon. Our analysis identified 4.25 million acres of public and private forests in 20 counties where measures of fire risk are moderate to high and mechanical thinning treatments could be effectively used to reduce fire risk. These treatments could generate 1 million bone dry tons of biomass annually over 20 years.

- **Evidence supports the conclusion that forest restoration needs, not the need for renewable energy or rural development, is the key driver of this issue.**

  Developing renewable energy sources is an important public policy goal. At present, there are more economically viable alternatives to power generation that have yet to be fully developed in the Northwest. Considering only direct monetary costs, woody biomass power generation is not yet competitive with either traditional energy sources or other renewable options, across the entire area in need of treatment. However, for portions of eastern and southern Oregon, woody biomass can be competitive if cost of harvest and transport of biomass is assisted by harvesting and transporting merchantable timber and steam and waste heat are sold or used. Currently, use of forest biomass for production of cellulosic ethanol is not commercially feasible although it may become so within a decade. Other sources of cellulosic feedstock such as agricultural residues are likely to be less expensive feedstock than forest biomass, although conversion of woody biomass appears to hold great promise for the future.

  Rural economic development is also an important public policy goal and certainly a positive benefit that would be derived from development of a forest biomass-based energy sector. However, we have not encountered an argument that this goal, in itself, is the main driver of a woody biomass energy industry strategy.

  Ecological goals are not the only rationale for forest fuel reduction treatments. For example, public safety and property protection are important public policy goals. These objectives may drive treatment of some forests, especially within wildland-urban interface zones, where the ecological need for treatment may be less clear. However, these areas are relatively small and by themselves cannot support large scale biomass energy development. An alternative policy of more widespread thinning of public lands for the purposes of fueling an energy industry, beyond needs for forest restoration, is a non-starter due both to the uneconomic nature of the proposal and the demonstrated lack of public support for using public lands in this way.

- **At the same time, tapping Oregon's excess of forest biomass as a renewable energy source can help meet Oregon's need for renewable energy.**

  A wide variety of energy sources will be required to significantly reduce Oregon's dependence on fossil fuels and foreign oil. Woody biomass energy development can play a role in meeting the Governor's renewable energy goal. Our analysis shows that one million BDT per year of biomass from forest restoration thinnings could provide about 150 MW of power for 20 years. By comparison, Oregon's growth in electricity demand is expected to be a little more than 100 MW annually. Alternatively, one million BDTs could be used to produce approximately 61 – 66 million gallons of ethanol annually; slightly more than was used by Oregonians in 2002.

- **If forest restoration goals can be identified and agreed upon, energy needs can provide a market for the biomass that is removed and at the same time provide for economic revitalization of Oregon's rural areas.**

A major impediment to implementing forest restoration treatments is disposing of excess small diameter woody biomass. Energy and small diameter log markets can provide a use for this material as an alternative to open burning on-site and can help to partially cover restoration treatment costs. This would also provide opportunities for job creation and family wage jobs in rural areas at processing facilities, in transportation, and in the forest.

- **Oregonians want action to address severe wildfire. However, there does not seem to be agreement over the specifics regarding where and how treatments should occur and whether or not the biomass material should be removed from the site and used for energy production.**

  Recent destructive wildfires have drawn attention to the issue of forest health. Costs in terms of fire suppression, loss of resources and environmental damage have been high. A strong majority of Oregonians are in agreement with actions to address severe wildfire. This includes support for removing dead and diseased trees (83%), removing thick, dry underbrush (81%) and thinning trees from dense, overcrowded areas (79%).

  However, agreement over specifics is more elusive. Some stakeholder groups support treatment in Ponderosa pine types for example, but not mixed conifer forests. There is disagreement over removal of merchantable size trees even when needed to reduce fuel loading. Trust is an issue. Some stakeholder groups are skeptical of the motives behind the drive for forest-based biomass energy development. Questions remain about the various potential impacts on the environment.

- **Recent collaborative efforts around the state involving land management agencies, tribes, local communities, conservation organizations, and other stakeholders have been successful in breaking down barriers, rebuilding trust and building public support for forest restoration projects.**

  On-going collaborative efforts and continued multi-party monitoring of the results will be key to maintaining this momentum. Based on our interviews with stakeholder groups, we believe there is potential for further strengthening public support for restoration treatments. The keys are community collaboration and science-driven policy.

- **Increasing our scientific understanding of the ecological underpinnings of forest restoration treatments, along with demonstrated success of on-the-ground treatments, is essential to gaining public confidence in the need for forest restoration.**

  The lack of public consensus on management of the nation's public lands has led to extended controversy which has greatly reduced the opportunity for active management of federal lands. Regardless of the worthiness of other goals such as renewable energy and rural development, growth of a forest biomass energy industry will not proceed until the public reaches a consensus on what management strategies are appropriate on these public lands. Together with community collaboration, scientific evidence and demonstrated results should be the foundation for building public confidence and support for restoration efforts.

- **At the same time, it must be remembered that scientific certainty, especially regarding natural resource questions, is seldom if ever possible. Some uncertainty and risk unavoidably accompanies natural resource decisions.**

  The Precautionary Principle is the idea that if the consequences of an action are unknown, but are judged to have some potential for major or irreversible negative consequences, then it is better to avoid that action. Applied in the context of forest restoration, this would require perfect knowledge of complex, long term consequences that cannot possibly be known with certainty. This approach to decision-making is a prescription for inaction – quite possibly with adverse consequences that exceed those of the proposed action.

  Natural resource decisions must be based on the principle of Reasonable Certainty. Risks of action must be balanced by the often unacknowledged risks of inaction. Short term risks of acting without perfect information must be balanced with long-term risk of losses of resource and amenity values resulting from a failure to act. Because scientific proof is so elusive in the natural resource sciences, there must be a willingness to take action in advance of scientific certainty on the grounds that further delay will prove ultimately more costly to society and nature. While our knowledge of forest restoration science is imperfect, there is enough known to justify experimenting with new techniques. Until a more complete knowledge is gained, we need to use the science we do have to make reasonable decisions.

  Best available science should guide management efforts. Adaptive management – a systematic process for continually improving management in response to new information and learning – provides the tool for reacting to unintended consequences and adverse effects. It must be a key component of any forest restoration strategy.

- **If forest restoration is to drive the development of a biomass energy industry, and not the other way around, policymakers must first resolve the issues surrounding forest restoration.**

  Public acceptance of a forest biomass energy industry hinges on support for the forest restoration treatments. Until the latter is achieved, removing other constraints that relate to the development of the industry will be ineffective in promoting forest biomass energy.

- **Once forest restoration issues are resolved, if forest biomass removal is part of the forest health solution, there are other challenges to be addressed by policymakers.**

  If Oregon is to pro-actively develop a renewable energy industry as a means of achieving forest restoration goals it will need to find ways to address the many constraints and challenges identified in the previous chapter. It must also use care to design appropriate incentives and policies that promote forest restoration goals first and encourage an industry that is scaled appropriately based on these goals.

6.2 Guiding Principles & Recommendations

We offer these Guiding Principles and Recommendations for Action as a starting point. The Principles describe the over-arching principles we believe the State should consider when making policy. The Recommendations for Action describe more specific actions that should be pursued by the State in collaboration with federal agencies, the forest products and energy industry, communities, environmental organizations and other stakeholders.

Guiding Principles for Forest Restoration & Woody Biomass Energy Development in Oregon

- Use collaborative, transparent decision-making processes
- Rely on best available science and adaptive management
- Start small and monitor the results
- Assure a sustainable level of development
- Promote the highest use of forest biomass
- Reduce market risk to attract private investment
- Environmental benefits of biomass energy should be paid for by the beneficiaries

Recommendations to Promote Forest Restoration

1. Build forest restoration program on scientific understanding of restoration needs and treatments, and increase knowledge through research, monitoring and adaptive management.
2. Encourage community collaboration and multi-party monitoring.
3. Initiate an outreach effort to build awareness of forest restoration needs, science-informed treatments and bio-energy opportunities among the Oregon public.
4. Initiate an outreach effort to build awareness of forest restoration needs, science-informed treatments and bio-energy opportunities among the Oregon public.
5. Build federal land management agency capacity.
6. Develop larger scale, long term, fully-funded forest stewardship contracts and restoration programs.
7. Promote long-term research efforts into the methods and effects of forest restoration and juniper control.

Recommendations to Promote Biomass Energy Development

8. Explore development of a Renewable Portfolio Standard for Oregon that creates a market for woody biomass energy and resolves concerns about unintended adverse consequences to rate payers.
9. Explore development of a Renewable Fuels Standard for Oregon that creates a market for woody biomass energy and resolves concerns about unintended adverse consequences to the Oregon economy.

