Preliminary Feasibility Study
Clackamas County Biomass Assessment
September 2010

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DISCLAIMER

The information, observations and recommendations contained in this preliminary feasibility study represents the work of the research team. Biomass, in general, and biomass utilization in particular, is an emerging field of academic research and practical application. There are many definitions of “biomass” and widely varying attitudes toward biomass as a resource.

The policy context is particularly complex, constantly changing and was beyond the achievable scope of this project.
ABSTRACT

Clackamas County seeks to create a biomass utilization industry as a means of rural and agricultural economic development and renewable energy production.

A prefeasibility study of the forest, agricultural and animal biomass residues was completed for Clackamas County in September 2010. Research goals were 1) quantify the biomass energy potential based on residue resources; and 2) recommend potential biomass utilization strategies and conduct a SWOT analysis for decision-makers.

The preliminary finding is that there are sufficient biomass residues available to provide approximately 31.95 MWe of electrical power from all available residue materials. Current federal policy prohibits the widespread use of national forest materials. The County is 40% national forest land.

The study presents the SWOT analysis and recommendations.
ACKNOWLEDGEMENTS

This preliminary feasibility study was funded by Clackamas County Business & Economic Development, in collaboration with the Oregon Institute of Technology (OIT).

OIT adjunct professor-biomass, L. Davis (Dave) Clements, Ph.D., served as principal investigator. The research team included OIT biomass course students Leslie Annan, Jacob Hickman, Brandon Little, and volunteer Emilia Gonzalez-Clements, Ph.D., who provided training in applied research.

The Project Team would like to thank our two main project contacts, Dustin Kohls, Program Manager-Agricultural Investment Plan in the Clackamas County Business and Economic Development office, and Lita Colligan, Associate Vice President-Strategic Partnerships of the Oregon Institute of Technology. Dustin served as the primary contact for the client, Clackamas County Business & Economic Development, helping to focus the project and clarify the scope. Lita was invaluable in contacting key interviewees and arranging appointments.

The team also extends thanks to the following individuals for providing information, recommending interviewees and participants and offering assistance in their areas of expertise:

Jamie Johnk, Rural Economic Development Coordinator, Clackamas County Business & Economic Development

Mike Bondi, OSU Extension Agent-Forestry

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Stephanie Page, Renewable Energy Specialist-DOA, State of Oregon

Alison Craig, District Aide, Congressman Kurt Schrader

Warren Shoemaker, Former County Resident and Consultant, Renewables Business Development

The Project Team would like to also thank those Clackamas County residents who served as interviewees on this project.
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EXECUTIVE SUMMARY

INTRODUCTION

Clackamas County recognizes the need to facilitate new economic opportunities for its agricultural and rural base as well as develop new and innovative ways to reduce the region’s dependence on fossil fuels by creating locally generated, regionally renewable energy. Biomass and agricultural residues can be used in a number of valuable ways, including for energy from combustion or digestion, as soil amendments and compost, or as inputs to value-added wood products.

Purpose. This prefeasibility study is designed to quantify the type and amount of forest, agricultural and animal biomass in the County and identify potential strategies for biomass utilization for economic opportunities and renewable energy projects.

Biomass Definition. In this study, “biomass” is defined as recently-living plant or animal materials and agricultural residues used for production of fuels, energy or as a source of industrial chemicals.

Scope. The study encompasses agricultural biomass residues found in all of Clackamas County, with an emphasis on potential strategies for the unincorporated rural and agricultural areas.

Project Research Goals. The two project goals are 1) to quantify the agricultural waste residues found in the County (amount, location, availability, sustainability, seasonality, assembly and transportation, and current use); and 2) to identify strategies for accumulation and supply created for potential utilization options in the southern part of the County.

BIOMASS ASSESSMENT FINDINGS AND ANALYSIS

Forest Residues Analysis

Timber Land-Public. The large 400,000 acres of public timber land within the County suggests that forest residues and harvested materials could hypothetically be a significant resource for forest products and biomass energy. Only a small percentage of the national forest lands are available for use, however, and current owners, both private and public, already use this resource for timber harvest.

In the national forest lands, approximately 113,000 dry tons of older stock biomass per year could be collected on the basis of overstocked material alone. This resource has been consistently available for the past 20 years. This overstock resource is equivalent to approximately 11.9 MWe\(^1\) of electricity, enough to power a small town.

\(^1\) Energy Calculation Method: Divide dry tons of annual biomass by 365 days to estimate tons/day available. Divide result by 27 (average tons/day of woody materials to produce one MWe). Source: [http://cogentech-inc.com/](http://cogentech-inc.com/) Accessed 083010/ L. Davis Clements, Ph.D.
national forest management policy precludes use of significant quantities of forest products for energy.

Timber Land-Private. There are two large commercial tracts of corporate holdings that dominate the County’s private actively-managed timber lands. A number of smaller private holdings within the region are managed by “mom-and-pop” owners. These holdings are scattered and taken individually are too small to make a significant contribution to biomass-based energy in the County.

One potential strategy for small forest holders would be to form a cooperative venture for the production of pelletized or briquetted wood. The equipment needed for moderate sized-pelleting operations costs between $150,000-$250,000.

Christmas Trees. Approximately 5,000 tons per year of Christmas tree residues are distributed in the growing areas. This quantity of resource, by itself, is too small for a single commercial-scale power plant. This amount of biomass, however, can be converted into wood pellets for use either in heating or for sale.

Agricultural Residues Analysis

The agricultural residues from vegetables, nuts, fruits and berries are insufficient, in quantity, to be economically viable as a fuel source, though these residues are valuable for other uses.

Animal Residues Analysis

Poultry Litter
Poultry litter is the largest single resource in the County, approximately 144,000 dry tons, for the production of energy from biomass. The proximity of producers and tonnage make it a viable energy resource. In addition, poultry litter offers an opportunity for a related fertilizer production facility.

Bovine Residues
There are approximately 4,500 dry tons of bovine manure across 16 confined animal feed operations (CAFO), which is insufficient at any one site to justify a separate digestion – gasification system. However, operating a combined facility (Co-op?) could prove to be economically viable, if transportation issues and other barriers can be overcome.

Equines Plus “Other”
The equine and “other” (hogs, rabbits and goats) category is too small to be considered, approximately 16 dry tons. The horses are not kept in a manner that provides ready collection of residues.
### SWOT Analysis: Utilization Options

**Forest Residues • Agricultural Residues • Animal Residues**

#### Forest Residues

(Potential strategies are in bold underlines type)

<table>
<thead>
<tr>
<th>Category</th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timberland</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private—Small</td>
<td></td>
<td>Higher financial value of residue as firewood (cords)</td>
<td>Excess wood could be converted into pellets</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Not enough residue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private—Large</td>
<td></td>
<td>No residue available; large companies use all the resources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td>Large amounts; explore feasibility to sustainably harvest for small biomass and meet federal land mgmt policy goals</td>
<td>Environmental Safety</td>
<td>Environmental Concerns</td>
</tr>
<tr>
<td><strong>Stewardship Contracts 35,000 tpy</strong></td>
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<tr>
<td>Christmas Trees</td>
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<tr>
<td>Christmas Trees</td>
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<tr>
<td><strong>Potential Estacada Scalable Facility</strong></td>
<td>Dependable resource</td>
<td>Collection issue</td>
<td>Briquettes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Piled materials</td>
<td>Dispersed sites</td>
<td>Combined Heat + Power (CHP)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Location Business development sites</td>
<td></td>
<td>Syngas</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Recycling program</td>
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</table>

#### Agricultural Residues

Several nursery operators expressed fear that the wood chips would be captured by biomass facility.

<table>
<thead>
<tr>
<th>Category</th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farms</strong></td>
<td></td>
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<tr>
<td><strong>Possible Molalla Grass Seed Residue Biodigester</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Not enough biomass</td>
<td>Multi-county collaboration</td>
<td>Specific technology need</td>
</tr>
<tr>
<td><strong>Nurseries/Greenhouses Residue</strong></td>
<td></td>
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<tr>
<td><strong>Farms plus Nurseries/Greenhouses Residue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Possible Boring Biodigester Facility</strong></td>
<td>Scalable</td>
<td>Require Co-op</td>
<td>Fertilizer for farms will benefit farmers and create jobs</td>
<td>Fear of materials being taken</td>
</tr>
<tr>
<td></td>
<td>Small, possible</td>
<td>Small farms Collection system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retain nutrients</td>
<td>Fertilizer by-product</td>
<td></td>
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</tbody>
</table>

**PORTLAND**

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### Animal Residues

<table>
<thead>
<tr>
<th>Category</th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry Litter</td>
<td>Intrinsic value of residue</td>
<td>Cost of assembly</td>
<td>Biodegradable de-icer product</td>
<td>Ordinance re transport of septic material</td>
</tr>
<tr>
<td></td>
<td>Dependable, concentrated resource</td>
<td>Current use as fertilizer</td>
<td>Jobs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Retains fertilizer value</td>
<td>One primary producer</td>
<td>CHP for schools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Scalable</td>
<td></td>
<td>Syngas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multiple Products</td>
<td></td>
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<tr>
<td></td>
<td>Technology available</td>
<td></td>
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<tr>
<td>Potential Molalla Anaerobic digester plus gasification facility</td>
<td></td>
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</tr>
<tr>
<td>Bovine Residue</td>
<td>Integrated technology, resource, use</td>
<td>Small number of dairies</td>
<td>Jobs</td>
<td>Perceived resistance from local dairies</td>
</tr>
<tr>
<td></td>
<td>Technology available</td>
<td>Low intrinsic value of residue</td>
<td>Multiple installations</td>
<td>Low intrinsic value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Co-ops</td>
<td></td>
</tr>
<tr>
<td>Equine + “Other” Residue</td>
<td>County initiative: reduce school costs via CHP</td>
<td>Dispersed, small, isolated locations</td>
<td>Jobs</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Collection issue</td>
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### Conclusions

From April to June of 2010, the Project Team assessed the quantity of agricultural waste residues and the potential energy and other bi-products that could be generated if it was feasible to accumulate and process the waste. The team identified five areas of opportunity for Clackamas County, during this preliminary study phase. This report provides possible directions for the county to pursue with more in-depth and comprehensive analysis or other economic development efforts.

1. Based on the amount of forest waste and its energy potential, the County should consider engaging in a public awareness campaign related to the economic benefits and energy potential of forest thinning, as well as the risks and security impacts of overstocked national forest lands that result from historic fire suppression and reduced harvest.

2. Forest thinning could support Combined Heat and Power (CHP) applications for public, industrial, commercial or residential districts or buildings. We estimate the energy potential to be approximately 10 MWe.

3. Poultry litter has the potential to provide approximately 10 MWe of capacity. Molalla and vicinity is strategically located to become an energy power hub.
4. Regulatory limits on burning grass materials offer an opportunity to monetize the residues as energy products. This is an opportunity for the County, and could be expanded through regional partnerships with surrounding counties.

5. Smaller sources of animal waste have the potential for on-site power generation or for aggregation if other barriers can be overcome.
1.0 INTRODUCTION

1.1 Background
Clackamas County recognizes the need to facilitate new economic opportunities for its agricultural and rural base as well as develop new and innovative ways to reduce the region’s dependence on fossil fuels by creating locally generated, regionally renewable energy. Biomass and agricultural residues can be used in a number of valuable ways, including for energy from combustion or digestion, as soil amendments and compost, or as inputs to value-added wood products.

This study indicates that Clackamas County can contribute to Oregon’s Renewable Energy Portfolio Standard (REPS) and help to reach the 25% renewable energy goal of 2020 by becoming a leader in bio-fuel and bio-CHP (Combined Heat + Power) production. The county has long-term goals for reduction in greenhouse gas emissions, as well as long-term strategies for local energy security and sustainable employment opportunities. It is vital to the economic health and well-being of the region that foundational natural resource and agricultural lands are provided sustainable, creative opportunities to maintain the long-term health of these lands, retain their revenue generating capacity, reduce costs in times of financial and traded-sector transition, as well as find new ways to expand their product line into value-added opportunities and secondary product development.

1.2 Purpose
The County’s proposal for a preliminary feasibility study (April, 2010) stated:

Clackamas County is interested in investigating the preliminary feasibility of developing a countywide biomass industry, specifically focusing on redevelopment and revitalization of the rural areas of the county. The County seeks emerging opportunities to utilize existing organic residues and waste material from a variety of feedstock sources. The County ultimately seeks to create a market for these materials in a number of technological applications including biomass CHP energy generation, supplementary fuel for finite resource replacement, and secondary product creation such as biofuels, char, briquettes, syngas, and pellet manufacturing.

…By looking at general information, Clackamas County has the available resources to support this industry from a variety of agricultural and timber operations. These fuel stocks need to be further quantified, and strategies for accumulation and supply created, in order to provide a framework of data for a countywide and larger Willamette Valley operational strategy.

Biomass Energy Facility Proposal (April 2010)
1.3 Biomass Definition
In this study “biomass” is defined as recently-living plant or animal materials and agricultural residues used for production of fuels, energy, or as a source of industrial chemicals.

1.4 Scope
The study encompasses agricultural biomass residues found throughout Clackamas County, with an emphasis on potential strategies for the unincorporated rural and agricultural areas and their economic interaction with rural jurisdictions including Molalla, Estacada, and Canby.

1.5 Project Research Goals
The two primary project research goals are to quantify the agricultural waste residues found in the county and to identify strategies for accumulation and use of supply in the study area.

This preliminary study will help the County determine if a more complete feasibility study is needed to further evaluate the availability and processing of feed stocks, matching technologies and markets from processing and energy conversion, and detailed environmental and economic analysis. The necessary, reliable data on some of the available resources are lacking due to time limitations and reluctance of some sources to be interviewed.

1.6 Project Team
The research was supervised by L. Davis Clements, Ph.D., OIT Adjunct Professor, Renewable Energy Engineering-Biomass Program. Dr. Clements selected three OIT REE students to conduct the research. Leslie Annand, Jacob Hickman and Brandon Little were assigned “Agriculture” “Forest” and “Animal” topics, respectively. Emilia González-Clements, Ph.D., an applied anthropologist, volunteered to train the students in applied research methods.

Lita Colligan, OIT Vice President for Strategic Alliances, served as the OIT contact. She was instrumental in providing contact with state officials.

Dustin Kohls, Program Manager, Agricultural Investment Plan, was the liaison with Clackamas County and provided guidance in the project goals and identified County staff to serve as interviewees.

