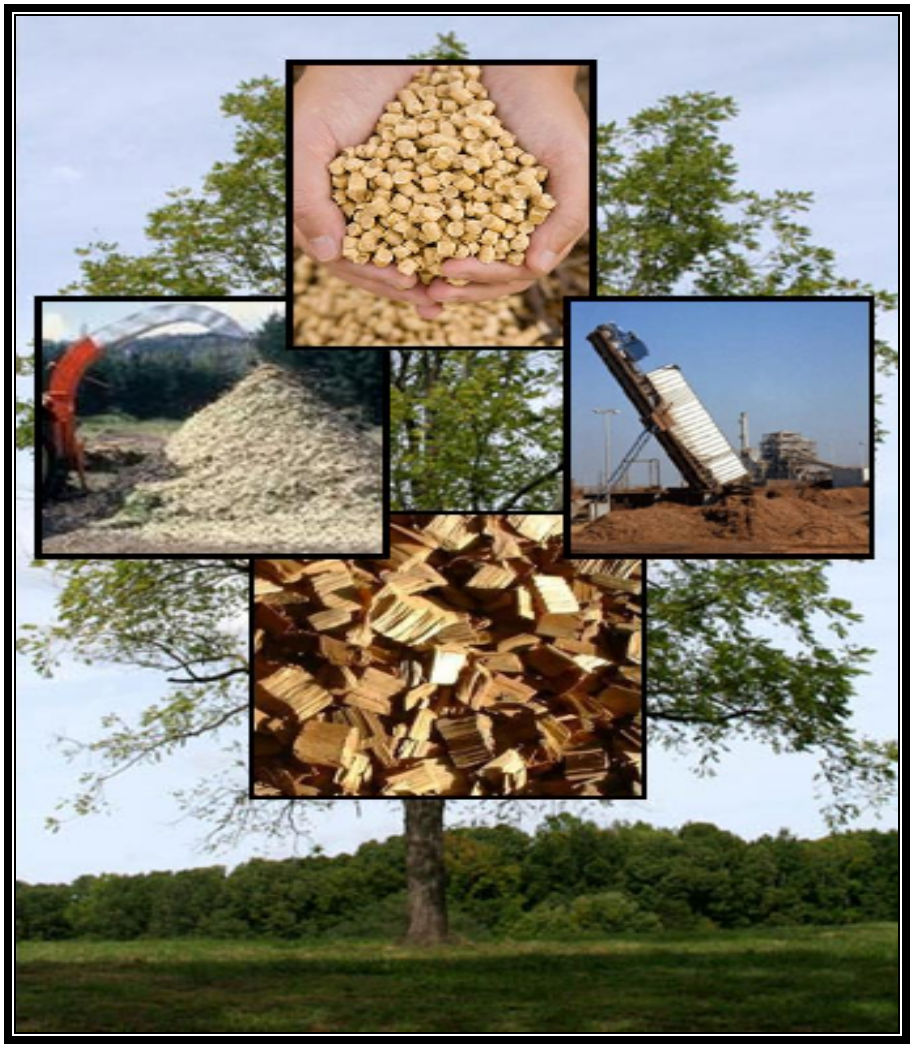
KANSAS STATE-WIDE WOODY BIOMASS SUPPLY & UTILIZATION ASSESSMENT



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OCTOBER 2009

ACKNOWLEDGEMENTS

This study was funded by the Kansas Forest Service in cooperation with the USDA – Forest Service to produce a statewide woody biomass supply assessment as a necessary step to ultimately increase the utilization of low-value wood waste and the production of bio-energy.

The researchers at Camas Creek Enterprises, Inc. would like to thank the citizens of Kansas who work in the wood processing, municipal & utility line tree care, and urban forestry fields for their valuable time and knowledge. We also would like to thank the City and County Clerks throughout Kansas for their collaborative efforts with data collection from their city parks/municipal tree care departments and the numerous landfills/transfer stations. We appreciate the time that many respondents took to complete and return the questionnaires and to answer our questions over the phone. Camas Creek Enterprises especially values the leadership and communication abilities demonstrated by State Forester Larry Biles and the Kansas Forest Service staff in their assistance with this project.

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1.0 EXECUTIVE SUMMARY

Woody biomass utilization offers opportunities to produce renewable energy, develop bio-based businesses, generate energy cost savings and create new markets for low value waste wood resources. The Kansas Forest Service (KFS) contracted with Camas Creek Enterprises, Inc of Missoula, Montana (Camas Creek) to conduct a wood waste supply assessment for the entire state and to perform a geo-spatial analysis that identified potentially-optimal locations for new wood-to-energy projects. Camas Creek examined two major sources of existing and potentially-available wood waste supply.

- **Wood Processing By-Products** from primary and secondary wood manufacturing operations.
- **Urban Tree Waste**, which includes public & private tree care service providers, utility line construction & maintenance activities, and tree debris separated from the municipal solid waste stream.