10. Level the playing field vs. other renewables and non-renewables.
11. Adopt a comprehensive state policy on renewable energy.
12. Promote the goals of sustainable biomass energy development.
13. Promote increased use of incentives and grant programs.
14. Look for synergies that make biomass energy economically sustainable.
15. Build community and workforce capacity
16. Promote establishment of a pilot cellulose-to-ethanol plant.
17. Promote small-scale uses of biomass where appropriate.
18. Encourage involvement of existing bio-energy producers.
19. Engage the state pulp and paper industry in examining the potential for co-production of biochemicals and biochemical feedstocks.
20. Promote needed research and development efforts.
21. Recognize the role of woody biomass in achieving the Governor's 2025 carbon emission goal.
22. Encourage local governments to adopt the ODOE model land use standards for small-scale energy development.

6.3 Recommendations to Promote Forest Restoration

6.3.1 Build forest restoration program on scientific understanding of restoration needs and treatments, and increase knowledge through research, monitoring and adaptive management

Continuous improvement in scientific understanding of forest restoration needs and treatments is important in guiding forest restoration efforts, including fuel reduction and forest health treatments and biomass extraction. Best science should be applied to early efforts with the understanding that we will learn more about the science of forest restoration through active monitoring of results. This will allow adaptation to new knowledge gained from early experiences.

Forest restoration activities should follow the following principles:

- Use the best available science in pursuing treatment opportunities, methods and managing their effects.
- Implement monitoring programs designed to evaluate the positive and negative impacts of restoration projects.
- Support and use findings of long term research projects on the ecological effects and environmental impacts of forest restoration work.
- Annually audit ongoing research efforts and incorporate new information into research and management design.
- Learn from forest restoration projects through adaptive management strategies.

There are a few things the State can do to proactively move Oregon toward a consensus on forest restoration based on best available science.

First, the Forest Biomass Working Group could take the lead in collecting and synthesizing broad input from the scientific community on issues surrounding forest restoration needs, methods, and impacts. Areas of agreement, as well as areas of disagreement where additional research is needed, could be highlighted and documented. This could be accomplished through a scientific symposium or through other means. The composition of the Working Group includes a broad range of stakeholders including scientists, federal agencies, energy and conservation groups as well as state agency and industry representatives. This group may be the natural venue by which to help generate consensus.

Secondly, the State should continue to encourage and be involved in early projects like those at Lakeview, Warm Springs and elsewhere. State assistance can help build support, bring expertise and resources that ensure that good planning and collaboration happen, and encourage monitoring and sharing of the results. Importantly, experiences and learning from one project can be shared with other projects at earlier stages of development.

Pros: The benefit of these efforts is the opportunity to begin to fully understand the effects of forest restoration using best available science, monitoring and adaptive management.

Cons: There appears to be a lack of consensus about the scientific understanding of forest restoration needs and treatment priorities, at least in some areas. These areas of disagreement should be identified and targeted for further analysis.

6.3.2 Encourage community collaboration and multi-party monitoring

Evaluation of successful biomass utilization efforts from forest restoration and wildfire prevention projects on public lands clearly indicates that collaborative efforts involving local communities, potential developers, environmental organizations and other stakeholder groups are needed to develop projects that are appropriate for the local forest and social conditions. Collaboration and performance monitoring are essential components of stewardship contracting but are also important in other aspects of forest biomass energy development.

The state can encourage this by continuing to support current efforts, such as the Lakeview Biomass Project which the State has designated as an Oregon Solutions Project. Learning from this and similar projects can be replicated in other communities. There are a number of successful efforts in Oregon and elsewhere that should be used as models.

Independent, third-party monitoring and evaluation after a project has been initiated is important in attracting public support for continued work, and will serve to indicate that agencies are willing to be accountable for outcomes and make adjustments and changes as learning takes place. Although it is expensive and time consuming, public involvement in planning and project monitoring goes a long way to building trust.

Pros: Collaborative efforts have been shown to work effectively to build positive, constructive relationships in a number of local cases to create win-win results. Local communities and other stakeholders feel they have an influence in the outcome, which builds personal commitment.

Cons: No one can be forced to the table—every participant has to be there willingly and want to see the process work. Collaborative planning and monitoring is expensive and time-consuming and difficult to maintain over a long period of time because of funding uncertainties.

6.3.3 Initiate an outreach effort to build awareness of forest restoration needs, science-informed treatments and bio-energy opportunities among the Oregon public

Social acceptance of forest restoration treatments is critical to successful implementation of restoration efforts on public lands in Oregon. The literature review on public perceptions in Chapter 1 as well as stakeholder interviews in Chapter 4 support the position that there is widespread support for removing excess biomass from Oregon forests by means of mechanical thinning to create fire-resilient forests. Position papers from community, conservation and industry interest groups indicate that the public would support using the biomass removed from the forest for energy, as long as biomass removal was the result of legitimate forest restoration needs.

Oregon can build on this generally supportive atmosphere through an outreach effort that provides the interested public with more specific information on issues of concern. These include:

- **Science-informed restoration needs** – what is the scientific or ecological basis behind calls for forest restoration and how would proposed treatments address forest health issues?

- **Environmental impacts** – what are the environmental implications of proposed forest restoration treatments, including the trade-offs between on-site impacts of management activities and broader environmental benefits that are often unrecognized?

- **Role of biomass energy** – how does development of a forest biomass energy industry support the goals of restoration forestry in Oregon? What other benefits does it bring?

The outreach effort should build on results from the first two recommendations, incorporating both the scientific information collected and synthesized by the Forest Biomass Working Group and the outcomes of collaborative efforts and monitoring where they are occurring. Existing projects such as Lakeview and Warm Springs, treatment demonstration areas, and stewardship contract treatment areas could be used as examples to illustrate forest restoration needs and treatment methods. A web-site devoted to disseminating forest restoration information would be useful for those interested in acquiring additional information.

The Forest Biomass Working Group could lead in this effort on behalf of the State, assisted by OFRI. This recommendation is consistent with OFRI's mission of forestry education and outreach.

Pros: A public outreach effort should help to increase public awareness and support for forest restoration efforts and a related forest biomass energy industry.

Cons: Cost.

6.3.4 Where consistent with management objectives, encourage integrated forest management across all diameter classes of trees

The focus of forest restoration and fuel treatment efforts should be on what is left after treatment, not what is taken during treatment. Results of modeling silvicultural treatments for fuel reduction in this study, and others, indicates that under some conditions, fire risk reduction goals cannot be achieved without removing some larger trees from overcrowded forests. Imposition of artificial maximum diameter limits may impede appropriate treatment of high risk stands.

Integrated forest management across all diameter classes of trees in a stand combines harvesting and collecting costs associated with biomass with the costs associated with merchantable timber. Harvesting and collecting costs for biomass would be much higher if only non-merchantable material is harvested.

Pros: Cost of harvesting and collecting non-merchantable material is reduced. Cost of producing electricity from biomass is competitive with other sources of electricity. Restoration projects that treat the entire range of diameter classes will more effectively reduce the risk of uncharacteristically severe wildfires.

Cons: Although there is widespread consensus for the removal of small unmerchantable material in forest restoration projects, there is less consensus for the removal of larger merchantable material. Integrated forest management across all diameter classes may be viewed by some environmental groups as an excuse to harvest large trees that is not warranted on an ecological basis.

6.3.5 Build federal land management agency capacity

The Forest Service and BLM are making internal changes to re-align organizational direction toward achieving goals of forest restoration in areas where it is needed. These efforts must now be converted from the planning stage to the implementation stage.

Biomass utilization should be designated as a program with a line-item budget within the USFS and BLM. Agency performance measures should be modified to ensure that the right acres, as determined through collaborative efforts, are treated and biomass is utilized when appropriate and possible.

Agencies must build capacity to implement projects on the ground by adding staffing where the priorities for ecosystem restoration are the highest, as identified through the collaborative process with local and state interests. This includes appropriate staff and resources to plan and implement large scale restoration projects. Consideration should be given to contracting out NEPA document development to qualified consulting firms with experience in the process.

Innovative approaches and collaborative efforts should be rewarded. Success stories and effective programs should be shared widely throughout the agency. Management procedures more appropriate to forest restoration and low value materials should be adopted in areas where old procedures do not fit.

Congressional action may be required in some areas to free agencies to adapt to meet these new challenges.