1.7 Methodology
The biomass materials were investigated separately, according to the origin of resource; namely, trees and forests, agriculture and animals. Each of these broad categories was further broken down into sub-categories appropriate for each group in order to more accurately analyze and describe the resource, options and strengths and weaknesses
of the County. Critical importance was given to sub-category resources with the research questions:

1. Amount
2. Location
3. Availability/Sustainability
4. Seasonality
5. Assembly and Transportation
6. Current Use

Sub-categories, in conjunction with their respective broad category, were analyzed according to the five important factors to determine feasible recommendations for biomass utilization. Similar methodology to the Washington State “Biomass Inventory” report by Mark Fuchs, et al (2005) was used to quantify the amount of residue. For example, the assumptions to determine the amount of collectible residue from chickens were obtained from the report. Identification of potential strategies for use of residue utilization was led by Dr. Davis Clements.

Research methods included a literature review of previous studies, articles and documents. This secondary research was enriched by individual interviews with local producers, processors, county and state agency staff; as well as review of maps, government and statistical documents and census materials. This research project did not require an Institutional Review Board (IRB) process; all information used is public and interviews were conducted with permission of the individual.

Students made at least three attempts to contact each selected person, agency and organization. Approximately 50 individuals were interviewed. Contacts were made by telephone, e-mail and in person.

1.8 Previous Studies and Government Reports

The research team collected several reports as part of the literature review and did not locate previous biomass assessments conducted for Clackamas County. The primary studies reviewed included:

4. Appendix 9 Renewable Energy Incentives & Tax Credits²

² University of North Carolina, under NREL Subcontract No. XEU-0-995-01: DSIRE http://www.dsireusa.org/ Accessed June 18, 2010

2.0 PROJECT DESCRIPTION AND STUDY OUTLINE

This research project was designed to provide answers to the primary research topics, divided into four Elements:

- **Element 1**: Identify Waste Materials, Sources and Potential End Products from In-County Fuel Stocks
- **Element 2**: Evaluate Types of Facilities, Power, and Cost
- **Element 3**: Analyze Policy Implications
- **Element 4**: Preliminary Feasibility Study

Following the 1.0 Introduction, and 2.0 Project Description and Report Outline, the findings and analysis are reported in section 3.0, Biomass Assessment Findings. Section 4.0 contains the Data Analysis, and Section 5.0 includes Recommendations.

The four elements are outlined as follows:

**2.1 ELEMENT 1: IDENTIFY WASTE MATERIALS, SOURCES AND POTENTIAL END PRODUCTS FROM IN-COUNTY FUEL STOCKS**

Consider all types of residue, volume, when available, and transportation costs to the southern rural areas of the county, with a focus on primary fuel sources and stability of sources. Produce data on available resources.

- a. Forest waste-private land, county land, federal forest land (include timber, unused Christmas trees and small tree plantations, forests overdue for fire prevention thinning, and timber land production);
- b. nursery, farm and greenhouse waste;
- c. agricultural waste; and
- d. animal waste.

**2.2 ELEMENT 2: EVALUATE TYPES OF FACILITIES, POWER, AND COST**

a. Facility types and sizes:

   - I. Secondary product replacement fuel (such as briquettes for replacement fuel); consider efficiency and conversion rates when mixed with coal or natural gas.
   - II. Gasification and syngas technologies for medium-scale use and opportunities for biofuel conversion.
   - III. CHP direct firing for small and medium scale usage, on-site farming operations, and institutions like hospitals or former mills.

b. Estimated power to be generated by each type.

c. Cost to generate compared to revenue for power.
2.3 ELEMENT 3: ANALYZE POLICY IMPLICATIONS  
   a. Review the Renewable Portfolio Standard and other energy policy in Oregon that might impact the sources of energy or their value to utility companies.  
   b. Review other relevant codes or regulations that could impact the project.  
   c. Factor policy implications into feasibility analysis and provide a brief summary to help policy makers focus on policy changes that would best benefit the industry.

2.4 ELEMENT 4: PRELIMINARY FEASIBILITY STUDY  
   a. Provide findings from elements of analysis and an assessment of the feasibility of developing a biomass energy industry in Clackamas County.  
   b. Include a SWOT analysis for the opportunities and barriers to each option.  
   c. Identify any policies in Oregon that could hinder development of biomass energy facilities and recommend changes in policy.
3.0 BIOMASS ASSESSMENT FINDINGS
3.1 Forest Biomass

*Forest biomass* is the residue material generated from logging or thinning activities in forests. Although biomass refers to the entire main stem, branches and tops of trees, the term is commonly understood to refer only to the small diameter residue material, less than 5 to 7” in diameter, that cannot be used for traditional timber products. (Bowyer, 2006)

This section of the study discusses the amount of biomass that is available from woody residues in the study area. Cull products from two primary areas of focus will be considered:

a) naturally grown timberland residue, and
b) agriculturally grown Christmas tree residues.

Biomass calculations broadly encompass every acre, tree, or large bush in a region. As full removal of greenery from any area is neither advisable nor desirable from an economic or cultural perspective, effort has been taken to ensure conservative estimates. Many categorical filters must be applied to limit the estimated supply to reasonable and attainable amounts that protect the health of the land and ensure that boom-bust cycles are avoided. The following calculations represent the highest degree of accuracy attainable in the focused period of study, but as the study writers are not trained or experienced foresters, other unforeseen factors could modify the findings presented.

3.1.1 Timberland

Timberland includes forestland that has not been withdrawn from timber utilization by statute or regulation and is capable of producing a minimum of 200 cubic feet/acre/year of merchantable wood in natural stands. It excludes parks, monuments, Wilderness Areas and other designated lands and can either be publicly or privately owned. Timber tree species include Douglas Fir, Western Red Cedar, Western Hemlock, True Fir, Red Alder, and many more Western hard and softwoods. There are 350 million live trees in Clackamas County with a basal area greater than 1 inch across. In addition Clackamas County holds more than 16 million standing dead trees over with a basal area greater than 1 inch.

3.1.1.1 Location

Timberland supply lies primarily to the east of all industrial, commercial and residential areas of the County as seen in Figure 1.
Figure 1: Broad Overview of Division between Forest Land and Incorporated Areas in Clackamas County

Estacada is advantageously located for reception and delivery of forest products. The community is an established timber town on a primary exit point for Clackamas County timberland. If the county or a private partner chose to aggregate the resource for a biomass project, an optimal location for a central processing site could be located near or around this exit point, and most beneficially at or below Estacada’s elevation (approximately 780 feet above sea level). Existing processing facilities have been identified in the area, as well as potential industrial locations.

3.1.1.2 AMOUNT

Clackamas County encompasses 1,196,800 acres, 74% of which (896,462 acres) are forest land. Of this forestland 84% (759,932 acres) are not in reserved status and thus considered timberland. 55% (417,718 acres) is federally owned. Only 1% (7,404 acres) of Clackamas County’s timberland is state owned.

Stocking condition is a measure of the tree density relative to optimal density and defined by the Forest Inventory Analysis National Program of the USFS as follows:

- Overstocked (100+% of full stocking)
- Fully stocked (60 – 99%)
- Medium stocked (35 – 59%)
- Poorly stocked (10 – 34%)
- Nonstocked (0 – 9%)
As of 2008, 5% of the timberland acreage (36,172 acres) is in an overstocked condition as shown in the table above. The largest portion is privately owned lands (23,213 acres). Overstocked and fully stocked acreage combined includes 49% of the timberland, of which 233,888 acres are federal lands.

A biomass feasibility study should also address further complexities such as slope restrictions, timber harvest regulations, Fire Regime Condition Class, and roadside accessibility, as well as considerations such as the economic viability of a timber stand. Usually a supply forest must contain more than 300 ft$^3$ of merchantable timber per acre, however analyzing merchantable timber is outside the scope of this study.

The Oregon Forest Resources Institute study of 2006 included merchantable timber estimates for three counties with similar topography to Clackamas County (Douglas, Jackson, and Josephine). By extrapolation, all federal and private timber land in Clackamas County could provide 190 million ft$^3$ of merchantable biomass (higher value lumber products) and 2,280 thousand Bone Dry Tons of net biomass (amount usually available for biomass utilization) at its current condition. Spread over a twenty year period this would mean a minimum of 114,000 BDT/year, assuming zero growth and no replanting efforts, although further growth and replanting are likely to take place. A majority of private timberland in the county is already harvested for profit. Accounting solely for untouched federal timberlands, 58.5 million ft$^3$ of merchantable timber and a minimum of 35 thousand BDT/year over 20 years is available.

### 3.1.1.3 Availability

According to the Biomass Resource Assessment,³ “Forest biomass availability is affected by a variety of factors. Some biomass must be left on-site to reduce soil erosion and compaction, conserve soil nutrients, and retain dead standing and fallen trees for wildlife habitat. Slope constraints also limit biomass recoverability.

“Yield assumptions used to estimate forest biomass generation ... are consistent with actual biomass removals from fuels reduction and thinning projects after the projects have satisfied all planning requirements, management practice guidelines and laws related to soil conservation, wildlife habitat, and forest productivity. It should be recognized that biomass availability is ultimately site-specific.”

This assessment was used as a model for estimating potential forest biomass for the county due to the similarity with the study area.

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3.1.1.4 **Seasonality/Sustainability**

Only the largest of processing plants could use the full, estimated 114,000 BDT of annual biomass potentially available. The 114,000 BDT of annual biomass corresponds to an estimated electrical generation capacity of 12 MWe. The real amount available would have to be determined by a sustainability analysis and forest management plan.

3.1.1.5 **Assembly and Transportation**

“Methods used to collect and process forest biomass vary from site to site based on slope, climate, soils, forest stand density and a variety of other site specific factors.”

This section discusses methods and costs for collecting and processing forest biomass from thinning projects and assembly of timber harvesting residues.

In forest thinning projects whole, small diameter trees and underbrush are removed to reduce forest density and obtain the desired forest structure. Removing trees is accomplished in three primary steps:

- **Felling**: cutting the trees to be removed
- **Bucking**: cutting trees to length
- **De-limbing and forwarding**: downed trees to a landing site for further processing and transportation to a conversion facility

Felling is typically accomplished manually with chainsaws or mechanically using a feller-buncher, which can grasp and cut trees. When cut trees are bucked in the woods, the resulting logs can be loaded onto a forwarder for transportation to the roadside. A forwarder typically consists of a rubber-tired modified tractor with a grapple loader and a log trailer. Alternatively, logs can be transported to a landing site in the woods for processing using a skidder, a rubber-tired machine with grapple of cabled drum that drags partially-suspended whole trees. A crawler is similar in function but has tracks rather than tires.

In conventional timber harvest operations tops and branches are often lopped and dispersed, left in skid trails to reduce soil disturbance, or piled on-site for a future burn. A portion of these residues could be collected and transported to a landing for chipping or grinding.

Systems for collecting and transporting timber harvest residue are similar to those for harvesting whole, small diameter trees. It is typically less costly to utilize timber harvesting residue with a mechanized, ground-based system that processes trees at a landing site. With a ground-based system, the whole tree is transported to a landing site, where it is de-limbed and cut to length. Then a grapple loader can be used to load timber residue directly into a chipper or grinder and skidder/crawler equipment. Labor is

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not used to transport low value materials. A cut-to-length felling and processing system fells, bucks and de-limbs trees in the forest in one process. Cut trees can then be forwarded to a roadside area for transportation to a mill. Cut-to-length systems are best for operations in medium size (7 to 18 inches DBH) forest stands and can cost more than other mechanical ground-based systems.

Processing typically occurs at forest landing sites in order to increase the density of the biomass for transportation, thereby reducing trucking costs, allowing more biomass weight to be shipped per truckload. The most common methods of processing residue into denser biomass material at a landing site include chipping and grinding. Chipping often produces a uniform size and shape product for feedstock handling systems used in biomass power generation or ethanol manufacturing.

Table (1) provides estimates of roadside forest biomass costs based on time and motion studies for the western United States. Roadside is an encompassing term that captures costs associated with felling, skidding, chipping and loading material into a chip van for transport.

### Table 1 Estimated Roadside Forest Biomass Costs

*(Based on Time and Motion Studies for the Western United States)*

<table>
<thead>
<tr>
<th>Project</th>
<th>Roadside chip cost ($/Gross Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ponderosa Pine Partnership</td>
<td></td>
</tr>
<tr>
<td>Unit 1</td>
<td>41.76</td>
</tr>
<tr>
<td>Unit 4</td>
<td>46.41</td>
</tr>
<tr>
<td>Unit 5b</td>
<td>39.06</td>
</tr>
<tr>
<td>Unit 5e</td>
<td>29.80</td>
</tr>
<tr>
<td>Wyoming Time and Motion Studies</td>
<td></td>
</tr>
<tr>
<td>Wyoming – Neuson</td>
<td>41.68</td>
</tr>
<tr>
<td>Wyoming – Manual</td>
<td>30.88</td>
</tr>
<tr>
<td>Average</td>
<td>38.26</td>
</tr>
</tbody>
</table>

Chipping costs for both the Ponderosa Pine Partnership and Wyoming Time and Motion Studies were assumed to be $6.39/GT. Chipping cost estimates were escalated from 1997 values to 2003 using an assumed 2% inflation rate. Source: S. Haase and T. Rooney, NEOS Corporation, Evaluation of Biomass Utilization Options in the Lake Tahoe Basin (U.S. DOE Western Regional Biomass Energy Program September 1997)

Bundling systems that produce bales for transportation to a conversion site are beginning to see use in the U.S. as an alternative to chipping and grinding in the forest. These systems could reduce the costs of biomass, however to be conservative, we assumed that biomass would be chipped and blown into a ‘chip van’ for transport.”
The biomass resource assessment prepared by McNeil Technologies, Inc. used $5.50/ton as a fixed cost in delivering biomass from forest roads to processing facilities, and though prepared in 2003, is logical for use in current estimates. Additionally, $0.088/mile/ton needs to be included to reflect price changes based on distances traveled resulting in savings for localized deliveries and added cost for longer hauls. “Costs may be lower if arrangements such as back hauls can be made to use empty chip vans on return trips from another location. However, because it is likely that the location of forest management projects will change, relying on lower costs for planning purposes is not prudent.”

More specific data on the location of overstocked stands would permit a more accurate transportation analysis. Geographic Information Systems (GIS) software could then be used to map the locations of future projects, after which estimated biomass availability could be calculated for each location and more localized costs would be attainable.

3.1.1.6 ISSUES AND CONCERNS
Adequate supply of woody biomass is the critical determining factor when implementing any form of utilization in Clackamas County. Supply from federal lands is entirely dependent on its current stewardship contracts from federal departments, which are cautious about opening up forest land as they risk litigation from multiple interested parties. This results in delays and limits potential supply from federal lands.

Implementing a power supply station relying primarily on feedstock from Federal or state land is fraught with uncertainty, and generally unadvisable. It would be preferable to develop value-added energy that is independent of this massive source, yet scalable when/if it opens up.