Forest biomass generated as a result of commercial logging and forest stand improvement activities was not examined in this research. Kansas has and is expected to maintain relatively low timber harvest levels. Additionally, the partially-mechanized harvest systems and selective logging techniques practiced in the state currently preclude the economical collection of forest biomass.

833 questionnaires were mailed to 716 "Wood Waste Supply Sources" (410 individual businesses, 105 counties, 201 cities (population 1,000 or greater), plus 117 organizations and/or individuals otherwise connected to urban forests and/or possessing information regarding wood waste. The overall survey response rate exceeded 50%. Survey response data was used as a basis to estimate additional supply for non-respondents using conservative extrapolation methods. Statewide, there is an estimated 282,724 green tons of woody biomass produced annually by wood manufacturing companies and urban tree care activities. Due to a lack of demand for this material, 66% or almost 187,000 tons of wood waste are potentially available as a wood energy feedstock at this time. There is an additional 67,822 green tons of suitable wood waste received at waste disposal sites each year and only 14% of that material is currently utilized.

Potential locations for wood to energy production exist in, and adjacent to thirty-eight counties that exceed annual wood waste supply of 1,000 green tons. Based on supply locations, the optimal locations for wood to energy utilization exist in eastern Kansas, primarily in the Topeka, Kansas City, Wichita, and Pittsburg areas.

This state-wide wood waste supply assessment provides baseline information that will be fundamental to the state of Kansas as it progresses towards future development of wood-to-energy opportunities. Additional in-depth feasibility analyses are necessary to implement site-specific investments for individual wood-to-energy projects.

Processed Wood Waste Stock-piled by a Commercial Arborist in McPherson County

2.0 INTRODUCTION

The state of Kansas is historically known for its 47 million acres of agricultural land and the extensive production of wheat, sorghum, sunflowers, and cattle. With a population of 2.8 million citizens, the state has a gross domestic product of $117 billon and its manufacturing sector and other institutions consume large amounts of energy in industrial and heating/cooling processes. Although Kansas regularly ranks in the top ten states in the nation for its production of oil and natural gas, it is believed that this state also has significant opportunity to increase its utilization of waste wood as a feedstock to produce bio-energy and bio-fuels for local and national consumption.

Increased utilization of wood waste can help decrease our Nation's dependence on foreign energy purchases, generate energy cost-savings, reduce the amount of wood waste disposed of in landfills and stimulate local economic development. In 2006 a Rand Corporation analysis found that 25% of the Nation's energy could be competitively produced from ethanol, wind power and other forms of renewable energy such as woody biomass[1]. A national alliance, known as the Energy Future Coalition, has subsequently advanced the "25 x 25 Initiative"[2]. The Coalition's vision, now endorsed by the National Association of State Foresters, states: "By 2025, America's farms, forests and ranches will provide 25 percent of the total energy consumed in the United States, while continuing to produce safe, abundant and affordable food, feed and fiber."

Wood has long been used as an energy source throughout the globe and the forest products industry is known for capturing the energy value of wood waste to produce heat, steam and electricity. With a renewed emphasis, many states are putting woody biomass to work for energy. Eleven western states, including Kansas currently have facilities operating that use woody biomass and other wood waste material to produce renewable energy and power heating systems in building complexes such as college campuses, schools, hospitals, and business facilities. For instance, two alfalfa hay de-hydration plants in Kansas are using wood waste as a source of heat energy. The Frito Lay Corporation is currently burning municipal and utility waste wood in their production plant in Topeka to heat the oil used for cooking potato chips. Northwest Missouri State University in Maryville, Missouri has used waste paper and sawdust to fuel its wood-fired boiler for many years and Chadron State College in Nebraska uses forest biomass to heat and cool

[1] Rand Corporation. 2006. Impacts on U.S. energy expenditures of increasing renewable energy use. TR-384-EFC. www.rand.org/pubs/technical_reports/2006/RAND_TR384.pdf

[2] 25 X'25 Alliance. Lutherville, MD. www.25x25.org

its campus. In other states, such as Montana, Idaho, Nevada, and North Dakota, woody biomass feedstocks such as chips, sawdust, processed logging slash, and municipal waste wood are burned using highly-efficient, low-emission boiler technology to heat public schools through support from a program known as Fuels for Schools and Beyond[3].

The heat and steam produced as a result of burning wood waste (instead of coal, propane or natural gas) can also be used to generate electricity and power industrial processes. Utilization of wood waste biomass to generate bio-energy has the potential to improve the net energy balance of producing ethanol. In South Central Kansas, the Abengoa Bio-energy Corporation currently operates a bio-ethanol plant in Colwich that produces 25 – 30 million gallons of fuel ethanol per year primarily from Milo grains. They plan to construct an additional bio-energy facility in Hugoton by 2012 that will produce 11.7 million gallons of ethanol and will run on an assortment of agricultural products and other feedstock that may include woody biomass[4]. Prairie Fire Bio-energy Cooperative, located in Healy, Kansas, procures agricultural and woody biomass for production and sales of pellets and livestock bedding[5]. The company also has plans to initiate another woody biomass business venture in the Goodland area of northwest Kansas.