Pros: New approaches, skills, and procedures are needed to address forest restoration needs on public lands. An emphasis on collaborative management can increase trust between parties and decrease litigation costs

Cons: The agencies are already short of resources and lack energy for change. Organizational change will be difficult.

6.3.6 Develop larger scale, long term, fully-funded forest stewardship contracts and restoration programs

Science-based forest restoration activities should be undertaken using appropriate land management tools such as stewardship contracting. Forest stewardship contract offerings must be of the size and scope that are consistent with the forest restoration needs of the land as well as the long-term capital commitments being made by energy facility developers and stewardship contractors. They should be multi-year contracts with a minimum of 10 years in term. A twenty year term would be preferable to developers, although this would require new legislation. Extension options, based on performance, should be considered.

Stewardship contracts should be fully-funded up front rather than funded on a year to year basis so contractors and feedstock facilities have some certainty of future supply. Planning and National Environmental Policy Act documentation should be conducted up-front in a collaborative, public process. Supply over time should be coordinated within and between agencies using Coordinated Resource Offering Protocol or similar methods.

Stewardship contracting policies must recognize the difficulties of financing energy projects and provide some level of assurance that biomass supply will be made available. Agencies should recognize that ecosystem restoration goals will likely not be met without markets for some of the biomass material that needs to be removed and that these markets will not develop without an assured supply.

Mechanisms should be put in place to share the financial risk because the federal government benefits from the development of biomass markets. The key is to develop supply offerings that are perceived by debt and equity partners as sound, with real remedies if the Federal government fails to deliver. An alternative to performance guarantees could be loan guarantees. According to a recent GAO report, the USDA has facilitated biomass projects in the past by furnishing loan guarantees[1].

Stewardship projects should have annual, multi-party monitoring built into them to ensure that land management goals are being met. Monitoring funds need to be included as part of the contract for both data collection and analysis. Contracts need to be flexible enough to allow monitoring results to be incorporated into the next year's implementation of the contract.

Authority for entering into stewardship contracts expires in 2013 for the Forest Service and BLM. The U.S. Fish & Wildlife Service and National Park Service have permanent authority to enter

[1] Government Accountability Office. Woody biomass user's experiences offer insights for government efforts aimed at promoting its use. GAO-06-336. March, 2006. p. 23-24.

into agreements. Authorization for stewardship contracting should be extended beyond 2013 for all federal land management agencies.

Pros: Large, long term stewardship contracts will be better aligned with the long-term capital commitment being made by developers and assist in reducing feedstock supply uncertainty and the resulting investment risk. Once in place, larger, long term contracts should be more efficient for an agency to maintain and administer than many small contracts.

Cons: Larger stewardships contracts will be more complex and take more time to develop. Many environmental groups are wary of long-term contractual agreements. Without adaptability built in, they will not be acceptable to some stakeholders. A balance needs to be reached between supply assurance and adaptability.

6.3.7 Promote long-term research efforts into the methods and effects of forest restoration and juniper control

Areas of additional research identified by the scientific advisory committee should be given high priority within the State's higher education system and funded to achieve results in a timely manner, remove uncertainty and gain public support if restoration treatment is shown to be beneficial.

- Research into the ecological effects and environmental impacts of forest restoration will be important. Further research into the historical fire regimes, current conditions, and treatment needs is particularly needed in the mixed conifer forests of Southwestern Oregon. These forests have longer fire return intervals (35 - 100+ years) than, for example, Ponderosa pine types (0 - 35 years), and the impacts of fire suppression over the last century are less well understood in the mixed types.

- Research and development is also required to reduce biomass harvest and transportation costs and improve data regarding the biomass supply potential. This research needs to be Oregon-based.

- Additional research is also needed into the treatment of western juniper. This should generally include ecological costs and benefits of juniper control, development of methods of harvest and processing, and development of improved estimates of potential supply.

To the maximum extent possible, federal funds which may be available through various R&D grant programs should be leveraged with state funding and support from other sources.

Pros: Areas where scientific consensus has not been reached would receive targeted funding and be addressed and incorporated into adaptive management plans.

Cons: Research takes time and requires long term, consistent funding.

6.4 Recommendations to Promote Biomass Energy Development

If the public and policy makers determine through the above efforts that a sustainable energy industry can be developed utilizing byproducts of forest restoration efforts, then the following recommendations may assist in creating an energy market and promoting the development of the industry.

6.4.1 Explore development of a Renewable Portfolio Standard for Oregon that creates a market for woody biomass energy and resolves concerns about unintended adverse consequences to rate payers

Woody biomass energy from stand-alone power plants is more expensive than some alternatives, yet there are significant non-market benefits to this energy source that are not considered in cost-focused debates. Some of these benefits result from forest restoration and some from replacement of fossil fuel energy, as we have documented.

A renewable portfolio standard is one means of creating a market for this energy source that will allow society to capture these non-market environmental benefits in addition to the energy produced. If drafted to include woody biomass, a renewable portfolio standard (RPS) could give a biomass power industry the assured market it will need to secure project financing. This is also important because California's RPS will be ramping up soon, and utilities will be looking for baseload resources that meet the standard. A biomass developer in Oregon should be able to sell to an Oregon utility for less cost per delivered MWh because of higher transmission costs to California.

An Oregon RPS should have a specific woody biomass target that recognizes a lack of current biomass capacity and the benefits of biomass development to both the energy market and forest health. It should also be crafted to encourage balanced renewable development by specifying an appropriate and specific woody biomass energy target. It should also recognize the value of reliable baseload capacity from woody biomass, because many of the available renewable technologies cannot provide baseload generation. To prevent costs that stifle economic development, the RPS should consider current measures that encourage renewables, maximize use of incentives over penalties, is inclusive of all renewable alternatives, and maintains reliability of electrical service.

Pros: An RPS will increase renewable energy resources and transfer the costs to those that benefit from the environmental and other non-market benefits. A specific woody biomass target will help it compete with other renewables, such as wind and specifically promote use of biomass from forest restoration treatments.

Cons: An RPS would cause the cost of electricity to increase for Oregon rate payers. If not implemented wisely, increased energy costs can stifle economic development and hurt existing industry, especially those dependent on energy use. Once a woody biomass target is set, there is the risk of having forest management being driven by the RPS rather than forest health issues. Regulatory creation of a market for renewable energy can create a long term resource misallocation; biomass may be allocated to lower value energy production instead of potential higher value uses. Provisions would need to be included in the RPS to prevent these negative impacts from happening.

6.4.2 Explore development of a Renewable Fuels Standard for Oregon that creates a market for woody biomass energy and resolves concerns about unintended adverse consequences to the Oregon economy

The rationale provided for an RPS applies to a renewable fuels standard as well. A renewable fuels standard would give a biofuels industry the assured market needed to secure project financing. Woody biomass is a significant potential source of feedstock for cellulosic ethanol production. Commercialization of the technology to produce ethanol from woody biomass is on the horizon and represents an opportunity for Oregon to produce home-grown transportation fuels.

The renewable fuels standard needs a target that recognizes the lack of current capacity and encourages future development without requiring biofuels be used in volumes that cannot be delivered in the near term or that imposes costs that stifle economic development.

Pros: Oregon currently has very little local production of liquid fuels, making it completely dependent on external sources. A Renewable Fuels Standard could encourage local production of liquid energy. Any reduction in fossil fuel usage, particularly from foreign sources, is an advantage to our state and country.

Cons: A fuel standard may cause the cost of fuel to increase for Oregonians. As with the RPS, it poses a risk of having forest management being driven by the Renewable Fuels Standard rather than forest health, and potential for misallocation of biomass to a lower value use. Provisions would need to be included in the standard to prevent this from happening.

6.4.3 Level the playing field vs. other renewables and non-renewables

The Federal Production Tax Credit should be modified to make open loop, woody biomass eligible for a 10-year credit at the same level per kWh as closed loop biomass (see Section 5.5.5). Existing facilities should receive the same tax credits as existing facilities for other types of renewable energy. Domestic and renewable energy sources should over time receive the bulk of federal tax incentive dollars. The marketplace should hear a clear policy preference for these resources, and a policy of promoting less future reliance on non-sustainable resources.

Pros: Since most of Oregon's woody biomass sources are external to the facility, expanding the PTC to include these sources would be enormously beneficial to development of a woody biomass energy industry.

Cons: Cost.

6.4.4 Adopt a comprehensive state policy on renewable energy

Removing barriers to renewable resource development requires state leadership. Oregon should develop a clear message regarding the power system and customer benefits of renewable and distributed generation as well as need for renewable transportation fuels. Oregon should actively encourage cooperation among stakeholders such as utilities, independent power producers, citizen's utility boards, environmental groups and economic development interests by raising awareness of the opportunities for mutual benefit.