Economic viability also limits expansion of the forest biomass industry. “For both public and private lands, costs to harvest, gather, and transport the woody biomass typically exceed the market value of the material.” This implies that woody biomass will generally remain a secondary product, and thus relies on the economic availability of the main source of revenue. While care was taken to present biomass material available only from land with greater than 300 cu ft (ft³) per acre this would still require an interested party to perform the extraction for the merchantable timber as a primary activity. This has been an issue for many years within the county and may stay that way for some time.

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### 3.1.2 Christmas Trees

Christmas trees in Clackamas County are approximately 47% Doug-Fir, 45% Noble Fir, and 5% Grand Fir. This is important in further calculations because each species varies in chemical makeup (limited) and by weight (greatly). For the purposes of this study the average weight of a supplanted Doug-Fir was 25 lbs without the root system. Noble Firs and Grand Firs each average 40 lbs. when harvested.

#### 3.1.2.1 Location

Christmas trees grown in Clackamas County cover 23,295 acres located primarily in the South Central region as seen in Figure 2 and are concentrated near the unincorporated community of Colton. The largest farms are South of Canby, near Aurora, and a few dispersed farms south of Sandy, Estacada, and Molalla.

![Figure 2: Clackamas County’s Largest Christmas Tree Farms](image)

#### 3.1.2.2 Amount

The quantity of Christmas tree biomass generation is a straightforward computation compared to determining the quantity of material available for recovery. Trees are

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6 The hyphen in the name implies that the Doug-Fir is not a true Fir as it is not a member of the genus *Abies*. 
grown in arranged patterns and individually tagged according to quality. If a tree is considered of low value it will either be cut down, piled, and generally burned or given another year to monitor improvement and then either harvested for profit or burned. Unlike other crops with a shorter lifecycle and depends on weather, crop rotation, wind patterns, and other variables, Christmas trees tend to have relatively consistent yields year after year.

An estimated 4,876 tons of usable Christmas tree biomass is accumulated annually throughout Clackamas County. This is a two-year average comparing the number of trees cut versus the number of trees sold.

An alternative calculation closely matches this estimate: Christmas tree farmers report that 5-10% is culled on their fields, resulting in an estimated 4,748 tons of annual biomass, a difference of 2% between the calculations. This is assuming that 100% of the available biomass was collected and transported to a processing facility. It is unlikely that all the material would be collected from all sources. The 4,748 tons per year of Christmas tree residue could yield about 0.5 MWe of power.

3.1.2.3 Availability
The quantity of harvest depends mostly on the expected demand by consumers. Christmas trees battle public perception as many people believe that having a tree in their homes is robbing the forest of natural assets, according to some of the interviewees. Plastic trees thus made inroads into the demand curve for real trees. In recent years, advertising has lifted the pressure and the volume of trees sold from Clackamas County has rebounded. From the perspective of biomass availability, the commercial supply is dependable. Commercial tree farmers generally have little objection to removal and distribution of their cull products, as they seldom use the residue for ground cultivation and it alleviates the need for burning. A few obstacles will be discussed in section 4.6.

3.1.2.4 Seasonality/ Sustainability
Christmas trees are replanted at a general ratio of two trees per one harvested. This helps the farmer balance incidental tree deaths at the early stages and ensures continued annual revenues.

Christmas trees are harvested annually, primarily between October and December. General upkeep of the crop land is year round, however only small amounts of residue are available off season.

Although a vast majority of the trees sold are exported to California, Washington, Canada, and Mexico, the trees sold here in the County could potentially be collected and processed using the same methods as culled trees. This would likely provide a small but annual supply of woody biomass. There is, however, competition for the
product as recycling centers have already been established to use the supply for yard mulch, hiking trail renovation, and various other uses.

3.1.2.5 Assembly and Transportation

Approaches used to collect Christmas tree biomass are few, but unique. One option is for the tree farmers themselves to transport the cull along with the merchantable trees from the fields to a collection point accessible by large machinery and tractor trailers. In this instance, loading or chipping the product is straightforward, with emphasis on making the acquisition as timely and harmless as possible to ensure continued cooperation from the land owner. A second option is to helicopter merchantable trees to maximize productivity and minimize damage to surrounding trees. Ground workers stack the felled trees near the growth site for collection. Trees that are to be burned are generally piled nearby on rough land inaccessible by tractor trailers. Change in practice would need to be recommended to the tree farmer, with unknown economic impact on the cost of delivered goods.

As machinery would be needed to grind and/or chip the material to a particle size usable in cellulosic ethanol conversion or other biomass power generation, it is most logical that this processing occur on site, thereby condensing the product and reducing trucking costs. Bundling systems are another method worth considering as they produce compact bales for transportation, where the material could be chipped by a more substantial stationary system. This would reduce costly break down of portable equipment and, depending on the end use, potentially reduce the cost of the biomass supply.

3.1.2.6 Issues and Concerns

Without going deeply into the complex economic variables of creating a new biomass processing facility, it is important to note several obstacles. For example, unless the supply could be acquired at limited or no cost or with the persuasion of tax rebates, the operation would have to pay an equivalent amount for raw materials as an existing pulp or paper mill to compete in the woody residue market.

Organizing some 459 Christmas tree farms, and actively harvesting to cull and collect the quantities stated above, is logistically challenging. Vital to the success of this plan is participation from at least the three major players in Christmas tree farming- Yule Tree Farms, Mckenzie Farms and Timbergrove Farms LLC. Relying on support from growers implies that the economics justify their efforts to supply the system. Individual business plans will not always include the added effort of collecting cull trees for biomass utilization, unless there is good reason to do so.

Case Study

As of the first quarter in 2008, a local company had successfully installed a combined heat and power system at their lumber plant. They took advantage of Oregon
Department of Energy Business Energy Tax Credits, Federal Production Tax Credits, and other incentives to install a 100,000lb/hr boiler in conjunction with a 10MW biomass powered generator. Although the facility is currently operated below capacity (20-30%), at full volume their facility could process approximately 10 BDT per hour. This unit enabled the employment of 9 full time workers, including a salaried manager. The lumber plant provides some of the biomass material in exchange for the heat necessary to dry their manufactured veneer, and therefore uses less natural gas. The remaining biomass needs to be purchased.
3.2 Agricultural Biomass

This section of the study discusses the amount of biomass that is available from farm and nursery residues in the County. Agricultural biomass, in this case, is unusable residue and bi-products from plant growth on farms, nurseries, greenhouses, and other plants grown for human or livestock use. Clackamas County has 215,210 acres that are actively farmed; 50% are farms smaller than 10 acres and 25% are larger than 21 acres. This study uses the metric of acres to estimate the tons of residue for a given crop.7

Clackamas County has many different types of agriculture consisting of feed grass, hay, berries, nursery stock, apples and other fruits. Currently, most farm residue is used as compost or is burned.

In the case of agricultural biomass it is quite likely that more than that listed may be available to a potential facility, once constructed, for two reasons. First, it’s difficult to estimate the possible contributions (if any) of the many small farms and nurseries that have only a few acres. Secondly, the amount of residue tends to fluctuate due to the yield of crops, due to factors such as weather conditions, rain fall, disease, or other unforeseen implications.

3.2.1 Nursery and Greenhouse

Nurseries are the largest consistent producers of residue. Clackamas County has several nurseries located in Boring, Canby, and Molalla, as seen in Figure 3.

3.2.1.1 Location

The nursery areas are concentrated outside of Boring, Canby, and Molalla, as seen in Figures 3 and 4.

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Figure 3: Registered Nurseries in Boring, OR. (F = Nursery Location)

Figure 4: Registered Nurseries near Canby, OR
3.2.1.2 **AMOUNT**
The 2007 census shows 12,859 acres in nursery and greenhouse land use. From our interview with the Oregon Association of Nurseries, this amount is considered to be applicable. Additional interviews and collected data reflect a consistent amount of biomass residue, as listed in Appendix A as woody biomass. The calculation shows the available amount as 395 dry tons of biomass per year, with an energy potential of 0.044 MWe.

3.2.1.3 **AVAILABILITY**
Nursery residue identified as woody biomass is harvested throughout the year, collected and stored on site, then burned in the fall and spring. This residue is not currently sought by outside sources and thus should be available for a low cost. The potential to avoid burn permit fees may also indicate that the material could be available for a low cost.

3.2.1.4 **SEASONALITY/SUSTAINABILITY**
Availability varies with specific crops, but residue is generally gathered for composting or burning in the spring and fall.

3.2.1.5 **ASSEMBLY AND TRANSPORTATION**
Transportation is needed for residue due to the size of the business and the equipment available. Residue storage is usually not an issue as many nurseries have existing collection areas. Nurseries without room to store residue on-site generally use a nursery recycling service to pick up and dispose of the cull. This service is performed for a small fee and is generally only needed for smaller farms. The collection services could benefit from expanded biomass utilization.

One of the goals of the project is to site a facility near one of the study areas (Canby, Molalla, and Estacada). Since the resources are largely concentrated near the Molalla area, a suitable project site near the resource will help to limit transportation costs. This would allow for the end product to be transported to Estacada for potential use heating the schools or other buildings. An alternate collection site might be in Boring, to utilize resources located in that area.

3.2.1.6 **ISSUES AND CONCERNS**
Being able to secure a site that is within a reasonable distance is a potential problem. There are few potential sites nearby that could work for each collection point. Former mill sites or on-site farm locations may be suitable for a project.

An additional concern is the availability of the product. Nurseries are dependent on weather and cannot produce a truly reliable resource. However, due to the storage availability of the residue, it is possible to allow for regulation of the residue which would help mitigate this fluctuation in availability. It is our opinion, however, that the amount of residue available would not be enough to power a large plant.
An anaerobic digester would allow for use of this material and could be operated as a co-op between small farms. This can be combined with the other residues, such as animal manure, to make greater use of the available material. An example of a working anaerobic digester is given later in the study.

### 3.2.2 Grass Seed

Grass seed is one of the largest resources of agricultural biomass material in Clackamas County. According to the 2008 census for Oregon, the 9,767 acres of grass seed earn over $10 million for sold product\(^8\) (OSU 2010). The stalks from the grass seed are available for use as energy raw material. Historically, the stalks have been burned in the field after harvest.

#### 3.2.2.1 LOCATION

There is a large concentration of grass seed outside of Molalla as seen in Figure 5. It may also be possible to look into Marion County for seed growers. A shared collection site or treatment facility would make this option more viable, despite lower numbers within Clackamas County itself.

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\(^8\) Oregon State University. 2010. Oregon County and State Agricultural Estimates. Corvallis.
3.2.2.2 AMOUNT
The amount of residue grass seed dry tonnage is 17,190 per year, (see the calculations in the Grass Seed Section of Appendix A3).

3.2.2.3 AVAILABILITY
This has been a consistent crop over the years. “Grass seed production is one of the state’s leading agricultural crops, it is ranked third in Oregon’s Top 40 Commodities of 2006.” ⁹(OGS, n.d.) Also the residue is normally burned rather than composted, so it may be more readily available from farmers.

3.2.2.4 SEASONALITY/SUSTAINABILITY
Grass seed is normally harvested in June or July, however the residue is not stored for long and has usually been burned once a year. The residue is a dependable source but does not have the ability to consistently be produced throughout the year.

3.2.2.5 ASSEMBLY AND TRANSPORTATION
Grass seed residue is concentrated in one area, as seen in Figure 5. The challenge is having the equipment to transport residue to a specified location near Molalla. This location allows for the adjacent farms located in Marion County to participate in the project, allowing for easier expansion of the storage or treatment facility.

3.2.2.6 ISSUES AND CONCERNS
Using grass seed waste for fuel rather than burning would solve a controversial health and pollution issue for the region, due to the considerable health risks from field burning. A challenge will be securing a site to aggregate the resource that is within a reasonable distance. There are a few potential sites nearby that could work for each collection point. Former mill sites or on-site farm locations may be suitable for a project.

3.2.3 Hay and Grains
Hay and grains are another large agricultural biomass materials in Clackamas County, representing 3% of the agricultural commodity sales. The 2007 Census reported 24,715 acres of forage and hay, and 1,212 acres of wheat and grains.

3.2.3.1 LOCATION
There are large concentrations, located in Estacada, Oregon City, Molalla, and Eagle Creek as seen in Figure 6. This could allow for a collection site and/or facility for larger community benefit.

3.2.3.2 **AMOUNT**
As residue, the amount of wheat tonnage is 7.8 tons per year and hay is 150 per year, not a significant resource for energy production (see the calculations in Appendix A3).

3.2.3.3 **AVAILABILITY**
Hay and grain residue is available and is not currently used for another purpose.

3.2.3.4 **SEASONALITY/SUSTAINABILITY**
Hay is harvested in May to October, where wheat is harvested June through November, depending on the variety.

3.2.3.5 **ASSEMBLY AND TRANSPORTATION**
The main location of the wheat and hay residue is concentrated in several areas, as seen in Figure 6. The challenge is having the equipment to transport the residue to a single location, perhaps near Molalla. A Molalla location will also allow for adjacent farms to participate in the project and allow for ease of expansion of a storage or treatment facility.

3.2.3.6 **ISSUES AND CONCERNS**
The ability to secure a site within reasonable distance to the residue presents a challenge, as there are limited sites nearby that could work for each collection point.
### 3.2.4 Berries and Small Fruits

The Agricultural Commodity Census for Clackamas County 2009 reflects that 5% of the farms produce small fruit and berries. The amount of berries in acres is 3,002, and 455 for small fruits, consisting of items such as cherries and grapes (Census 2007). This is a much dispersed resource as many farms are small. Most farms that deal in this commodity also have other items and collection of the mass is used for composting.

#### 3.2.4.1 Location

Although berries and small fruits make up a large portion of the sales in Oregon, the operations are small and dispersed, and the residue is generally composted. We can see by Figure 7 that the concentration of berries is throughout the County.

![Figure 7: Berries and Small Fruit Farms in Clackamas County](image)

#### 3.2.4.2 Amount

The amount of residue for the berries and small fruit is about 30 dry tons a year (see calculations from Appendix A3).

#### 3.2.4.3 Availability

The availability of these products is seasonal and is harvested during the summer months. Most of the residue is used for compost, however, as reported in interviews conducted, the amount of compost building up on farms is more than is needed.
3.2.4.4 **SEASONALITY/SUSTAINABILITY**
The berries are seasonal and, in most cases, cut down and used for compost in the summer months.

3.2.4.5 **ASSEMBLY AND TRANSPORTATION**
There are a large number of farms across a large area. Even with several collection sites, we estimate that it is unlikely that the residue would be fully utilized.