Most important is the recognition that responsible biomass development will make use of woody biomass that would otherwise burn in slash piles or potentially in wildfires, to the detriment of air quality and the long-term health of the forest. Regulatory agencies should be directed to look at net environmental benefits of a project rather than only the direct impacts.

Specific recommendations include the following:

- An executive level representative from the Oregon Department of Fish & Wildlife (ODFW) should be added to the Renewable Energy Working Group or Oregon Biomass Coordinating Group. These groups are formulating policy that may have a significant effect on fish and wildlife habitat; ODFW needs to be represented at the table.

- It is important that all State agencies recognize the priority placed on renewable energy. All agencies, including regulatory agencies, should make this a long term priority. Each agency's direction ought to be to figure out the right way to use biomass and recognize the broader environmental and economic benefits.

- We suggest that Oregon Progress Board benchmarks are needed to measure progress on:

    - Forest restoration and health
    - Renewable energy development
    - Biomass use

  This provides the agency heads with an important incentive to make these issues a priority within their agencies and allows the state to consistently measure progress toward these goals.

<u>Pros:</u> Many efforts are currently underway, and independent efforts can inadvertently lead to contradictory programs. A consistent set of performance measures are needed across agencies to ensure the agencies are moving in the same direction.

<u>Cons:</u> None

6.4.5 Promote the goals of sustainable biomass energy development

A coordinated effort is needed to increase awareness of the broad benefits and goals of the state's renewable energy strategy. Part of this effort should focus on the need for forest restoration treatments and biomass energy's potential role in addressing this need, the potential environmental benefits of woody biomass utilization, and opportunities for both in Oregon. These efforts should target the general public as well as the developer community, lender and investor groups, local opinion leaders and elected officials at all levels of government.

Awareness efforts should include a network of forest demonstration areas dispersed across the state where the interested public can view the effects of a range of restoration treatments in terms of their aesthetic, environmental and fire risk reduction impacts. The demonstrations should provide information on costs and benefit tradeoffs such as the economics of a restoration treatment in contrast to wildfire fighting costs. Opportunities to visit existing biomass processing facilities should also be provided.

"Fuels for Schools" projects have been very successful in other states in bringing small biomass energy projects into communities and increasing awareness via real life applications in schools and other public buildings. These projects should be actively pursued in Oregon.

Pros: The public needs increased understanding of the benefits of renewable energy and true cost of continued reliance on traditional sources. Increased understanding may lead to strong public support. Current high energy prices and other issues have combined to create a "teachable moment."

Cons: Public awareness campaigns are expensive and must be long term in nature. The public is bombarded with information on a wide variety of issues and gaining their attention is difficult.

6.4.6 Promote increased use of incentives and grant programs

There are many incentive and grant opportunities, and they change with each federal or state legislative cycle. It is difficult for small facility developers to keep track of what is available, and the best way to go about securing these resources. A comprehensive state-level clearinghouse of grant and incentive information would be very helpful to developers. Oregon Economic and Community Development Dept. should develop expertise to guide community economic groups and project developers with direct assistance.

Pros: Improved access to information on grant and incentives programs will encourage more efficient use of limited funds to develop the most promising and competitive projects. Currently, several federal grant programs are not being utilized for woody biomass utilization and renewable energy projects in Oregon. Increased use will leverage federal dollars to benefit developments in Oregon.

Cons: Cost.

6.4.7 Look for synergies that make biomass energy economically sustainable

The State should promote development that encourages the highest use of woody biomass wherever possible. Stand-alone power plants present the most expensive biomass development option. Synergies that allow development of multiple revenue streams will improve economics. For example, combined heat and power facilities – which make use of both steam and electrical generation – should be favored over steam only or power only facilities. Projects that merchandize material to its highest value uses should be favored. For example, a facility that produces small log products in addition to energy produces more value and is more likely to be economically sustainable.

State efforts should be directed at promoting opportunities at existing wood products facilities. By building on existing infrastructure, many costs can be avoided and biomass energy can be more economically viable. Combined heat & power applications present an efficient use of fuel. By locating at an existing forest products facility, fuel handling and maintenance operations can build on existing capabilities. By combining forest fuel reduction biomass with mill residues and/or other biomass feedstocks, fuel costs can be managed and reliance on public forest sources can be decreased.

In addition to existing facilities, abandoned mill sites with road, transmission and access to water could be an especially good opportunity to develop new facilities that integrate production of products from small diameter wood with energy production. The State could assist by cataloging potential sites and making this information available to potential developers. Local communities should be involved in this process.

Production of high value biochemicals will increasingly play a role in the industrial use of forest biomass. Biochemicals are directly linked to bio-energy. The revenue from biochemical production could help make biomass recovery an economically sustainable venture. In addition, these chemicals will be needed by society as chemicals now produced from petroleum become more expensive.

Other means of increasing and broadening revenue streams should also be pursued to strengthen the economic sustainability of woody biomass use. Developers should market green tags and carbon credits to provide an additional revenue stream.

Pros: By building facilities that can take multiple feedstocks and create multiple products, the infrastructure will be more sustainable as the future market shifts.

Cons: There may be higher initial capital costs to build a more flexible facility.

6.4.8 Build community and workforce capacity

Several communities and community-based organizations in Oregon have taken the lead in promoting forest restoration and/or biomass utilization goals in the forests surrounding their communities. Some examples are the Lake County Resource Initiative, Lakeview Stewardship Group, Wallowa Resources, and Central Oregon Intergovernmental Council. State government has provided support to many of these groups to aid their efforts. One example is designation of the Lakeview Project as an Oregon Solutions Project by the Governor. The state should continue to support these and other organizations and expand support where possible to provide expertise that is not likely to be available at the local level. One identified need is education on the energy industry and financial requirements of project development. Some community and stakeholder groups need to have information regarding what it takes to develop a financially viable energy project. There are issues to be considered beyond biomass supply, including for example, water rights and access to transmission infrastructure. The state should take proactive steps to provide these types of support on the energy, forestry and economic issues.

Another issue that needs to be addressed is expanding the workforce and capacity for harvesting and transporting biomass as well as developing a workforce capable of taking on forest restoration activities.

A coordinated plan is needed involving the Economic & Community Development Department, OSU College of Forestry, OSU Extension Service, ODF, ODOE, and perhaps other agencies is needed to address these two capacity building issues. This perhaps can be coordinated through the Forest Biomass Working Group. The state should seek federal grant funding through the Economic Action Program or other sources to implement this effort.

Pros: A coordinated effort to develop community capacity and workforce will facilitate the implementation of forest restoration and biomass development projects.

Cons: Effort may require state funding if federal grants are not available.

6.4.9 Promote establishment of a pilot cellulose-to-ethanol plant

In conjunction with one of the proposed grain-based ethanol plants, Oregon should promote the establishment of a pilot cellulosic ethanol plant. Initial development of cellulose to ethanol production capacity may be most easily done at an existing grain-based plant. Such a facility might produce a dilute glucose solution that could be used to "cook" the grains for the main production facility. Such a plan would reduce energy costs for the cellulose portion of the plant, and allow development at a small scale to begin with, building capacity as experience is gained and available feedstocks allow.

Various existing grant and loan programs (state and federal) might be used to fund to this effort. These could include the ODOE's Small Scale Energy Loan Program, USFS/USDI Fuels Utilization and Marketing Program, USFS Woody Biomass Grants, and USDA Rural Development grants described in Chapter 3.

Pros: A small scale commercial demonstration plant is a first step toward promoting a cellulosic ethanol industry in Oregon.

Cons: Technology is still expensive.

6.4.10 Promote small-scale uses of biomass where appropriate

Some areas of the state, based on our assessment, may not have enough biomass supply potential from forest restoration treatments to support a medium or larger energy facility. Small-scale biomass energy or value-added projects should be proactively encouraged particularly in these areas.

For example, the Fuels for Schools program has been widely used in other intermountain states, particularly Colorado, Idaho and Montana, to provide district heating for schools and other public buildings, as a way to demonstrate the use of forest biomass energy. Small scale district heating applications might also be appropriate for Oregon's nursery industry.

Wood pellet and compressed fire log manufacturing has also been suggested as a small-scale biomass application. Wood pellets are a wood by-product that is burned for heat and energy. An operation in New Mexico manufactures wood pellets from woody biomass primarily obtained from a forest stewardship agreement. Manufacturers of wood pellets in British Columbia export wood pellets are used primarily in European electric plants where they are burned along with coal. Wood pellet consumption is also growing in the U.S. and Canada.