3.2.4.6 **ISSUES AND CONCERNS**
According to interviews conducted, this source of residue is readily available. The need for transportation equipment and lack of concentration amongst the many dispersed small farms, and how this will impact the ease of availability, is a concern. Therefore, consideration may be given to have pick-up sites for a community digester in farm areas to reduce these concerns. However, the amount of available residue would not be enough to power a large plant. An anaerobic digester would allow for use of this material and could be operated as a co-op between small farms. This can also be combined with the other listed residues to make greater use of the available material.

3.2.5 **Apples and Pears**
Apples and pears consist of 54 and 124 acres in Clackamas County (Census 2007).

3.2.5.1 **LOCATION**

![Map of Apple Farms in Clackamas County](image)

**Figure 8: Apple Farms in Clackamas County**
The overall contributions from this category are essentially from Boring, Eagle Creek, and Beaver Creek as shown in Figure 8.

**3.2.5.2 Amount**
There are 49 dry tons per year of apple and pear residue.

**3.2.5.3 Availability**
Producers that participated in our interviews stated that the availability of this residue is seasonal. Residue from the fruits themselves is composted, however there is some limb and tree residue that is burned.

**3.2.5.4 Seasonality/Sustainability**
The months to harvest apples are July through November and pears are harvested from July through October. Apple and pears are both well established crops in Clackamas County.

**3.2.5.5 Assembly and Transportation**
Many farms do not have the capability of transporting the residue. However, due to the amount concentrated in only two areas, there can be an effective pickup area in Boring, Molalla, or Beaver Creek.

**3.2.5.6 Issues and Concerns**
This residue source is readily available, however there is limited availability of transportation equipment to haul the product. Unlike some of the other agricultural products, disperse production areas are not as great a concern. The amount of residue available would not be enough to power a large plant. An anaerobic digester would allow for use of this material and could be operated as a co-op between small farms. This can also be combined with the other listed residues to make greater use of the available material.

**3.2.6 Nuts**
Nuts (primarily hazelnuts) account for 4,554 of the acres farmed in Clackamas County (Census 2007).
3.2.6.1 LOCATION

Figure 9: Nut Farms in Clackamas County
(source: tricountyfarms.org)

3.2.6.2 AMOUNT
The overall contributions from this category are 1,091 dry tons a year (per oregonhazelnuts.org). The amount of hazel nuts in Clackamas County is 15% of the total Oregon and Washington Crop, totaling 5,197 tons of hazelnuts harvested and 65% sold in the shell (1,819 tons). Approximately 60% of the weight is considered shell, leaving 1,091 tons of unused biomass residue.

3.2.6.3 AVAILABILITY
Many of the producers who participated in our interviews stated that there was a large availability of biomass from this crop.

3.2.6.4 SEASONALITY/SUSTAINABILITY
The nuts are available during the fall and the trimmings are done in the spring and fall, allowing for collection several times during the year.

3.2.6.5 ASSEMBLY AND TRANSPORTATION
Many farms do not have the capability of transporting the material. Due to the amount of concentrated in three areas, there can be an effective pickup area in Eagle Creek, Molalla, or Beaver Creek.
3.2.6.6 **ISSUES AND CONCERNS**
Securing a site within a reasonable distance to the supply is a concern as there are limited sites suitable as collection sites in the production area. An additional concern is that the amount of residue available would not be enough to power a large plant. An anaerobic digester would allow for use of this material and could be used as fuel gasification.

3.2.7 **Corn**
The corn crops account for 4,672 of the acres farmed in the Clackamas County Area (Census 2007).

3.2.7.1 **LOCATION**

![Figure 10: Corn Farms in Clackamas County](image)

3.2.7.2 **AVAILABILITY**
The overall contribution from this category is 19.337 dry tons a year. Those producers participating in the project interviews stated that there was a large availability of biomass from this crop.

3.2.7.3 **SEASONALITY/SUSTAINABILITY**
Corn crops are harvested during the summer, allowing for biomass to be available in the fall after harvesting season. This is a consistent annual crop with an availability that allows for planning.
3.2.7.4 ASSEMBLY AND TRANSPORTATION
As stated previously, many farms do not have the capability of transporting residual material. However, due to the amount concentrated in only 2 areas there can be an effective pickup area in Eagle Creek, Molalla, or Boring.

3.2.7.5 ISSUES AND CONCERNS
Securing a site within a reasonable distance is a potential concern as there are limited sites available suitable as collection sites. An additional concern is that the amount of residue available would not be enough to power a large plant. An anaerobic digester would allow for use of the residual material and could be operated as a co-op between small farms. This can also be combined with the other listed residues to make greater use of the available material.

OVERRIDE CONCERNS AND COMMENTS WITH AGRICULTURAL BIOMASS
Due to difficulties in making contacts with large producers in Clackamas County, our assumptions are based primarily on small farms and nurseries. For most growers interviewed, the primary concern was cost versus the return on investment. If there was not sufficient return on their investment, they would rather continue with their existing practices of burning and composting their residues. Once the County’s Agriculture Investment Plan was shared, growers were encouraged about future prospects.

Farms:

- Majority of excessive residues are burned, mulched, composted.
- Burning of non-composting value.
- The payment for residue must be cost effective.
- Many think this is a good idea.
- Several farms under the size of 5 acres have stated they do not have enough residue to be counted or their residue is needed for their own use.
- There are individual concerns about allowing a plant to be built in close proximity (not-in-my-backyard).
- Many interested in the benefits that they would see personally.
- Most farms are only open for a short time during the year.
- Aggregating multiple crops and residues may provide the greatest opportunity.

Small Nurseries:

- S+H is a recycling group that will pick up yard debris and recycle for a fee starting at $10 a week.
- For a three acre farm, 1-2 pickup trucks would be available for 9 months out of the year for trimming and weeds.
- Many are requesting some to pick up due to not having appropriate equipment.
Many feel that this is a good idea.
For smaller nurseries (under 2 acres) they do not produce enough residue, but do produce a great amount of compost.
Suggestion from some nurseries - composting center.

Large Nurseries:

- Many do twice yearly ‘fall’ cleanup.
- Almost all soil is recycled or foliage is burned.
- For nurseries over 20 acres, majority feel a need to have any access chipped and reused on site or composted. However, this is a smaller amount in comparison with the amount produced and is taken into account.
- The most that is burned per year is 2 tons for every 65 acres, which is shrubs and trimmings that cannot be used.
- Some stated: do not have the equipment to move the residue.
- Statements of concern on assumption that “the biomass plant will steal the wood chips” that are necessary for the products so they cannot use them.

Table 2: Summary of Agricultural Residues and Energy Equivalent

<table>
<thead>
<tr>
<th>Source</th>
<th>Acres</th>
<th>Residue (Dry Tonnage/year)</th>
<th>Energy Equivalent (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery and Greenhouse</td>
<td>12,859</td>
<td>276</td>
<td>0.003</td>
</tr>
<tr>
<td>Grass seed</td>
<td>9,767</td>
<td>17,190</td>
<td>1.81</td>
</tr>
<tr>
<td>Hay and Grains</td>
<td>25,927</td>
<td>157.8</td>
<td>0.15</td>
</tr>
<tr>
<td>Berries and Small Fruits</td>
<td>3,457</td>
<td>30</td>
<td>0.003</td>
</tr>
<tr>
<td>Apples</td>
<td>54</td>
<td>54</td>
<td>0.006</td>
</tr>
<tr>
<td>Pears</td>
<td>124</td>
<td>124</td>
<td>0.14</td>
</tr>
<tr>
<td>Nuts</td>
<td>4,554</td>
<td>4,383</td>
<td>0.461</td>
</tr>
<tr>
<td>Corn</td>
<td>4,672</td>
<td>19,337</td>
<td>2.04</td>
</tr>
<tr>
<td>Total</td>
<td>61,414</td>
<td>4.39</td>
<td>4.05</td>
</tr>
</tbody>
</table>
3.3 Animal Biomass

Braeside Farm is a small farm located in Clackamas County. The farm currently utilizes animal and crop residue via a batch-style anaerobic digester (soon to be a flow-through digester). The digester is small, but fitting for the quantity of residue generated by the farm. The methane produced is used to heat tables in a greenhouse, allowing crop growth at times where Oregon’s climate would not generally permit. Braeside Farm is one example of how animal and plant biomass can be used to benefit the rural areas of Clackamas County.

This section discusses the amount of biomass that is available from animal residues in the County. Since animal concentration is an important factor in the ability and applicability of collecting sufficient amounts of residue for utilization, only Concentrated Animal Feeding Operations (CAFO’s) are included in the analysis. Small operations having only a couple of animals are more likely to use the animal residue on the farm (fertilizer, etc.) and are very unlikely to invest the time and expense to collect residue for such a small contribution. The CAFO’s in Clackamas County have a variety of animals, including: chickens, bovine, elk, water buffalo, equines, goats, hogs and rabbits. Some of the sections below are identical for each category of animal.

It is quite likely that there is more biomass available for a potential facility(ies) than stated in the study, due to the difficulty in estimating the possible contributions (if any) of the many small farms that have only a few animals and are not large CAFO’s. Even though it is unlikely for many small facilities to contribute, it is still possible that some may be interested. Also, the feather and meat processing residue may be attainable from processing facilities and not from the farm where they are grown. These processing facilities are not included in the analysis for any of the animals.

3.3.1 Poultry
Poultry is the most significant source of animal biomass material produced in the County, representing over 93% of the dry tons produced in Clackamas County annually.

Figure 11 reflects proportionately the biomass material attributed to each animal residue.
3.3.1.1 LOCATION
The only CAFO’s in the Clackamas County are from chicken-based operations and no other birds are included in the analysis.

There are 11 registered chicken-based CAFO’s in Clackamas County, with locations shown in Figure 12. Appendix A-1 contains detailed information for each numbered CAFO.

Figure 12: Chicken-based CAFO Locations in Clackamas County.
See Appendix A-1 for Associated numbers representing individual farms.
Molalla is the closest proximity to the majority of the CAFO facilities. Since proximity to the resource is crucial for the feasibility of a biomass project, the optimal location for a central processing site is located where there is the least amount of transportation distance required for the material.

### 3.3.1.2 Amount

The recorded poultry population in Clackamas County amounts to more than 3 million tons per year, representing 65% the CAFO’s (USDA, 2007). The remaining 35% is comprised of smaller chicken operations and other poultry types including turkeys, ducks and geese. Table 3 reflects the amount of dry tons of chicken manure produced per facility location and the percentage of overall chicken manure that can be obtained from each facility location. It is important to note that sites 18, 19 and 21 are listed with a Canby address, but are actually closer to Molalla.

**Table 3: Annual Dry Tonnage of Chicken Manure by Listed Address**

<table>
<thead>
<tr>
<th>City</th>
<th>Tons of Dry Biomass (annual)</th>
<th>Dry Tons</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver Creek</td>
<td>10,220</td>
<td>7.09%</td>
<td></td>
</tr>
<tr>
<td>Canby</td>
<td>30,913</td>
<td>21.45%</td>
<td></td>
</tr>
<tr>
<td>Oregon City</td>
<td>3,837</td>
<td>2.66%</td>
<td></td>
</tr>
<tr>
<td>Molalla</td>
<td>97,651</td>
<td>67.74%</td>
<td></td>
</tr>
<tr>
<td>Woodburn</td>
<td>1,524</td>
<td>1.06%</td>
<td></td>
</tr>
</tbody>
</table>

We have not included in Table 3 the amount of dry tons available from poultry feathers, poultry meat processing and poultry mortality. However, the contributions of the feathers, meat processing and mortalities would yield only a 2% increase in annual dry tons. Amounts of dry tonnage manure resource were calculated using assumptions found in Appendix A-2.

The chicken manure is produced from seven different CAFO’s in the County. The ability of the different farms to produce biomass varies drastically because of the number of animals that the different companies are using. A company comparison is shown in Table 4, reflecting the estimated biomass contributions of each chicken-based CAFO in Clackamas County.
Table 4: Estimated Biomass Contributions of Poultry-based CAFO’s in Clackamas County

<table>
<thead>
<tr>
<th>Company</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>WILLAMETTE EGG FARMS LLC</td>
<td>75.20%</td>
</tr>
<tr>
<td>MURATA POULTRY</td>
<td>2.85%</td>
</tr>
<tr>
<td>OAK GROVE POULTRY INC</td>
<td>4.64%</td>
</tr>
<tr>
<td>HEILMAN, ED &amp; LISA</td>
<td>2.66%</td>
</tr>
<tr>
<td>BRADLEY FARMS</td>
<td>7.09%</td>
</tr>
<tr>
<td>MOLALLA POULTRY INC</td>
<td>5.49%</td>
</tr>
<tr>
<td>D &amp; B POULTRY</td>
<td>2.06%</td>
</tr>
</tbody>
</table>

The types of chicken operation in Clackamas County (broilers versus layers) heavily influences the amount of manure produced. Table 5 reflects the breakdown according to the type of chicken operation.

Table 5: Biomass Produced by CAFO’s in Clackamas County by Type of Operation

<table>
<thead>
<tr>
<th>Chicken Type</th>
<th>Dry Tons (annual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layers</td>
<td>108,402</td>
</tr>
<tr>
<td>Broilers</td>
<td>35,744</td>
</tr>
</tbody>
</table>

Further consideration to the amount of potential biomass produced in the County is facility capacity. The combined total of all broilers in the County is 90.1% of the permitted capacity. The combined total of all facilities with layers amounts to 81% of the permitted capacity. Since operating at 100% capacity is not entirely realistic, a 95% capacity for each category can be used to show what biomass could potentially be produced if farms were operating closer to the permitted amounts. The increased capacity would result in an increase of 20,673 annual dry tons, a 13.4% increase.

3.3.1.3 Availability

There is monetary value in chicken manure to the businesses that produce it. The business with the largest potential source of chicken manure (75% of total dry tons) sells nearly all of the residue as fertilizer for $18-$30 per dry ton. An assumption can be drawn that other CAFO’s in the County also sell their residual, although it has not been verified. Manure could be available at a cost, which must be accounted for when determining whether or not it would make economic sense for energy production. Facility operators may make the residual product available if offered a higher economic return.
3.3.1.4 **Seasonality/Sustainability**

The Clackamas County poultry population provides that the residue amounts will be available consistently throughout the year.

3.3.1.5 **Assembly and Transportation**

The means of assembly of biomass for the majority of the poultry farms is done by using a conveyer belt. This system is used to dry the manure from approximately 75% moisture to 20-25% moisture. The manure is then loaded into trucks for shipment to its end destination. The quantity of manure the system is able to collect is significant. Appendix A-2 describes the specific assumptions used to calculate the collection amount of manure produced and the collection percentage.

One of the economic development goals of the project is to site a facility near one of the study areas (Canby, Molalla and Estacada), so that transportation is not an issue.

3.3.1.6 **Issues and Concerns**

Securing a site within a feasible transport distance is a potential concern. There are a few potential sites that could work, including a former mill sites or an on-site farm location.

Another potential concern is the value of the manure and market changes resulting from a competitor’s ability to secure enough biomass to supply a facility.

The heavy reliance on a single producer (70% of the county total of animal-derived biomass) is also a concern, although other feedstock may be utilized in the process.

Rules and regulations regarding the transportation of animal residue products may also factor into the feasibility of this opportunity. If anaerobic digestion is utilized and drying the manure is not necessary, there may be transportation implications with the liquidity of the manure, if the digester is located off site.

3.3.2 **Bovine**

Bovine manure is the second largest source of animal biomass material in Clackamas County. It should be noted that there is an elk farm and a water buffalo farm included in the bovine category, and treated as free ranging cattle for simplicity and due to similarity in residue.

3.3.2.1 **Location**

There are 16 bovine-based CAFO’s (including one elk and one water buffalo farm) in Clackamas County. The locations of the farms are shown in Figure 13 and reflect both cattle and dairy facilities (the green marker indicates the location of the water buffalo farm). The numbers next to each marker are facility identifiers with a detailed description found in Appendix A-1.
3.3.2.2 Amount

Bovine-based biomass represents 3% of the total animal-derived biomass for the County and is much more dispersed than the poultry resource (as seen in the figure above). There are over 20,000 cattle (dairy and beef combined) according to the last census taken; CAFO animal count represents only 18% of that number (USDA, 2007). As with the chickens and other animals, a large amount of bovine not accounted for in this study leaves the possibility that the information reported herein is understated.
Table 6: Dry Tonnage of Poultry Manure Produced by Listed Address

<table>
<thead>
<tr>
<th>City</th>
<th>Dry Tons</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aurora</td>
<td>801</td>
<td>17.84%</td>
</tr>
<tr>
<td>Beavercreek</td>
<td>115</td>
<td>2.56%</td>
</tr>
<tr>
<td>Boring</td>
<td>516</td>
<td>11.49%</td>
</tr>
<tr>
<td>Canby</td>
<td>780</td>
<td>17.39%</td>
</tr>
<tr>
<td>Culver</td>
<td>83</td>
<td>1.85%</td>
</tr>
<tr>
<td>Hubbard</td>
<td>338</td>
<td>7.53%</td>
</tr>
<tr>
<td>Molalla</td>
<td>210</td>
<td>4.67%</td>
</tr>
<tr>
<td>Mulino</td>
<td>105</td>
<td>2.34%</td>
</tr>
<tr>
<td>Oregon City</td>
<td>1,170</td>
<td>26.07%</td>
</tr>
<tr>
<td>Wilsonville</td>
<td>9</td>
<td>0.19%</td>
</tr>
<tr>
<td>Woodburn</td>
<td>362</td>
<td>8.07%</td>
</tr>
</tbody>
</table>

Bovine businesses usually consist of free range operations, producing less manure and with significantly less collection ability than dairy operations. Amounts were calculated differently for free-range bovine and dairy bovines, as outlined in Appendix A-2.

The distribution of the resource is fairly diverse with regard to the companies involved. Tables 7 and 8 reflects the contributions of the CAFO’s and the relative amount of biomass produced by the type of operation (cattle versus dairy), respectively.
Table 7: Estimated Biomass Contributions of Bovine-Based CAFOs in Clackamas County

<table>
<thead>
<tr>
<th>Company</th>
<th>Biomass Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>WIL-VIEW FARMS</td>
<td>0.19%</td>
</tr>
<tr>
<td>BEAVERCREEK MEAT CO</td>
<td>2.56%</td>
</tr>
<tr>
<td>PERRIN FARMS</td>
<td>8.07%</td>
</tr>
<tr>
<td>STAEHELY BROTHERS</td>
<td>26.07%</td>
</tr>
<tr>
<td>CASCADIA FARMS, LLC</td>
<td>5.63%</td>
</tr>
<tr>
<td>FALLEN OAK JERSEYS</td>
<td>4.35%</td>
</tr>
<tr>
<td>CLOUD-CAP FARMS</td>
<td>9.94%</td>
</tr>
<tr>
<td>BENNETT’S ACRES</td>
<td>1.55%</td>
</tr>
<tr>
<td>ALBER DAIRY</td>
<td>2.32%</td>
</tr>
<tr>
<td>HOODVIEW DAIRY LLC</td>
<td>8.15%</td>
</tr>
<tr>
<td>TMK FARM</td>
<td>1.29%</td>
</tr>
<tr>
<td>AAMODT DAIRY INC</td>
<td>7.53%</td>
</tr>
<tr>
<td>LADY-LANE FARMS</td>
<td>2.34%</td>
</tr>
<tr>
<td>MAYFIELD FARMS LLC</td>
<td>17.84%</td>
</tr>
<tr>
<td>ROSSE POSSE ACRES</td>
<td>0.32%</td>
</tr>
<tr>
<td>SPRINGWATER FARMS</td>
<td>1.85%</td>
</tr>
</tbody>
</table>

Table 8: Biomass Produced by CAFOs in Clackamas County by Type of Operation

<table>
<thead>
<tr>
<th>Bovine type</th>
<th>Dry Tons (annual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef (farm)</td>
<td>221</td>
</tr>
<tr>
<td>Dairy</td>
<td>4,267</td>
</tr>
</tbody>
</table>

A further consideration to the amount of potential biomass produced in the County is facility capacity. Currently, the combined total of all cattle in Clackamas County is 76.7% of the permitted capacity. The combined total of all dairy production in the county amounts to 74.8% of the permitted capacity. Using the same theoretical 95% capacity for each category (as with poultry) can be used to show what biomass could potentially be produced if the farms were operating closer to the permitted amounts. The larger capacity would result in an increase of 1,669 annual dry tons; a 1.1% increase. Even with an increase in capacity of 20% for all bovine-based CAFO’s, which is much more than that of the chickens, the relative insignificance of the bovine contributions is clearly seen by the small gain in biomass produced.
3.3.2.3 **Availability**
Dairies interviewed for this project stated that the current bovine residues have little economic benefit to them other than being spread out onto other parts of the property as nutrients. It is unknown whether or not the majority of CAFO’s are in a similar situation as they were not interviewed. Assuming that none of the residues for the farms are being sold for use as other products, the availability should be high and relatively inexpensive.

3.3.2.4 **Seasonality/Sustainability**
Due to the nature of bovine the residue amounts are available on a consistent throughout the year.

3.3.2.5 **Assembly and Transportation**
The way that the manure is assembled depends on the type of operation and also the individual company. In many CAFO cases, the manure is scraped off a concrete slab, and piled on a regular basis. Whatever the manure collection form, the amount of time the bovine spends in a collection area will vary considerably between dairy and free-range cattle and between operations.

In considering the economic development goal of citing a facility near Canby, Molalla or Estacada, transportation is a factor. There is a concern regarding the location of a desired processing plant and the location of the resource in the case of bovine-based biomass. An increase in transportation distance very quickly decreases the economic feasibility of a biomass project. The three largest contributors of biomass (54% of bovine resource) are all in completely different parts of the County (numbers 4, 7, & 14 on the location map). There is limited opportunity to source the material to a sole processor; resulting in two possibilities:

1. The largest facilities may have enough biomass to process independently on-site; or
2. The facilities could contribute to a different, nearby, processing plant (i.e. the plant processing chicken residue).

3.3.2.6 **Issues and Concerns**
As with the poultry manure transportation, there may be regulations restricting the amount, distance and type of substance being transported.

The amount of biomass material that is left after the farm has used what it needs would further reduce the amounts available for other uses and may even be significant enough to eliminate the feasibility of the on-site processing option.
3.3.3 Equine

The equine population in the county numbers over 10,000 and is the ninth largest in the nation (Hunsberger, 2006). The estimated amount of biomass available from equine manure is still only about as much as what is available from the bovines, which are small compared to the amount available from the chickens.

3.3.3.1 Location

The location of the single equine-based CAFO in the county is shown in the figure below.

![Equine-Based CAFO Locations in Clackamas County.](image)

See Appendix A-1 Associated Number Representing Individual Farm.

3.3.3.2 Amount

The amount of equine material available is unknown since there is only one registered equine-based CAFO, and that operation contains only 12 animals, despite being permitted for 275.

The details for the amount of equine manure produced by the single CAFO are displayed in the Table 9.
Table 9: Equine CAFO Locations and Estimated Annual Dry Tons

<table>
<thead>
<tr>
<th>FARM</th>
<th>CITY</th>
<th>DRY TONS (annual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT HOOD EQUESTRIAN CENTER</td>
<td>BORING</td>
<td>16</td>
</tr>
</tbody>
</table>

Operations that contain large numbers of animals in one location are the majority of any potential resources, small farms that house a limited number of equine are not considered as significant contributors for biomass amounts. However, it has been estimated that with all of the stables and medium-sized equine facilities in the County, there could be additional quantities of manure available. The total equivalent amount of equine used to determine the overall biomass production is 3,600 (roughly a third of the County population, producing 4,842 dry tons of biomass annually and calculated using the methods explained in Appendix A-2).

3.3.3.3 Availability
The availability of the equine manure is unknown, largely due to the limited data collected. Therefore, despite the large population of equines in the County, it is difficult to determine the quantity of residue produced and its availability.

3.3.3.4 Seasonality/Sustainability
Due to the nature of animals, the residue amounts are available on a consistent basis throughout the year.

3.3.3.5 Assembly and Transportation
Assembly will depend on the facility setup. If the equines are largely in open fields, then the amount of collectible manure will be much less than if the equines are in stables. The living conditions will also determine how the manure is collected. As with the bovines, the manure will likely come from whatever is in the stalls (or concrete slab) that is collected and piled.

Uncertainty of the location and number equine throughout the County limits the ability to determine the transportation details of a potential project. Based on the limited data collected, the only option would be an on-site processing setup. Unless the business operates at a much higher capacity of animals, there is little incentive to even produce on-site.

3.3.3.6 Issues and Concerns
The key issue for the equine resource is the large discrepancy between the popularity of equines in the County and the lack of readily available resource (CAFO’s and other densely-populated operations). A lack of these type of facilities suggests that the large populations of equines is due to individual owners with only a few animals and would likely not be contributing factors of biomass material.
3.3.4 Other

“Other” is a catch-all category for the few animals that are located on a smaller number of farms. The animals included in this analysis include rabbits, hogs and goats.

3.3.4.1 LOCATION

The locations of the three different CAFO’s are shown in the Figure 15.

![Map of Clackamas County showing CAFO locations](image)

**Figure 15:** Other CAFO Locations in Clackamas County: Hogs (purple), Rabbits (yellow) and Goats (blue).

See Appendix A-1 Associated numbers Representing Individual Farms.

3.3.4.2 AMOUNT

The overall contributions from this category represent less than 0.5% of the total resource available from animal manure. The actual amount of biomass available from the collection of different animals is 504 dry tons, which accounts for the swine residue. There was not sufficient data available to compute the amounts available from goats and rabbits, therefore their contributions have been omitted. Assumptions used for the hog biomass yield is detailed in Appendix A-2.

The farm, location and amount of biomass calculated for the “Other” animals are shown in Table 10.
Table 10: Clackamas County Other CAFO Annual Biomass Production

<table>
<thead>
<tr>
<th>FARM</th>
<th>CITY</th>
<th>DRY TONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BISCHOF, DON</td>
<td>WILSONVILLE</td>
<td>504</td>
</tr>
<tr>
<td>GOLDIN ARTISAN GOAT</td>
<td>MOLALLA</td>
<td>-</td>
</tr>
<tr>
<td>CHEESE LLC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WEISDORFER FUR FARM</td>
<td>BORING</td>
<td>-</td>
</tr>
</tbody>
</table>

3.3.4.3 Availability
Facilities were not contacted and thus the current availability of the resources is not known.

3.3.4.4 Seasonality/Sustainability
Due to the nature of the animals the residue amounts are available and consistent throughout the year.

3.3.4.5 Assembly and Transportation
Assembly of the three different types of operations is likely very different. Where the rabbit farm is dealing with closely contained (caged) animals and easily attainable residue, the hogs and goats each have some pasture.

As with the bovine facilities, these three CAFO’s are very spread out as seen in the map of locations. Without any nearby alternative facilities to utilize the residue, the only potentially feasible option is for on-site processing.

3.3.4.6 Issues and Concerns
The unknown availability of resources leaves questions to be answered. Also, the actual production for the goats and rabbits (and other fur bearing animals) is not accounted for due to insufficient data on the subject.
4.0 Data Analysis and Findings

4.1 Element 1: Biomass Assessment

This research project had two primary research goals:

Research Goal 1: Quantify Biomass Availability in Clackamas County
Research Goal 2: Identify Strategies for Accumulation and Supply for Utilization Options (such as CHP operations)

**Research Goal 1** is reported in this section, 4.0 Data Analysis and Findings. Data is provided for the three categories of biomass: forest, agricultural, and animal. The specific research provided answers to the following questions, including:

1. Available quantity?
2. Where is supply located?
3. Sustainability of available supply?
4. Seasonality of supply?
5. Assembly and transportation?
6. Current use?

The aggregate biomass resource identified in the County is equivalent to about 39.5 MWe of energy.

There are a number of distinct resources available that will require a variety of technologies to fully utilize the available energy potential. These technologies are described in the following section, Element 2.

**Research Goal 2** findings are reported in Element 2: Types of Facilities, Power, and Cost in the following pages.

**Forest Residues**

Clackamas County has 759,000 acres of forest land, of which 400,000 acres are public forests and approximately 300,000 acres are private lands. Nearly half of the private lands are owned by Weyerhaeuser.

We have estimated that there are approximately 300 cu. ft. of residue per acre; 780 dry tons per year can yield 1 megawatt of energy.

**Timber Land-Private**

Private timber lands comprise about half of the resource.
Large industrial forest owners do not have available biomass. Companies use all of their residues in internal operations. Weyerhaeuser is considering converting cellulose to ethanol.

Small timber lands are generally “mom and pop” acreages where timber processing is not the primary income-generating activity.

Biomass utilization operations on private timber land must be cost effective. There is currently no labor force or equipment in place for the small acreages.

Small acreages are near Estacada and while there is no steady biomass, when a tree must be removed, the entire tree is available. One idea for a small business start-up could be a contractor to gather any residue.

**Timber Land-Public**

The 400,000 acres of public timber land is not currently available for resource utilization, however approximately 113,000 dry tons per year could be collected from overstock. This amount has been consistent for the past 20 years.