Pros: Small scale uses of biomass will provide local social and economic benefits and familiarize communities and stakeholder groups with the technology.

Cons: None.

6.4.11 Encourage involvement of existing bio-energy producers

It is well accepted in economic development that the greatest likelihood of success in seeking economic growth is through expansion of existing businesses rather than creation of new ones. It seems reasonable to consider what kinds of efforts might be effective in bringing existing bio-energy producers to the table. Many of these are forest products manufacturers including the state's pulp and paper manufacturers and solid wood industry. There are 49 wood-fired combustion boiler facilities in Oregon and 6 pulping liquor facilities. Twelve of these facilities are cogen facilities which produced 1.1 million MWh of power from 1.6 million BDT of biomass fuel in 2004 (Chapter 1, *Market Conditions for Woody Biomass*).

These businesses are adept in the procurement of biomass, have relationships with lenders and investors, and are familiar with permitting processes. A first step might be to conduct interviews or a focus group involving such people to see what it would take to create interest in expansion of the bio-energy and bio-refinery aspects of their existing businesses. It may also be worthwhile to tap experience gained by the industry in California, Minnesota or other states with industry experience in biomass energy development.

One encouragement of additional power generation at pulp mills would be designation of pulping liquor as a form of woody biomass usable for renewable energy production. Pennsylvania's recent RPS legislation (2004) specifically recognizes power generated utilizing byproducts of the pulping process (including spent pulping liquor) as a renewable energy source. Technologies for effective, clean energy recovery from spent pulping liquor have been in place for years, and black liquor gasification technologies that will significantly increase energy recovery from this raw material are close to commercialization. Such designation would provide an incentive for the state's pulp mills to add power generating capability for the market.

Pros: The existing industry has some of the expertise and facilities to develop the biomass energy industry sooner. It could help revitalize and diversify existing businesses. They may be a market for resulting heat and steam and may be able to combine forest biomass from thinnings with low cost residuals to reduce overall costs. Engaging in discussions about how to revitalize this segment of the industry while also moving Oregon into biofuels and biochemicals markets could be a win-win opportunity.

Cons: The state's existing pulp and paper industry is located in western Oregon, outside of the geographic area where fuel reduction treatments are needed. There may be little interest from that sector.

6.4.12 Engage the state pulp and paper industry in examining the potential for co-production of biochemicals and biochemical feedstocks

Opportunities for improved biomass use is not limited to production of electricity and liquid fuels, but also includes the potential for replacement of fossil-fuel derived fuels, chemicals and chemical feedstocks. Biorefineries have the potential revitalize Oregon's ailing paper industry by supplementing production of conventional paper products with co-production of value-added products. A bio-refinery, in concept, allows full utilization of the incoming biomass and other raw materials, including energy, for simultaneous production of fibers for paper products, chemicals and energy. Hemicelluloses can be extracted from residuals from wood manufacturing or from wood chips destined for pulping. The hemicelluloses are then converted to ethanol, acetic acid, or chemical intermediates. After the wood has been pulped, the residual pulping liquors can be gasified. The resulting synthetic gas can be converted to electric power, fuels such as hydrogen or transportation fuels, and/or to high value chemicals.

The State should consider ways which it can proactively involve the industry in this opportunity. This might include, for example, tax incentives of various sorts to encourage research and development and/or capital expenditures for development of cellulosic ethanol and bio-chemical production capacity.

Pros: Development of a biorefining industry in Oregon could revitalize the state's pulp and paper industry, produce ethanol to reduce dependence on imported fuel, and provide economic benefits to the state's economy.

Cons: Technologies are in early stages of development and therefore carry a financial risk.

6.4.13 Promote needed research and development efforts

Oregon should establish a cellulosic ethanol pilot research laboratory as OSU. Research on technologies to reduce the cost of converting cellulosic biomass to transportation fuels is critically needed to commercialize this process. Effort is specifically needed on the softwood species predominant in Oregon's forests. Research should also address the potentials for production of bio-chemicals and feedstocks since the economics of any liquid fuels initiative is likely to be enhanced by the ability to operate as an integrated bio-refinery.

Biomass energy and/or biofuels production technologies that may lower production costs, such as portable production facilities that operate on or close to harvest sites, should be examined. In order to build on program strengths and maximize returns on research dollars, these efforts should be coordinated through OSU's Sun Grant Center and Wood Innovation Center.

Pros: Research into renewable transportation fuel technology offers the promise of replacing foreign oil with home-grown renewable fuels. Other research will improve the public support and economic viability of forest restoration efforts.

Cons: Research takes time and requires long term funding. Oregon will not be able to solve the energy technologies by itself but can contribute to the national effort and address regional questions of importance such as use of conifer fiber.

6.4.14 Recognize the role of woody biomass in achieving the Governor's 2025 carbon emission goal

Oregon is developing targets, courses of action and legislative concepts to guide the state toward reductions in carbon dioxide emissions. Biomass use as an energy resource could be an important part of reaching these goals.

Pros: Carbon reduction is a growing global concern, and Oregon would be in an advantageous position to be the forefront of efforts to reduce carbon emissions.

Cons: None.

6.4.15 Encourage local governments to adopt the ODOE model land use standards for small-scale energy development

The Oregon Department of Energy has developed a set of model land use ordinances for use by cities and counties with standards and requirements specifically written for renewable resources, combined heat and power facilities and small transmission lines in mind. Adoption of these ordinances in most of Oregon would give developers a set of requirements that are consistent from jurisdiction to jurisdiction, designed considering the specific details of energy facilities and would make clear the requirements for meeting local land use ordinances.

Pros: Local land use ordinances are rarely developed with energy facilities in mind. As a result, local ordinances generally are not applicable to this type of development. Use of the ODOE model ordinances would assist local governments in planning for these developments and provide consistency between localities, which reduces uncertainty for developers.

Cons: Local governments rarely have the resources to devote to an issue like this until it comes before them.

Appendix A – Acronyms & Glossary

Acronyms

Organizations:

AF&PA	American Forest & Paper Association
BLM	Bureau of Land Management
BOF	Oregon Board of Forestry
DOI	U.S. Department of the Interior
EIA	Energy Information Administration
EPA	U.S. Environmental Protection Agency
FIA	USDA Forest Service, Forest Inventory & Analysis Program
GAO	Government Accountability Office
NREL	National Renewable Energy Laboratory
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish & Wildlife
ODOE	Oregon Department of Energy
OFRI	Oregon Forest Resources Institute
ORNL	Oak Ridge National Laboratory
OSU	Oregon State University
PUC	Oregon Public Utility Commission
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USDOE / DOE	U.S. Department of Energy
USFS	USDA Forest Service
USGS	U.S. Geological Survey
WGA	Western Governors' Association

Technical Terms:

aMW	Annual Megawatts
BDT / bdt	Bone dry tons or dry tons
BETC	Oregon Business Energy Tax Credit
BF / bf	Board foot or board feet
btu	British thermal unit
CREB	Clean, Renewable Energy Bond
CF / cf / cu.ft.	Cubic foot or cubic feet
CHP	Combined Heat and Power
CI	Crowning index
CRL	Composite residue log
CROP	Coordinated Resource Offering Protocol
CTL	Cut-to-length logging system
EMAP	EPA Environmental Monitoring & Assessment Program
FRCC	Fire Regime Condition Class
FRCS	Fuel Reduction Cost Simulator
FTE	Fuel Treatment Evaluator Model
GIS	Geographic information system

HHV	Higher Heating Value (btu's per oven dry pound of fuel)
kW	Kilowatt (1,000 watts)
kWh	Kilowatt-hour
MBDT	Million bone dry tons
MBF	Thousand board feet
MMBF	Million board feet
mgy	Million gallons per year
mmbtu	Million British thermal units
MTBE	Methyl tertiary butyl ether
MW	Megawatt-electric
MWh	Megawatt-hour
NEPA	National Environmental Policy Act
NFP	National Fire Plan
OBP	Oregon Business Plan
PPA	Power Purchase Agreement
PTC	Federal Production Tax Credit
PURPA	Public Utility Regulatory Policy Act
REC	Renewable Energy Credit or Certificate
REPI	Renewable Energy Production Incentive
RFS	Renewable Fuels Standard
RPA	Resources Planning Act
RPS	Renewable Portfolio Standard
TI	Torching index
WUI	Wildland/Urban Interface

Glossary

Anaerobic digestion – Anaerobic digestion is a biological process that produces a gas principally composed of methane (CH_4) and carbon dioxide (CO_2) otherwise known as biogas.

Avoided cost – Avoided cost is the cost the utility would have incurred had it supplied the power itself or obtained it from another source. Avoided cost is the price at which an electric utility purchases the output of a Qualified Facility under PURPA.

Basal area – A measure of timber stand density. It is determined by estimating the cross-sectional area of all trees at 4.5 feet above the ground. Basal area is expressed as square feet per acre.

Baseload power – Minimum amount of electric power delivered or required over a given period of time.

Biodiesel – Fuel derived from vegetable oils or animal fats. It is produced when a vegetable oil or animal fat is chemically reacted with alcohol.

Bio-energy – Useful, renewable energy produced from organic matter – the conversion of the complex carbohydrates in organic matter to energy. Organic matter may either be used directly as a fuel, processed into liquids and gases, or be a residual result of processing and conversion.

Biofuels – Fuels made from cellulosic biomass resources. Biofuels include ethanol, biodiesel, and methanol.

Biogas – The combustible gas produced from the anaerobic decomposition of organic material. Principally composed of CH_4 and CO_2.

Biomass – Organic matter in trees, agricultural crops and other living plant material. Biomass is made up of organic compounds called carbohydrates. These compounds are formed in growing plant life through photosynthesis, a natural process by which energy from the sun converts carbon dioxide and water into carbohydrates, including sugars, starches and cellulose. Biomass can be broken down into:

- **Closed Loop Biomass** - which refers to energy crops or trees (including coppiced willow) specially grown for fuel.
- **Open Loop Biomass** - which refers to all other types of biomass

Bioproducts – A commercial or industrial product (other than food or feed), that is composed in whole or in significant part, of biological products or renewable domestic agricultural materials (including plant, animal, and marine materials) or forestry materials.

Biorefinery – A facility that processes and converts biomass into value-added products. These products can range from biomaterials to fuels such as ethanol or important feedstocks for the production of chemicals and other materials. Biorefineries can be based on a number of processing platforms using mechanical, thermal, chemical, and biochemical processes.

Board Foot – The amount of wood contained in an unfinished board that is nominally 1 inch thick, 12 inches long, and 12 inches wide; because of the use of nominal measurements in computing board foot volume, it is important to recognize that the actual cubic volume of a board foot varies by lumber size and species. Common units as related to saw log volume measurement include - 1,000 BF or MBF and 1,000,000 BF or MMBF.

Bone Dry Ton – Traditional unit of measure used by industries (pulp/paper, biomass power) that utilize biomass as a primary raw material. One bone dry ton (BDT) is 2,000 pounds of biomass (usually in chip form) at zero percent moisture. Typically biomass collected and processed in the forest is delivered "green" to the end use facility at 50% moisture. One BDT (assuming 50% moisture content) is two green tons (4,000 pounds at 50% moisture content).

British Thermal Unit – The quantity of heat required to raise the temperature of one pound of water, 1 degree F (Fahrenheit).

Cellulosic ethanol - A type of ethanol that uses grasses, agricultural waste, and woody material containing cellulose as feedstock.

Chip – A small piece of wood typically used in the manufacture of pulp/paper, composite panels, fuel for power/heat generation, and landscape cover/soil amendment.

Circuity factor - is the average ratio of road miles to air miles between two points on a landscape. For Oregon, this has been calculated as 1.4 –1.5.

Closed Loop Biomass – biomass derived from dedicated energy crops specifically grown for fuel. See also, "open-loop biomass."

Cogeneration – The combined generation of both heat and power at one facility using the same fuel source. Typically the heat is used to generate steam that is utilized on site (process steam). Power generated is in the form of electricity that is utilized on site or sold to a local utility.

Combined Heat and Power – See "cogeneration."

Canopy base height – The lowest height above ground at which there is a sufficient amount of canopy fuel to propagate a fire vertically into the canopy.

Crown fire – Any fire that burns in canopy fuels, the live and dead foliage, branches, and lichen of trees and tall shrubs that lie above the surface fuels.

Crowning Index (CI) – the wind speed at 20-feet above the ground at which an active crown fire is possible for the specified fire environment. CI is a function of canopy bulk density, slope steepness and surface fuel moisture content. High risk stands have a crowning index value of 25 miles per hour (mph) or less. See also, "Torching Index."

Ethanol – An alternative automotive fuel derived from grain and corn (CH_3-CH_2-OH); usually blended with gasoline to form gasohol.

Even-aged – In an even-aged stand, all trees are the same age or at least of the same age class. The range of ages represented in the stand generally does not exceed 20% of the rotation age. See also, "Uneven-aged."

Fire Regime Condition Class – is a measure of how much a forest has departed from natural wildfire conditions. The following summarizes the FRCC system and describes the type of management activities needed to treat each class.

- **Condition Class 1** - Fire regimes are within an historical range and the risk of losing key ecosystem components is low. Vegetative attributes (species composition and structure) are intact and functioning within an historical range.

- **Condition Class 2** - Fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one or more return intervals (either increased or decreased). This results in moderate changes to one or more of the following: fire size, intensity and severity, and landscape patterns. Vegetative attributes have been moderately altered from their historical range.

- **Condition Class 3** - Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This results in dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetative attributes have been significantly altered from their historical range.

Forest biomass – Material generated from logging or thinning activities in forests. Strictly speaking, forest biomass refers to the entire main stem, branches and tops of trees. However, the portion of a tree's wood volume that is merchantable for use in traditional timber products such as saw logs and veneer logs is usually excluded. Because this volume clearly has a higher value use, it is generally not considered for use in energy production. Usually, only the residual portion of large trees (tops, branches) and the volume of smaller trees is included when considering biomass for energy use. We refer to this as **Net forest biomass**.

Forest type – a classification of forests based on the predominant species present in the stand. In our assessment of potential, we grouped forest types into 2 classes based on fire regimes as shown in the following table. Group I includes forest types that tend to have surface or mixed fire severity. Group II types include those that tend to have high-intensity fire regimes, where severe fires are routine under natural conditions.

Forest type classification into fire regime groups

Group I Forest Types	Group II Forest Types
Douglas-fir	Lodgepole pine
Ponderosa pine	Fir-spruce
Western white pine	Hemlock-Sitka spruce
Larch	
Unclassified/other	
Pinyon/Juniper	

Gasification - The thermo-chemical conversion of organic solids and liquids into a producer or synthetic gas (syngas) under very controlled conditions of heat and strict control of air or oxygen.

Generation – The process of creating electricity. Typically generation is accomplished to supply electricity to an on site facility and/or for sale to an electric utility.

Greenhouse Gases – Those gases, such as water vapor, carbon dioxide, tropospheric ozone, nitrous oxide, and methane, that are transparent to solar radiation but opaque to longwave radiation. Their action is similar to that of glass in a greenhouse.

Historic Fire Regime – generally describes the frequency and severity typical of fires occurring within a forest type prior to the marked land-use changes of the mid 19th century and the advent of modern-day fire control measures. Two factors comprise a fire regime: 1) fire return interval, a range of time in years between naturally-occurring fires and 2) fire severity, the effects of fire on an ecosystem defined here in terms of the effects on overstory vegetation mortality. The five regimes include:

- I – 0-35 year frequency and low (surface fires most common) to mixed severity (less than 75% of the dominant overstory vegetation replaced)
- II – 0-35 year frequency and high (stand replacement) severity (greater than 75% of the dominant overstory vegetation replaced)
- III – 35-100+ year frequency and mixed severity (less than 75% of the dominant overstory vegetation replaced)
- IV – 35-100+ year frequency and high (stand replacement) severity (greater than 75% of the dominant overstory vegetation replaced)
- V – 200+ year frequency and high (stand replacement) severity

Kilowatt – A measure of instantaneous electric power consumption or production. A standard unit for expressing the rate of electrical output equal to 1,000 watts.

Kilowatt-hour –The most commonly–used unit of measure describing the amount of electricity produced or consumed over time. It means one kilowatt of electricity supplied for one hour. The amount of electricity needed to light ten 100–watt bulbs for an hour.

Megawatt – A measure of instantaneous electric power consumption or production. A unit of electricity equal to one thousand kilowatts or one million watts. Enough electricity to support approximately 750 to 1,000 households.

Megawatt-hour – One million (1,000,000) watthours. One megawatt produced or consumed over a period of 1 hour.

Moisture content – The amount of moisture contained in biomass material. Typically expressed as a percentage of total weight.

Net metering – A method of crediting customers for electricity that they generate on site in excess of their own electricity consumption.