**Christmas Trees**

There are approximately 5,000 tons per year of woody biomass, which could provide 5.5 megawatts of energy. The Christmas tree operations are dispersed, and collection may be an issue. The residue is piled and the current practice is to burn the trimmings and cull trees. This can provide 0.05 MWe of energy.

A potential strategy is a scalable plant in the Colton, Molalla or Estacada area. Residues could be processed into briquettes for domestic and export sales, provide CHP for schools or other uses, or produce synthetic natural gas. A demonstration plant could “prove the model.”

Smaller producers could operate a co-op with incentives and funding if there is interest in this type of collaboration.

**Forest Residues Analysis**

**Timber Land-Public**

On the surface, the large 400,000 acres of public forest within the County suggests that forest residues and harvested materials should be a significant resource for utilization as an energy source. However federal policy provides that only a small percentage of the forest lands are available for use as part of the US National Forest System. There are approximately 400,000 acres of public timber land which are open to resource utilization. However, current owners already utilize this resource.
On national forest lands, there are approximately 113,000 dry tons of stock biomass per year that could be collected on the basis of overstocked material which has been consistently available for the past 20 years. This overstock resource is equivalent to approximately 89 MW of electricity (~65 persons), enough to power a small town. Accessing this resource will require a change in federal policy.

Timber Land-Private

The private timber lands are made up of two large tracts of corporate holdings. These companies take complete responsibility for the management and utilizations of the resource. There are a number of smaller private holdings within the region, which are managed by "mom-and-pop" owners. These holdings are dispersed and generally too small to significantly contribute to biomass-based energy in the County.

A potential strategy for small timber land holders could be the formation of a cooperative venture for production of pelletized or briquetted wood. The cost associated with this type of venture for a moderate-sized pelletization operation ranges between $150,000-$250,000 for the equipment.

Christmas Trees

There are approximately 5,000 tons per year of Christmas tree residues that are distributed in the growing areas. This quantity of resource, by itself, is too small for a commercial power production operation, however, these residues could be converted into wood pellets for use in on-site heat production or processing for sale.

Agricultural Residues

For purposes of this study, agricultural resources are categorized as farms or nurseries/greenhouses, depending on how the operation is registered with the state.

Farms

Based on the Oregon Agricultural Census (USDA, 2007) farms have diversified their productions to include berries and fruits, as well as bovine, hazelnuts or other agricultural products.

Table 11: Summary of Agricultural Residue Resources and Energy Equivalents

<table>
<thead>
<tr>
<th>Source</th>
<th>Acres</th>
<th>Residue (Dry Tonnage/year)</th>
<th>Energy Equivalent (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery and Greenhouse</td>
<td>12,859</td>
<td>276</td>
<td>0.03</td>
</tr>
<tr>
<td>Grass seed</td>
<td>9,767</td>
<td>17,190</td>
<td>1.81</td>
</tr>
<tr>
<td>Hay and Grains</td>
<td>25,927</td>
<td>157.8</td>
<td>0.0172</td>
</tr>
<tr>
<td>Berries and Small Fruits</td>
<td>3,457</td>
<td>30</td>
<td>0</td>
</tr>
</tbody>
</table>
Overall, farm residues are not sufficient as materials, are in dispersed locations, and most of the residual material is used for composting.

There is interest in providing biomass for energy production; however there is a need for collection of the residual material.

**Nurseries and Greenhouses**

Nurseries and greenhouses are considered as a single category by the Oregon Association of Nurseries. Nurseries produce mostly shrubs and greenhouses sell “starts” for the domestic market.

The material is collected and stored twice annually, then burned.

A potential strategy for this residual material might be a bio-digester, possibly located in the Boring area that utilizes residues from local farms, nurseries and greenhouses.

**Grass Seed**

Another placement could be a bio-digester in the Molalla-Canby area for grass seed residue conversion to methane, with additional residues available from nearby counties in the Mid-Willamette Valley.

**Woody Biomass**

Pelletized wood for CHP, similar to a project with the Estacada School District, or processing for sale or export is feasible. Another potential is gasification to produce syngas for a gas turbine or to fire steam boilers.

**Agricultural Residues Analysis**

The agricultural residues from vegetables, nuts, fruits and berries produce insufficient quantities to be economically viable.

**Animal Residues**

Clackamas County has a number of CAFO’s that would be able to provide substantial quantities of residue that could be utilized in a number of ways. A summary of the animal residue produced in the County is shown in the Table 12.
Table 12: Summary of Animal Residue Resources and Energy Equivalents

<table>
<thead>
<tr>
<th>Residue</th>
<th>Amount (Tons per year)</th>
<th>Energy Equivalent MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry Litter</td>
<td>144,000</td>
<td>15.17</td>
</tr>
<tr>
<td>“Bovine” Manure</td>
<td>4,400</td>
<td>0.42</td>
</tr>
<tr>
<td>Equine</td>
<td>4,800*</td>
<td>0</td>
</tr>
<tr>
<td>Other**</td>
<td>504</td>
<td>0.</td>
</tr>
</tbody>
</table>

*Based on assumptions for equine population and residue availability
**Other includes hogs, rabbits and goats

Potential Strategies for Animal Residues

Although the potential strategies are broken down into various animal groups, they are not exclusive. For example, poultry and bovine residues could both be used in the same processing facility.

Poultry Litter

An anaerobic digester plus gasifier, potentially located in the Molalla area, could produce syngas that could be used for heating and electricity production. Co-products include fertilizer, minerals and heat for schools and other public buildings. Combining digestion with gasification yields triple the output of digestion alone.

Bovine Residues

Large dairies could convert residues on-site with anaerobic digesters to produce methane. A co-op may be developed in the Canby and Molalla areas using the same technology.

Equines Plus “Other”

The equine and “other” residues could possibly contribute to other facilities. For example, manure from the largest equine CAFO could be combined with the residue from nearby rabbit and hog residues from the Wilsonville area, or could likewise be used in nearby poultry operations.

Animal Residues Analysis

Poultry Litter

Poultry litter is the largest single resource in the county for the production of energy from biomass, in addition to an opportunity for a related fertilizer production facility.
Bovine Residues

There is insufficient bovine manure to justify a separate digestion – gasification system; however, operating a combined facility or co-op could prove to be economically viable.

Equines Plus “Other”

The equine and “other” category is too small to be considered as the animals are not housed in a manner that provides for ready collection of residues.
4.2 Element 2: Modes of Energy Production

4.2.1. Direct Combustion

Biomass particles typically burn easily in a variety of burner designs from fixed grates, moving beds or suspension burners. A potential danger in burning very small biomass particles is quick combustion resulting in an explosion.

4.2.2. Burning Pelletized Woods or Straws

Pelletized biomass retains the moderately high heating value of the woody fuel with a high density, easily moved fuel. Pellet stoves have been gaining in popularity as sources for heat and cooking.

There is an active market for compressed pellets and briquettes as a fuel source.

4.2.3. Gasification Methods

Gasification is termed as a thermo-chemical process. Essentially, biomass materials when heated to high temperatures (>450° F), in the absence or reduced amount of oxygen, will partially or completely decompose into smaller molecules ranging from organic tars, organic acids, or small molecules, including methane, hydrogen, carbon monoxide and carbon dioxide. The specific decomposition products depend on the temperature, heating rate and the degree of oxygen exclusion.

A biomass gasifier is a device designed to convert biomass into a combustible fuel gas, called syngas (synthetic natural gas). Depending on the gasifier design, the syngas will have a heating value of 250 Btu per cubic foot. Natural gas, by comparison, has a heating value of about 550 Btu per cubic foot.

For example, syngas can be used directly in an internal combustion engine, a gas turbine, or a steam boiler to produce electricity or for other energy purposes. Syngas can be transported for small distances (1-3 miles) by pipeline, however the presence of carbon dioxide and carbon monoxide prevent use of high pressure gas pipelines.

Gasification processes are sensitive to the amount of moisture present; as moisture above 15-20% makes it difficult to maintain the high temperatures needed for high-yield gasification.

4.2.3.1 Anaerobic Digestion

Plant biomass can be converted into a mixture of flammable methane and carbon dioxide using a complicated consortium of micro-organisms found in the paunch of ruminant animals (cattle, horses, goats, etc.).
Anaerobic digestion is a process that begins with the fermentation of natural sugars or starches found in fruits, vegetables, and in forage. Also present are organisms that convert some woody-like materials into sugars. The sugars are then converted further to methane and carbon dioxide. The bas, bio-gas, is a mixture of 60% methane and 40% carbon dioxide. Bio-gas is a fuel used worldwide.

Water is essential to bio-gas production. For this reason, anaerobic digestion is a method of choice for getting energy from animal manures. The process can be managed to provide a consistent supply of fuel gas and the residual biomass solids can be recovered and burned, gasified or used as fertilizer. Gasification of digestor solids retains the fertilizer minerals as a solid fertilizer.

4.2.3.2 **Chemical Conversions of Biomass**

Biomass materials are primarily made up of carbon, hydrogen, and oxygen with very predictable chemical properties. There is a vast array of technologies to convert biomass hydrocarbons into industrial organic chemicals, including petrochemical analogs. Not included in the evaluation are chemicals derived from protein products and products from fats and oils.

4.3 **Element 3: Policy Implications**

The policy context is particularly complex, constantly changing and was beyond the scope of this project.
4.4 Element 4: Strategies and SWOT Analysis

Potential strategies are shown in **bold** in Table 13. *Please note that blank cells reflect no comment(s) for that category.*

**Table 13: SWOT Analysis: Utilization Options**

Forest Residues • Agricultural Residues • Animal Residues

**Forest Residues**

<table>
<thead>
<tr>
<th>Category</th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Timberland</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private - Small</td>
<td></td>
<td>Make more money if sell residue as firewood (cords)</td>
<td>Excess wood could be converted into pellets (Seen as a weakness.)</td>
<td></td>
</tr>
<tr>
<td>Private - Large</td>
<td></td>
<td>No residue available; used internally</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stewardship Contracts 35,000 tpy</strong></td>
<td>Large amounts</td>
<td>Federal policy restraint</td>
<td>Environmental Safety</td>
<td>Environmental Concerns</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Jobs</td>
<td>Public opinion</td>
</tr>
<tr>
<td>Christmas Trees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Christmas Trees</td>
<td>Dependable resource</td>
<td>Collected issue</td>
<td>Briquettes</td>
<td></td>
</tr>
<tr>
<td><strong>Possible Estacada Scalable Facility</strong></td>
<td>Piled materials</td>
<td>Dispersed sites</td>
<td>CHP</td>
<td>Syngas</td>
</tr>
<tr>
<td></td>
<td>Location</td>
<td></td>
<td>Recycling program</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Business development sites</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Animal Residues**

<table>
<thead>
<tr>
<th>Category</th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Poultry Litter</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Poultry</strong></td>
<td>Intrinsic value of residue</td>
<td>Cost of assembly</td>
<td>Biodegradable deicer product</td>
<td>Ordinance re transport of septic material</td>
</tr>
<tr>
<td></td>
<td>Dependable, concentrated resource</td>
<td>Current use as fertilizer</td>
<td>Jobs</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>One primary</td>
<td>CHP for schools</td>
<td></td>
</tr>
</tbody>
</table>
### Possible Molalla Anaerobic digester plus gasification facility

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retains fertilizer value</td>
<td>Not enough biomass</td>
<td>Multi-county collaboration</td>
<td>Specific technology need</td>
</tr>
<tr>
<td>Scaleable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Products</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology available</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Bovine Residue

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated technology, resource, use</td>
<td>Small number of dairies</td>
<td>Jobs</td>
<td>NIMBY</td>
</tr>
<tr>
<td>Technology available</td>
<td>Low intrinsic value of residue</td>
<td>Multiple installations</td>
<td>Low intrinsic value</td>
</tr>
</tbody>
</table>

### Equine + “Other” Residue

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>County initiative: reduce school costs via CHP</td>
<td>Dispersed, small, isolated locations</td>
<td>Jobs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collection issue</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Agricultural Residues

Several nursery operators expressed fear that the wood chips would be captured by biomass facility.

<table>
<thead>
<tr>
<th>Category</th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Molalla Grass Seed Residue Biodigester</td>
<td>Scalable</td>
<td>Require Co-op</td>
<td>Fertilizer for farms use or sale</td>
<td>Fear of materials being taken</td>
</tr>
<tr>
<td></td>
<td>Small, possible</td>
<td>Small farms Collection system</td>
<td>Can benefit farmers and create jobs</td>
<td></td>
</tr>
<tr>
<td>Nurseries/Greenhouses Residue</td>
<td>Not applicable</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farms plus Nurseries/Greenhouses Residues</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible Boring Biodigester Facility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.0 Recommendations

To proceed, Clackamas County needs a Full Feasibility Study to explore economic benefits of the various courses summarized in this preliminary study. The full study should include:

- Economic Benefits Analysis
- Economic/Political Incentives
- Environmental Issues Analysis
- Policy Issues
- Stakeholder Analysis
- Local and State Experts’ Participation (e.g. Mike Bondi and Jamie Johnk, Matt Krumenauer)
- Identification of Potential Facility Sites and Development Strategies

From April to June of 2010, the Project Team assessed the quantity of agricultural waste residues and the potential energy and other bi-products that could be generated if it was feasible to accumulate and process the waste. The team identified five areas of opportunity for Clackamas County, during this preliminary study phase. This report provides possible directions for the county to pursue with more in-depth and comprehensive analysis or other economic development efforts.

1. Based on the amount of forest waste and its energy potential, the County should consider engaging in a public awareness campaign related to the economic benefits and energy potential of forest thinning, as well as the risks and security impacts of overstocked national forest lands that result from historic fire suppression and reduced harvest. The objective is to inform the public about how forest waste from national lands could be used for energy production, and the potential impacts of excessive fuel stocks.

2. Forest thinning could support Combined Heat and Power (CHP) applications for public, industrial, commercial or residential districts or buildings. We estimate the energy potential to be approximately 10 MWe.

3. Based on the preliminary findings in this study, poultry litter has the potential to provide approximately 10 MWe of capacity. Molalla and vicinity is strategically located to become an energy power hub.

4. Regulatory limits on burning grass materials offer an opportunity to monetize the residues as energy products. This is an opportunity for the County, and merits exploration through regional partnerships with surrounding counties.
5. Smaller sources of animal waste have the potential for on-site power generation or for aggregation if other barriers can be overcome. There is potential for power and fertilizer in the Molalla area and possibly the Boring area by using anaerobic digestion to produce biogas and residual co-products.
Bibliography


USFS. (2008). *FIDO*. Forest Inventory and Analysis Database.
Appendix A-1 Timberland Details and Calculations

Clackamas County encompasses 1,196,800 acres, 74% of which, or 896,462 acres, are forest land. Of this forestland 84% (759,932) acres is not in reserved status, and thus considered timberland. A slight majority of this land (55%) is federally owned (417,718 acres). Only 1% of Clackamas County’s timberland is state owned (7,404 acres).

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Not reserved (b)</th>
<th>Reserved (1)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unknown/Not reserved (c1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>National Forest (11)</td>
<td>417,716/11.1%</td>
<td>131,514/22.8%</td>
<td>549,230/8.7%</td>
</tr>
<tr>
<td>National Grassland (12)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other National Forest (13)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>National Park Service (21)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bureau of Land Management (22)</td>
<td>6,078/104.8%</td>
<td>6,018/96.0%</td>
<td>12,096/192.2%</td>
</tr>
<tr>
<td>Fish and Wildlife Service (23)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Department of Defense or Energy (24)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other Federal (25)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>State (31)</td>
<td>7,605/102.0%</td>
<td>-</td>
<td>7,605/102.0%</td>
</tr>
<tr>
<td>Local (county, municipal, etc.) (32)</td>
<td>7,604/104.1%</td>
<td>-</td>
<td>7,604/104.1%</td>
</tr>
<tr>
<td>Other non federal lands (33)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Undifferentiated private (45)</td>
<td>322,366/14.5%</td>
<td>-</td>
<td>322,366/14.5%</td>
</tr>
<tr>
<td>Totals</td>
<td>799,822/15.5%</td>
<td>112,529/22.1%</td>
<td>912,351/17.6%</td>
</tr>
</tbody>
</table>

*Figure 16: Clackamas County Forest Land by Ownership Class and Reserved Status. (USFS, 2008)*

Stocking condition is a measure of the tree density relative to optimal density. Stocking conditions are defined by the Forest Inventory Analysis National Program of the USFS as follows:

- **Overstocked** (100+ % of full stocking)
- **Fully stocked** (60 – 99%)
- **Medium stocked** (35 – 59%)
- **Poorly stocked** (10 – 34%)
- **Non-stocked** (0 – 9%)

*Figure 17: Clackamas County Timberland by Ownership Class and Stocking Condition. (USFS, 2008)*
As of 2008, 5% of the timberland acreage, 36,172 acres, is in an overstocked condition as shown in Table 17. The largest portion is privately owned lands (23,213 acres). Adding the Overstocked and Fully stocked acreage together, includes 49% of the timberland, of which 233,888 acres are federal lands. Notably, 30,148 acres are non-stocked and need to be restricted from any further calculations.

Complex data needs to be assembled to deduce any reasonable amount of biomass supply. Such factors as slope restrictions, timber harvest regulations, Fire Regime Condition Class, and roadside accessibility play an important part in a biomass feasibility study. Additional considerations such as economic attraction to an area (usually a supply forest must contain more than 300 ft$^3$ of merchantable timber per acre) and what will become of the merchantable timber is outside the scope of this study. The Oregon Forest Resources Institute Study of 2006 includes specific data about three counties with similar topography to Clackamas County (Douglas, Jackson, and Josephine), and their procedures will be used as a primary guideline.

Throughout this study priority was established to insure comparative measures were reasonably accurate. For example, Douglas County maintains that 59% of their available timberland is either state or federally owned and Jackson County is 60%; likewise 55% of Clackamas County’s timberland is in that realm.

Of the 759,932 acres of timberland, 30,148 were immediately disqualified as they were non-stocked lands. In order to filter out low fire hazard areas, typically those that are poor or medium stocked the acreage was reduced by 49%.

Inaccessible regions were deducted. Counties with infrastructure and forest systems similar to Clackamas County average a 29% deduct for these regions. The 254,000 acres remaining are used as the base case, representing all acreage potential for biomass utilization. Approximately 30% of this acreage has a slope of 30 degrees or higher, making timber harvesting more difficult and less cost effective, however still possible with specialized techniques.

Comparing the base case acreage with Douglas, Jackson, and Josephine Counties, who averaged 20.83 BDT per acre on this remaining land, Clackamas could remove 5,290,820 BDT from their timberlands. Further calculations are needed however, as much of this product is higher value timber than typically used for biomass. Of this 254,000 acre base case, 220 million ft$^3$ would be merchantable and the remaining 2,724,000 BDT would be suitable for biomass. Considering the 30% deduct for slope restrictions, brings these to 155 million ft$^3$ of merchantable timber and 1,906,838 BDT. Spreading the removal over 20 years and assuming zero growth, yields nearly 100,000 BDT/year for biomass utilization.
According to (McNeil Technologies, Inc., 2003), “Forest biomass availability is affected by a variety of factors. Some biomass must be left on-site to reduce soil erosion and compaction, conserve soil nutrients and retain dead standing and fallen trees for wildlife habitat. Slope constraints also limit biomass recoverability.

“Yield assumptions used to estimate forest biomass generation … are consistent with actual biomass removals from fuels reduction and thinning projects after the projects have satisfied all planning requirements, management practice guidelines and laws related to soil conservation, wildlife habitat, and forest productivity. It should be recognized that biomass availability is ultimately site-specific.”
### Appendix A-2 CAFO Details

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Facility City</th>
<th>Animal Type</th>
<th>Number Permitted</th>
<th>Total Juvenile</th>
<th>Total Adolescent</th>
<th>Total Adult</th>
<th>Total Animal Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 WILLOWFARMS</td>
<td>WILSONVILLE</td>
<td>Beef Cattle Ranching and Farming</td>
<td>800</td>
<td></td>
<td>-</td>
<td>150</td>
<td>500</td>
</tr>
<tr>
<td>2 BEAVERCREEK MEAT CO</td>
<td>BEAVERCREEK</td>
<td>Cattle Feedslots</td>
<td>800</td>
<td>-</td>
<td>-</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>3 PERRIN FARMS</td>
<td>WOODBURN</td>
<td>Dairy Cattle and Milk Production</td>
<td>400</td>
<td>-</td>
<td>180</td>
<td>120</td>
<td>300</td>
</tr>
<tr>
<td>4 STAHMELY BROTHERS</td>
<td>OREGON CITY</td>
<td>Dairy Cattle and Milk Production</td>
<td>2,000</td>
<td>225</td>
<td>220</td>
<td>480</td>
<td>900</td>
</tr>
<tr>
<td>5 ASCIDA FARMS, LLC</td>
<td>CANBY</td>
<td>Dairy Cattle and Milk Production</td>
<td>130</td>
<td>15</td>
<td>13</td>
<td>30</td>
<td>135</td>
</tr>
<tr>
<td>6 FALLON JOHNS</td>
<td>MOLALLA</td>
<td>Dairy Cattle and Milk Production</td>
<td>170</td>
<td>25</td>
<td>22</td>
<td>82</td>
<td>132</td>
</tr>
<tr>
<td>7 CLOUD-CAP FARMS</td>
<td>BORING</td>
<td>Dairy Cattle and Milk Production</td>
<td>425</td>
<td>65</td>
<td>22</td>
<td>195</td>
<td>285</td>
</tr>
<tr>
<td>8 BENNETT &amp; AGERS</td>
<td>BORING</td>
<td>Dairy Cattle and Milk Production</td>
<td>60</td>
<td>15</td>
<td>-</td>
<td>30</td>
<td>45</td>
</tr>
<tr>
<td>9 ALBER DAIRY</td>
<td>CANBY</td>
<td>Dairy Cattle and Milk Production</td>
<td>103</td>
<td>15</td>
<td>7</td>
<td>45</td>
<td>67</td>
</tr>
<tr>
<td>10 MOODYDAIRY LLC</td>
<td>CANBY</td>
<td>Dairy Cattle and Milk Production</td>
<td>350</td>
<td></td>
<td>180</td>
<td>178</td>
<td>258</td>
</tr>
<tr>
<td>11 TJK FARM</td>
<td>CANBY</td>
<td>Dairy Cattle and Milk Production</td>
<td>50</td>
<td>10</td>
<td>10</td>
<td>32</td>
<td>42</td>
</tr>
<tr>
<td>12 AMMERDAIRY INC</td>
<td>HUBBARD</td>
<td>Dairy Cattle and Milk Production</td>
<td>290</td>
<td>20</td>
<td>92</td>
<td>36</td>
<td>247</td>
</tr>
<tr>
<td>13 MURPHY LANE FARMS</td>
<td>MULLINO</td>
<td>Dairy Cattle and Milk Production</td>
<td>120</td>
<td>12</td>
<td>12</td>
<td>45</td>
<td>69</td>
</tr>
<tr>
<td>14 PAZIFIELD FARMS</td>
<td>ALPERA</td>
<td>Dairy Cattle and Milk Production</td>
<td>900</td>
<td></td>
<td>-</td>
<td>900</td>
<td>900</td>
</tr>
<tr>
<td>15 ROSE ROSE AGERS</td>
<td>MOLALLA</td>
<td>Pig Farming</td>
<td>90</td>
<td>61</td>
<td>-</td>
<td>61</td>
<td>70</td>
</tr>
<tr>
<td>16 BISCHOF, DON</td>
<td>WILSONVILLE</td>
<td>Hog and Pig Farming</td>
<td>5,611</td>
<td>-</td>
<td>3,067</td>
<td>3,067</td>
<td>3,067</td>
</tr>
<tr>
<td>17 WILLIAMS EGG FARMS LLC</td>
<td>MOLALLA</td>
<td>Chicken Egg Production</td>
<td>1,000,000</td>
<td>1,020,000</td>
<td>1,020,000</td>
<td>1,020,000</td>
<td>1,020,000</td>
</tr>
<tr>
<td>18 WILLIAMS EGG FARMS LLC</td>
<td>CANBY</td>
<td>Chicken Egg Production</td>
<td>370,000</td>
<td>214,800</td>
<td>240,330</td>
<td>240,330</td>
<td>1,020,000</td>
</tr>
<tr>
<td>19 WILLIAMS EGG FARMS LLC</td>
<td>CANBY</td>
<td>Chicken Egg Production</td>
<td>95,000</td>
<td></td>
<td>85,700</td>
<td>85,700</td>
<td>85,700</td>
</tr>
<tr>
<td>20 WILLIAMS EGG FARMS LLC</td>
<td>WOODBURN</td>
<td>Chicken Egg Production</td>
<td>89,000</td>
<td>19,700</td>
<td>-</td>
<td>19,700</td>
<td>19,700</td>
</tr>
<tr>
<td>21 WILLIAMS EGG FARMS LLC</td>
<td>CANBY</td>
<td>Chicken Egg Production</td>
<td>74,500</td>
<td></td>
<td>35,200</td>
<td>35,200</td>
<td>35,200</td>
</tr>
<tr>
<td>22 MULLA Poultry</td>
<td>MOLALLA</td>
<td>Broilers and Other Meat Type</td>
<td>73,500</td>
<td></td>
<td>85,400</td>
<td>85,400</td>
<td>85,400</td>
</tr>
<tr>
<td>23 OAK GROVE POULTRY INC</td>
<td>MOLALLA</td>
<td>Broilers and Other Meat Type</td>
<td>135,000</td>
<td></td>
<td>131,000</td>
<td>131,000</td>
<td>131,000</td>
</tr>
<tr>
<td>24 HEIRMAN, ED &amp; LISA</td>
<td>OREGON CITY</td>
<td>Broilers and Other Meat Type</td>
<td>88,000</td>
<td></td>
<td>75,000</td>
<td>75,000</td>
<td>75,000</td>
</tr>
<tr>
<td>25 BEAR CREEK</td>
<td>CANBY</td>
<td>Broilers and Other Meat Type</td>
<td>200,000</td>
<td></td>
<td>139,500</td>
<td>139,500</td>
<td>139,500</td>
</tr>
<tr>
<td>26 MOLALLA POULTRY INC</td>
<td>MOLALLA</td>
<td>Broilers and Other Meat Type</td>
<td>210,000</td>
<td></td>
<td>155,000</td>
<td>155,000</td>
<td>155,000</td>
</tr>
<tr>
<td>27 D &amp; B POULTRY</td>
<td>CANBY</td>
<td>Broilers and Other Meat Type</td>
<td>70,000</td>
<td></td>
<td>50,000</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>28 GOLDEN ARTISAN GOAT CHEESE LLC</td>
<td>MOLALLA</td>
<td>Goat Farming</td>
<td>30</td>
<td>13</td>
<td>-</td>
<td>14</td>
<td>27</td>
</tr>
<tr>
<td>29 PINEWOOD EQUESTRIAN CENTER</td>
<td>BORING</td>
<td>Horses and Other Equine Production</td>
<td>275</td>
<td></td>
<td>-</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>30 WEISCHER FUR FARMS</td>
<td>BORING</td>
<td>Fur-Bearing Animal and Rabbit</td>
<td>23,010</td>
<td>10,000</td>
<td>2,300</td>
<td>12,300</td>
<td>12,300</td>
</tr>
<tr>
<td>31 SPRINGWATER FARMS</td>
<td>CULVER</td>
<td>Water Buffalo</td>
<td>-</td>
<td>62</td>
<td>348</td>
<td>406</td>
<td>406</td>
</tr>
</tbody>
</table>

* assumes 87% adult and 13% adolescent
Appendix A-3 Biomass Quantity Assumptions

The amount of biomass available from a given source was determined using the same methodology as the Biomass Inventory report done by Washington State University (Mark Fuchs, 2005). We identified any deviations from the methodology in our calculations. For example, there was actual data obtained that separated juveniles from adults (see Appendix A-1) and the assumptions (percentages) used to estimate those numbers below were replaced with actual numbers. This adjustment to the age-based assumptions is true for all of the animals because of the data. One other difference consistent throughout all the animal analysis is that the animal quantities were obtained from the Oregon Department of Agriculture.

**Dairy Manure**

State Total – 457,032 dry tons

**Biomass Data Collection**

Dairy manure values were obtained by first taking the average county production for the combined total of milkers and calves for the years 2000-2003 and sub-dividing this total into 87% milkers and 13% calves (WASS, 2004). Then, dry manure values of 13.1 lbs/cow day and 3.66 lbs/cow day for the respective milkers (1,200 lbs) and calves (330 lbs) were multiplied to the sub-category totals and added to get the overall production of dry manure (USDA, 1985). An 82% collection availability factor was used for the state and its preponderance of medium to large confined animal operations (Jaycor, 1990).

The final calculation was \( \frac{((\text{county total} \times 0.87) \times 13.1 \times 365)}{2000} + \frac{(\text{county total} \times 0.13) \times 3.66 \times 365}{2000} \times 0.83 \).