Primary wood-using mill – A mill that converts roundwood products into other wood products. Common examples are sawmills that convert sawlogs into lumber and veneer mills that produce veneer from veneer logs.

Open loop biomass – Any agricultural livestock waste nutrients or any solid, non-hazardous, cellulosic waste material or non-hazardous lignin waste material which is segregated from other waste materials and derived from forest-related resources including mill and harvesting, residues, precommercial thinnings, slash, and brush, or solid wood waste materials including waste pellets, crates, dunnage, manufacturing and construction wood wastes, and landscape or right-of-way tree trimmings, or agricultural sources including orchard tree crops, vineyard, grain, legumes, sugar, and other crop byproducts or residues. Does not include municipal solid waste, gas derived from the biodegradation of solid waste, or paper which is commonly recycled. Does not include biomass burned in conjunction with fossil fuel (co-firing) beyond such fossil fuel required for startup and flame stabilization. See also, "closed-loop biomass."

Qualified Facility – A power facility from which a utility is obligated to purchase the output under PURPA.

Renewable energy – Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy sources include biomass, geothermal, wind, solar, ocean, and hydropower.

Renewable Energy Credits – Also known as RECs, green tags, green energy certificates, or tradable renewable certificates, certificates that represent the technology and environmental attributes of electricity generated from renewable sources.

Renewable Fuels Standard – A policy set by federal or state governments that transportation fuels contain a minimum percentage of renewable fuels such as ethanol and biodiesel.

Renewable Portfolio Standard – A policy set by federal or state governments that a percentage of the electricity supplied by generators be derived from a renewable source.

Residues (Wood) – Bark and woody materials that are generated in primary wood-using mills when roundwood products are converted to other products. Examples are slabs, edgings, trimmings, sawdust, shavings, veneer cores and clippings, and pulp screenings. Includes bark residues and wood residues but excludes logging residues.

Saw log – A log that meets minimum regional standards of diameter, length, and defect, intended for sawing into lumber products.

Secondary wood processing mills – A mill that uses primary wood products in the manufacture of finish wood products, such as cabinets, moldings, and furniture.

Torching Index (TI) – the wind speed at 20-feet above ground at which crown fire is expected to initiate in a specified fire environment. TI is a function of surface fuel characteristics (fuel model), surface fuel moisture contents, foliar moisture content, canopy base height, slope steepness, and wind reduction by the canopy. High risk stands have a torching index value of 25 miles per hour (mph) or less.

Uneven-aged – An uneven-aged stand of trees contains at least three age classes intermingled in the same area. Uneven-aged stands tend to have a diversity of tree sizes with many small trees and fewer large trees. See also, "even-aged"

Urban wood waste – Discarded wood and yard debris. This waste stream often ends up in landfills but more and more is being diverted for energy production.

Volume – Gross - Measurement of log content in log-scale board foot (see board foot definition – above) without deduction for defect.

Volume – Net – Measurement of the actual amount of merchantable wood in log-scale board foot – after deductions for defect.

Wildland Urban Interface – Zone where structures and other human developments meet, or intermingle with, undeveloped wildlands.

Woody Biomass – Any biomass that is composed of wood. Three components of woody biomass in Oregon include: 1) wood products residue, 2) forest biomass, and 3) urban wood waste.

Wood products residue – Wood waste generated at Oregon sawmills and wood products mills including trim, planer shavings, veneer cores, woodchips, sawdust, bark and other residues.

Appendix B
Historical Fire Regimes and Condition Classes in Oregon

In fuels reduction management, two interdependent criteria are used to delineate the need for action in a forest ecosystem: 1) historical fire regimes and 2) fire regime condition classes. The following discussion is meant to introduce the reader to these ideas and illustrate, at the state-level scale, the general patterns across Oregon. In order to maintain a point of reference for each criterion, a consistent color pattern progression will be used in the figures discussed below. The need for fuels reduction and restoration management intensifies as the color pattern progresses from green to yellow to red, where red exhibits the most need for restoration.

The data used to generate the following maps was produced as part of a joint venture between the USDA Forest Service and the Joint Fire Sciences Program. The data is available online at http://www.fs.fed.us/fire/fuelman/ for public use in GIS format. The producers of the data caution against fine scale use since the data was developed for national-level planning. The data was restricted to the state or Forest Service regional scale. Thus, the discussion below will focus on the state-level scale and not attempt to drill down further.

Historical Fire Regimes – Return Intervals & Severity

Historical fire regimes are used to describe the pattern and process of wildfire before Euro-American settlement. They can be compared to a site's more recent fire history to determine whether the site has deviated from its historical range and whether the site may have increased risk of uncharacteristic fire events. Two factors comprise a fire regime: 1) fire return interval, a range of time in years between naturally-occurring fires and 2) fire severity, the effects of fire on an ecosystem defined here in terms of the effects on overstory vegetation mortality. Fire regime classifications are an integration of site characteristics, habitat types, topographic attributes, and vegetation (Brown *et al.* 1994). The fire regime codes in Table 1 approximate the historical characteristics of wildfire in different forested ecosystems.

Table 1 – Description of Historical Fire Regime codes.

Regime	***Return Interval***	Severity
1	0 – 35 years	Low
2	0 – 35 years	Stand-replacement
3	35 – 100+ years	Mixed
4	35 – 100+ years	Stand-replacement
5	200+ years	Stand-replacement

All fires are spatially heterogeneous but generalizations within each regime can be made. For example, in low severity fires at least 70% of the basal area and more than 90% of the canopy cover of the overstory vegetation often survives (Morgan *et al.* 1996). Mixed-severity fires cause patchy mortality in the overstory, depending on fire behavior and species sensitivity to fire, and produce irregular spatial patterns resulting from different fire severities within the fire perimeter (Smith and Fischer 1997). Stand-replacement fires typically kill more than 90% of the overstory canopy cover (Morgan *et al.* 1996).

Fire functions as a natural means to reset forest succession. However, the spatial scale at which this is occurs varies depending upon fire regime. In low intensity fire regime forests, the fire initiates regeneration on a small scale, creating or advancing pockets of regeneration within a stand; here, stand-replacement fire is uncharacteristic. In mixed intensity fire regimes, the fire resets succession on a stand-level scale. However, stand-replacement fire will not occur over the entire area encompassed within the fire perimeter. In the stand-replacement fire regime, succession is initiated on a large scale, perhaps encompassing the entire burn area. Forests in Regime 5 are generally not considered in need of fuels reduction since fire suppression efforts have not been in effect long enough to alter their historical fire interval.

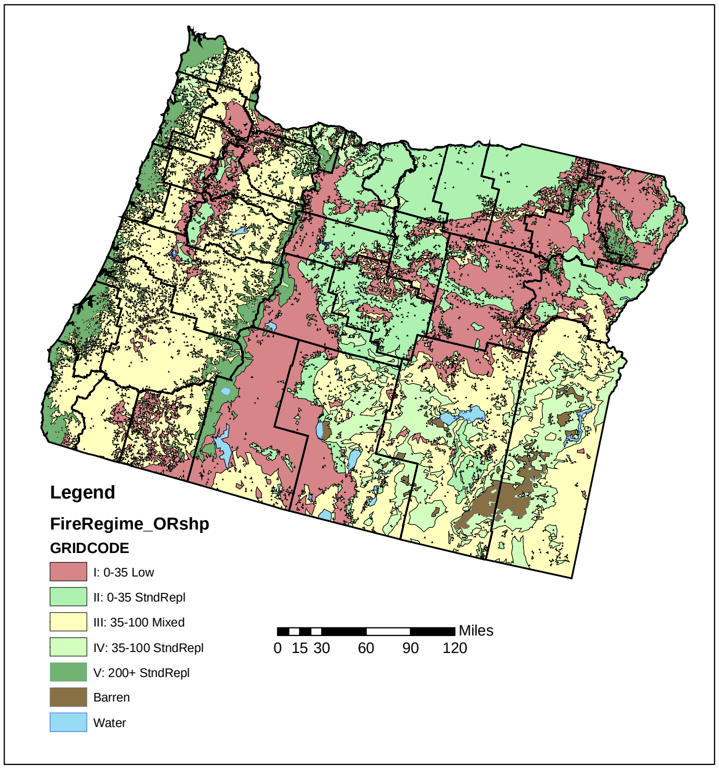

Figure 1. Historical Fire Regime Classifications for the State of Oregon.