**Data Collection Concerns and Comments**

Bedding was not inventoried in this report as most of the bedding would either be from inorganic nature like sand or from an organic recyclable that has already been counted in the inventory like straw, wood chips or composted fibrous solids.

For simplicity, the elk and water buffalo were grouped in as cattle and calculated in the same matter as shown below for cattle.
The equine manure collection rate and the manure production per day were used as in assumptions from the Washington State University Study. However, the equine correction factor was used differently, as explained in the Equine section.
Horse Manure

State Total~ 407,160 dry tons

Biomass Data Collection
Horse manure values were obtained by applying King County findings to the 2002 USDA NASS Washington State county horse data (King County, 2004; NASS, 2004). King County characterized the horse waste situation within their county through a statistical analysis of a county-wide survey. Their findings estimated the county horse population to be around 20,000 which was four times higher than that reported by NASS in the 2002 census. Further validation of the need for increasing the NASS horse numbers came from personal communications with Snohomish County (Bobbi Lindenmuder, Snohomish CD) which echoed the existence of a large number of hobby farms and horse farms that far exceed that stated by NASS and which potentially could be higher than the previously mentioned four multiplication factor. Thus, county wide NASS horse numbers were increased by a factor of 4 and then converted into manure values by assuming 11 lbs dry manure/horse day, 22% solids content, and a collection rate of 67% (King County, 2004).

The final calculation was (# of horses/county from NASS x 4 x 11.0 x 0.67)/2,000

Data Collection Concerns and Comments
Bedding was not inventoried in this report as most of the bedding would be from an organic recyclable that has already been counted in the inventory like straw, wood chips or composted fibrous solids. Of most concern is the lack of data on a county, state and national level in regards to horse numbers. King

Swine Manure

State Total~ 13,632 dry tons

Biomass Data Collection
Swine manure values were obtained by finding the average number of pigs per county over the years 1999-2003 (WASS, 2004) and then multiplying this by a manure production factor of 0.9 lbs/swine day assuming an average swine weight of 150 pounds (USDA, 1983). Lastly, the manure total was assumed 100% collectable (Jaycor, 1990).

The final calculation was (# of swine/county x 0.9 x 365)/2000

Data Collection Concerns and Comments
No particular concerns exist in regards to the parameters used for the collection of this biomass data.
Poultry Manure

State Total~ 784,577 dry tons

Biomass Data Collection
Poultry manure values were obtained by finding the total amount of manure for both broilers and layers and adding them together. Broiler chicken numbers were determined by taking the state yearly production and dividing it amongst the known production percentages for the counties (Washington Fryer Commission, 2004). Broiler manure was determined by using 2 pounds as the average weight of a broiler across its eight week life span (56 days) and applying a manure production factor of 0.35 lbs dry manure/day for this weight broiler (USDA, 1985). Layer chicken numbers were obtained from NASS 2002 county level census and then multiplied by a manure production factor of 0.53 lbs dry manure/day assuming an average weight of 4 pounds (NASS, 2004, USDA, 1985). Lastly, the manure total was assumed 80% collectable (Jaycor, 1990).

The final calculation is \[ \left( \frac{\text{egg layers} \times 0.53 \times 365}{2000} \right) - \left( \frac{\text{broilers} \times 0.35 \times 56}{2000} \right) \times 0.80 \]

Data Collection Concerns and Comments
Poultry litter products other than the manure itself were not inventoried in this report because like the other animal beddings it was believed that the majority of the bedding was from recycled organic material that is already being counted in the inventory.
Additional Calculation Factors:

- The amount of biomass available from a given source was determined using the same methodology as the Biomass Inventory report done by Washington State University (Mark Fuchs, 2005). We provided explanation on any deviations on the methodology in our calculations. For example, there was actual data obtained that separated juveniles from adults (see Appendix A-1) and the assumptions (percentages) used to estimate those numbers below was replaced with actual numbers. This adjustment to the age-based assumptions is true for all of the animals because of the data. One other difference consistent throughout all the animal analysis is that the animal quantities were obtained from the Oregon Department of Agriculture.

- Acreage of Nursery stock * 1 dry ton/32.5 acres (this is from interview)

- For wood assumed amount of 50% moisture.

- Calculations were based on interviews conducted then using the information on tree trappings from the WSU Report.

## Grass Seed Straw

**State Total~ 134,640 dry tons**

**Biomass Data Collection**

Grass seed straw residue values were obtained by averaging and adding the county production of bluegrass, alfalfa and other seed crops in terms of acres for the years 2000-2003 (WASS, 2004). The amount of sustainable residue was determined by using a ratio of 2.2 tons residue per acre planted (Johnston, 2004). A moisture content of 20% for grass seed crop residue was used to determine a final dry biomass (Johnston, 2004).

*The final calculation was \(\sum\)average total acres for seed crops) x 2.2 x 0.80

**Data Collection Concerns and Comments**

The use of this flat residue factor is again potentially not taking into account the varied moisture in the fields across the state and as such some areas might be inventoried as collecting too much residue while others would be collecting too little. In addition the residue factor was taken from a study about bluegrass seed and applied to other seed crops such as alfalfa.

Acreage of Grass seed: For simplicity, the calculations were modeled from the WSU report.
Berry Pomace

State Total~1,938 dry tons

Biomass Data Collection
Berry pomace values were obtained by averaging the county level production of berries for the years 1999-2003 (WASS, 2004). Berries inventoried include blueberries, raspberries, red strawberries, and cranberries. It was assumed that 90% of the berry production is used for processing (WASS, 2004) and the average solid waste produced from the berry processing was roughly 6% of the wet mass of the raw berry being processed (NRC, 1983). A moisture level of 37.5% was used to determine total dry matter (NRC, 1983).

The final calculation was \((\sum \text{county total}) \times 0.90 \times 0.06 \times 0.625\)

Grape Pomace

State Total~19,254 dry tons

Biomass Data Collection
Grape pomace values were obtained by averaging the state total production of wine and processed grapes for the years 1999-2003 (WASS, 2004) and using the 2002 Agricultural Census to determine a percentage of harvest by county (NASS, 2002). The use of both of these records led to the production of wine and processed grapes at a county level. On average, approximately 10% of the harvest grape weight is grape pomace (Ingels, 1992). A moisture level of 37.5% was used to determine total dry matter (NRC, 1983).

The final calculation was \(\text{state total} \times \text{county \%} \times 0.10 \times 0.625\)

Data Collection Concerns and Comments
No particular concerns exist in regards to the parameters used for the collection of this biomass data.
Other Field Residue

State Total~ 159,174 dry tons

Biomass Data Collection
Other field residue values from controlled and permitted burns were obtained from data already compiled by the Department of Ecology Air Quality Program using 2002 permitting data (WAEAQP, 2004). The controlled field burns were primarily due to burns of cereal grains, clearing of grasslands, pastures and CRP land, orchard tear-outs and orchard thinnings. The methodology used by the WAEAQP was to calculate tons of residue burned by multiplying the acres burned x fuel loading factor x fuel consumption factor. The number of acres burned, fuel loading factors, and fuel consumption factors where supplied by review of the actual permits or by supply of parameters by the local air quality departments. A moisture content of 20% for the miscellaneous woody/grassy mixture was used for final calculation of the dry mass.

The final calculation was \[ \left( \sum (\text{acres burned} \times \text{fuel loading factor} \times \text{fuel consumption factor}) \right) \times 0.80 \]

Wheat Straw

State Total~ 1,614,234 dry tons

Biomass Data Collection
Wheat straw residue values were obtained by averaging the county production of wheat in terms of yield and acre for the years 2002-2003 (WASS, 2004) and then using a conversion equation from wheat to straw (lbs straw/acre = 69.76 \times \text{yield/acre} + 1,067.7) to get total straw production (WSUCEEP, 2001). A sustainable collection factor of 25% was used across the board for all wheat fields to get an estimate of the potential harvestable straw with respect to conservation concerns (www.fiberfutures.org). A moisture content of 28% for wheat straw was used to determine a final dry biomass (Klass, 1998).

The final calculation was \[ \left( 69.76 \times \text{yield/acre} + 1,067.7 \right) \times \text{acres}/2,000 \times 0.25 \times 0.72 \]
**Cull Apples**

State Total~41,039 dry tons

**Biomass Data Collection**

Cull apple values were obtained by averaging regional state production for the years 1999-2003 (WASS, 2004) as well as determining from the 2002 Agricultural Census the percentage acre by county (NASS, 2002). With these two data sets a county level annual production was developed. A personal interview with Post-Harvest personnel at WSU Tree Fruit Extension pointed out that of 100 units of harvested apple, approximately 70 units are packed while 20 units are processed and 10 units are true culls used only for juice (WSU TFE, 2004). A moisture level of 84% was used to determine total dry matter (USDA, 2002).

*The final calculation was regional apple production tonnage % of regional harvest due to specific county x 0.10 x 0.15*

**Corn Stover**

State Total~ 73,502 dry tons

**Biomass Data Collection**

Corn stover residue values were obtained by averaging the county production of corn in terms of yield and for the years 2000-2003 (WASS, 2004) and then using a conversion equation from corn to straw (tons/yr of collectible corn stover = yield (tons/yr) x residue factor (1.1) x available factor (0.25)) to get total straw production (Klass, 1998)(Fiberfutures, 2004). Since the agricultural harvest statistics were given in number of bushels, conversion factors for bushel to cubic foot (0.8036:1) and bulk density of corn ear (56.0 pounds/cubic foot) were used to determine number of tons (SMICO, 2004). A moisture content of 47% for corn stover was used to determine a final dry biomass (Klass, 1998).

*The final calculation was yield x 1.1 x 0.25 x 0.53*
Apple Pomace

State Total~27,794 dry tons

Biomass Data Collection
Cull apple values were obtained by averaging regional state apple production for the years 1999-2003 (WASS, 2004) as well as determining from the 2002 Agricultural Census the percentage acre by county (NASS, 2002). With these two data sets a county level annual apple production was developed. A personal interview with Post-Harvest personnel at WSU Tree Fruit Extension pointed out that of 100 units of harvested apple, approximately 70 units are packed while 20 units are processed and 10 units are true culls used only for juice (WSUTFE, 2004). According to the National Research Council Committee on Animal Nutrition (NRC), 8.6% of the wet weight of the raw processed apple ends up as solid waste (NRC, 1983). A moisture level similar to that of grapes pomace at 37% was used to determine total dry matter (USDA, 2002).

The final calculation was regional apple production tonnage \( \times \) % of regional harvest due to specific county \( \times 0.20 \times 0.086 \times 0.63 \)

Other Fruit Pomace

State Total~11,865 dry tons

Biomass Data Collection
Other fruit pomace values were obtained by averaging regional state other fruit production for the years 1999-2003 (WASS, 2004) as well as determining from the 2002 Agricultural Census the percentage acre by county (NASS, 2002). With these two data sets a county level annual other fruit production was developed. Fruits inventoried in the other cull fruit category were apricots, cherries, pears, peaches, and prunes. A personal interview with Post-Harvest personnel at WSU Tree Fruit Extension pointed out that of 100 units of harvested apple, approximately 70 units are packed while 20 units are processed and 10 units are true culls used only for juice (WSUTFE, 2004). This ratio was assumed to be similar to that of other miscellaneous fruits. According to the NRC, 17% of the wet weight of the raw processed other fruit ends up as solid waste (NRC, 1983). A moisture level similar to that of grape pomace at 37% was used to determine total dry matter (USDA, 2002).

The final calculation was regional apple production tonnage \( \times \) % of regional harvest due to specific county \( \times 0.20 \times 0.17 \times 0.63 \)
## Appendix A-4 Animal Residue Calculation Tables

### Table 1: Net Number of Animals in Clackamas County by Type and Age and Assumption Used to Calculate Amount of Annual Dry Tons of Biomass Material

<table>
<thead>
<tr>
<th>Animal Type/Age</th>
<th>Juvenile</th>
<th>Adolescent</th>
<th>Adult</th>
<th>Total</th>
<th>Permitted</th>
<th>County Capacity</th>
<th>Collection percent</th>
<th>Juv./Adol. Manure (lbs/day)</th>
<th>Adult Manure (lbs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle/Elk/Water buffalo (farm and feedlot)</td>
<td>-</td>
<td>211</td>
<td>909</td>
<td>1,120</td>
<td>1,460</td>
<td>76.7%</td>
<td>22.8%</td>
<td>1.39</td>
<td>5.52</td>
</tr>
<tr>
<td>Dairy</td>
<td>408</td>
<td>722</td>
<td>1,784</td>
<td>2,914</td>
<td>3,898</td>
<td>74.8%</td>
<td>85%</td>
<td>3.66</td>
<td>13.1</td>
</tr>
<tr>
<td>Equine</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>12</td>
<td>275</td>
<td>4.4%</td>
<td>67%</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Poultry (broiler)</td>
<td>-</td>
<td>40</td>
<td>699,447</td>
<td>699,487</td>
<td>776,500</td>
<td>90.1%</td>
<td>80%</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Poultry (layers)</td>
<td>19,700</td>
<td>214,800</td>
<td>1,166,400</td>
<td>1,400,900</td>
<td>1,728,500</td>
<td>81.0%</td>
<td>80%</td>
<td>0.53</td>
<td>0.53</td>
</tr>
<tr>
<td>Swine</td>
<td>-</td>
<td>-</td>
<td>3,067</td>
<td>3,067</td>
<td>4,511</td>
<td>68.0%</td>
<td>100%</td>
<td>0.9</td>
<td>0.9</td>
</tr>
</tbody>
</table>

### Table 2: Total Annual Dry Tons by Animal Type in Clackamas County and Percentage of Overall Biomass Resource Represented

<table>
<thead>
<tr>
<th>Manure</th>
<th>Annual Amount (dry tons)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle/Elk/Water Buffalo Manure (farm and feedlot)</td>
<td>221</td>
<td>0.14%</td>
</tr>
<tr>
<td>Dairy Manure</td>
<td>4,267</td>
<td>2.77%</td>
</tr>
<tr>
<td>Equine Manure (w/correction)</td>
<td>4,842</td>
<td>3.14%</td>
</tr>
<tr>
<td>Goat Manure (other)</td>
<td>-</td>
<td>0.00%</td>
</tr>
<tr>
<td>Poultry Manure</td>
<td>144,145</td>
<td>93.61%</td>
</tr>
<tr>
<td>Rabbit Manure (other)</td>
<td>-</td>
<td>0.00%</td>
</tr>
<tr>
<td>Swine Manure (other)</td>
<td>504</td>
<td>0.33%</td>
</tr>
<tr>
<td>Total Biomass</td>
<td>153,979</td>
<td></td>
</tr>
</tbody>
</table>