Figure 1 shows the distribution of historical fire regimes, as determined by Schmidt *et al.* (2002), for the state of Oregon. Central and eastern Oregon show a lot of forested acreage in Fire Regime 1, 0-35 year frequency and low intensity. These forests are typically dominated by fire-adapted species that depend on frequent, low intensity fire for long-term maintenance of forest community structure and ecosystem processes such as nutrient cycling. Much of this acreage is associated with Ponderosa pine forest ecosystems, especially in central Oregon. Regime 2 is primarily reserved for grassland and shrub dominated ecosystems, where the majority of aboveground biomass is consumed in the fire.

The other fire regime class that warrants consideration for forest fuels restoration management activities is Regime 3, colored yellow in Figure 1. These forests historically experienced frequent fires but burned with mixed severities due to the varied fuel conditions resulting from the population of mixed conifer species that co-dominate the ecosystem. Additionally, the temporal variability of fire return intervals in these forests contribute to mixed fire intensity. For example, if a return interval is relatively short, i.e. 40 years, fuel buildups are relatively low and the fire may burn at a low intensity; however, if the return interval is longer, i.e. 95 years, there may be more stand replacement within the fire perimeter due to the additional buildup of fuels. The concern that these forests will experience stand-replacing fire at the landscape scale becomes elevated when fire intervals are prolonged.

Fire Regime Condition Classes

Forestland is classified into one of three Fire Regime Condition Classes, (FRCC) which are qualitative measures used to describe the degree of departure from historical fire intervals resulting from fire suppression (Schmidt *et al.* 2002). Class 1 indicates that a forest is within its natural range of fire return interval which can be as low as 35 years or greater than 200 years. Class 2 indicates a moderate deviation from the historical fire interval. Typically, fire frequency in Class 2 forests has departed from historical conditions by one or more intervals. Class 3 defines a forest in which there exists a significant risk of losing key ecosystem components due to uncharacteristic wildfire as a result of excessive fuel buildup. These forests have departed from historical frequencies by multiple fire intervals. These conditions can result in dramatic changes to fire size, intensity and severity.

Fire Regime 1 forests, with historic fire return intervals of up to 35 years, plausibly could reach FRCC 3 after 100 years of fire exclusion since the return interval is a fraction of the fire exclusion period. This effect is less clear in Regime 3 and 4 forests. With longer and more variable historic return intervals (35-100+ years), it would take a longer period of fire exclusion for these forests to miss several fire intervals and thus be classified as FRCC 3. Figure 2 depicts the fire condition classes across the state of Oregon, using year 2000 data. The area shaded red is forest categorized as Class 3 – forests that were identified as significantly departed from their historical intervals by Schmidt *et al.* 2002.

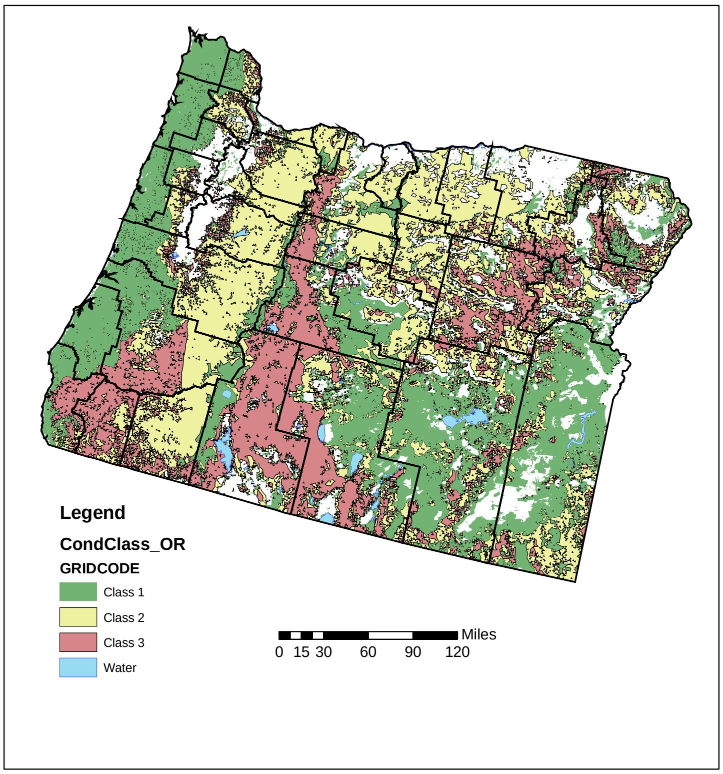

Figure 2 – Fire Condition Classes for the State of Oregon.

This map does not factor in proximity of an at-risk forest to an urban area nor the wildland-urban interface (WUI) where defensible space is a priority surrounding local infrastructure and private residences. The data used to generate these maps is not applicable at these spatial scales; however, these areas typically receive the majority of focus in initial fuels reduction efforts.

Combining Fire Regimes and Condition Classes

Figure 3 illustrates combinations of the fire regimes and condition classes defined above to indicate areas of highest fire risk: Regimes 1 and 3 and Condition Classes 2 and 3. When shown in this manner, it appears that the most immediate need for fuels reduction and restoration management primarily exists in central and eastern Oregon, indicated by the red and orange areas in the figure. This is the combination of Fire Regime 1/FRCC 2 or 3. These forests historically have experienced low severity frequent fires at intervals less than 35 years, but have skipped several intervals since the last natural fire due to fire suppression. The lack of fire has allowed an influx of forest vegetation, which in turn, has resulted in an elevated risk for uncharacteristic wildfire.

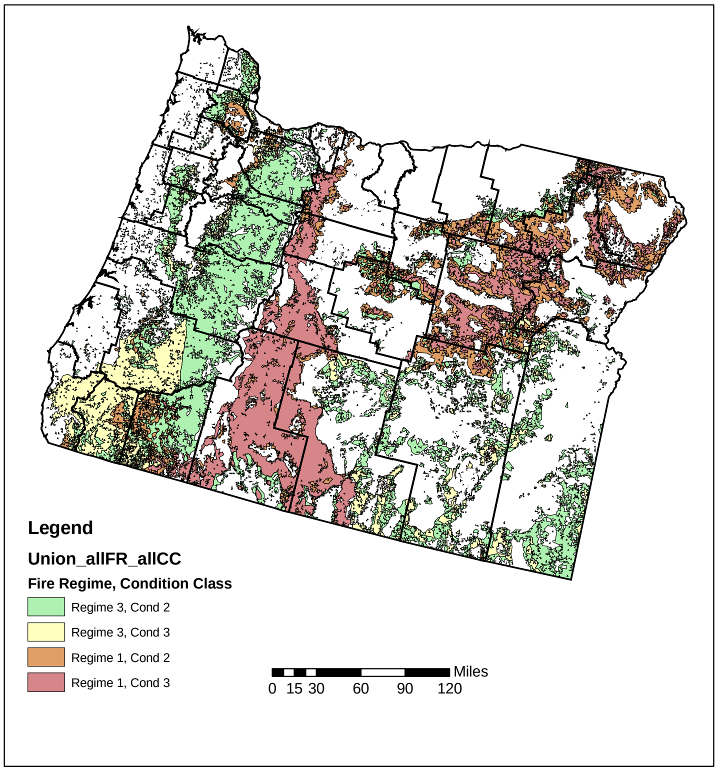

Figure 3 – Combined map with Historical Fire Regimes and Current Condition Classes.

Fuels reduction activities can have a significant impact in restoring the historical role of natural fire in Oregon's forested ecosystems. If this type of forest management is approved by the public for federal land, prioritizing forests for restoration will become an important goal. The ecological attributes of varying forests should be the mechanism which drives prioritization of fuels reduction projects for ecological purposes. Historical fire regimes and fire condition classes are two criteria that land managers can use to assess the potential need for fuels reduction treatments.

Literature Cited

Brown, J., S. Arno, S. Barrett, and J. Menakis. 1994. Comparing the prescribed natural fire program with presettlement fires in the Selway-Bitterroot Wilderness. International Journal of Wildland Fire. 4(3): 157–168.

Morgan, P. S. Bunting, A. Black, T. Merrill, and S. Barrett. 1996. Fire regimes in the Interior Columbia River Basin: past and present. Final Report for RJVA-INT-94913. On file at: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Missoula, MT. 31 p.

Smith, J. and W. Fischer. 1997. Fire ecology of the forest habitat types of northern Idaho. Gen. Tech. Rep. INT-363. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 142 p.

Schmidt, K.M., J. Menakis, C. Hardy, W. Hann, and D. Bunnell. 2002. Development of coarse-scale spatial data for wildland fire and fuel management. USDA For. Serv. Gen. Tech. Rep. RMRS-GTR-87.

Appendix C
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