Kansas is blessed with 2.1 million acres of forests that in the future have the potential to produce forest biomass feedstock as a by-product of silvicultural activities (see Forest Resources section below). Currently in Kansas, forest waste wood is only available from the forest products manufacturing sector, one step removed from actual forest management activities. A 2003 U.S.D.A. Forest Service report estimated that up to 29% of the primary mill residual by-products were not utilized in Kansas[6]. Today, there are approximately 53 stationary and portable primary processors (sawmills) and 218 "secondary" wood products manufacturers in the state.

Kansas has many large and small communities which are enhanced by the presence of urban forests. Tree debris created from the regular maintenance and removal of "city" trees can often represent an important component of the urban wood waste supply stream. Tree care service companies or city governments, who are normally

[3] Fuels for Schools and Beyond. www.fuelsforschools.info
[4] Abengoa Bioenergy. www.abengoabio-energy.com
[5] www.prairiefirecoop.com
[6] Reading WH and DL Bruton. 2003. Kansas Timber Industry- An Assessment of Timber Product Output and Use, 2003. USDA-Forest Service, North Central Research Station. Resource Bulletin NC-269.

responsible for the disposal of this material, produce a significant amount of tree waste wood that is often un-utilized. With over 2.8 million Kansans, the state's residents and businesses also deliver substantial amounts of tree waste to its landfills and city burnsites that could potentially be utilized in biomass energy facilities.

The presence and potential availability of these various types of wood and tree waste resources, combined with a heightened interest in increased production of bio-energy products, provided the impetus for the Kansas Forest Service (KFS) to assist with efforts that can help divert woody debris from landfills and burnsites and increase wood-to-energy opportunities.

Camas Creek Enterprises was retained by the KFS to complete a woody biomass supply assessment for the entire state of Kansas to meet the following objectives:

1. Locate, quantify, and characterize the various sources of current and potentially-available wood and tree waste supply in the state of Kansas.

2. Provide a geo-spatial analysis using the wood and tree waste supply dataset to help determine optimal locations for wood-to-energy enterprises.

2.1 Forest Resources [7]

The state of Kansas is positioned in a region where the eastern hardwood forests give way to the rolling prairies of the western Great Plains. The southeast portions of the state receive annual precipitation levels as high as 44 inches with as little as 16 inches in the more semi-arid western parts of the state. The landscape is largely dominated by agricultural grass and croplands, leaving forested areas relatively scarce in comparison. Forests are typically not found in large contiguous tracts, and tend to be more linear in shape, primarily located along streams and rivers.

In 2005, Kansas forests encompassed 2.1 million of the state's total 52 million acres. Only 4% of Kansas is forested, but the state currently boasts the highest inventory of timbered acres in recent times. Timberland acreage has nearly doubled since 1936, but still hovers well below the estimated 4.5 million acres estimated to exist in the European pre-settlement era. Hardwood trees occupy over 90% of the forested acres with species like elm, ash, hickory, oak, and cottonwood.

[7] Moser, K.W; Hansen, M.H.; Atchison, R.L.; Brand, G.J.; Butler, B.J.; Crocker, S.J.; others. 2008. Kansas Forests 2005. USDA Forest Service, Northern Research Station. Newtown Square, PA.

The remaining forested area is stocked with softwood species primarily consisting of eastern red cedar and smaller amounts of ponderosa pine.

Nearly all (91%) of the forestland in Kansas is privately owned by individuals or families. Private business groups have title to 4%, and government agencies own the remaining 5%. Family forests are clearly the dominant ownership group for the state of Kansas, with 65% of this group owning less than 10 acres of forest land within their total acreage. Forest owners are a diverse group with several different forest management objectives and practices. The most common reasons for owning forest land in Kansas, listed in order of importance, are:

- Part of the farm or a family legacy
- Aesthetics, nature protection
- Privacy
- Recreation
- Non-timber and timber forest products

While forest products utilization is not a primary objective for many timberland owners in Kansas, harvesting activities do occur in some forests to meet various silvicultural objectives. At this time forest biomass harvest is not a feasible supply source for bio-energy projects due to relatively low harvest levels, partially-mechanized harvest systems and selective logging techniques. The lack of a viable market for small diameter trees often hinders landowners' abilities to implement optimal silvicultural practices and efficiently utilize non-merchantable trees. However, growing stock volume has steadily increased in Kansas timberlands over the last 40 years with a current live tree volume of 2.7 billion cubic feet. The increasing density of forests suggests that many stands are transitioning towards fully stocked units. In the future, higher density stands and more diverse wood markets, may foster conditions that are more economically feasible for loggers to sustainably remove larger volumes of wood and wood waste at each location. If this level of harvest is reached, forest biomass may be more readily available and economically viable for bio-energy projects in the forested areas of state.

3.0 SUPPLY ASSESSMENT METHODOLOGY

3.1 Data Collection and Survey Development

The supply assessment was designed to include all wood waste supply sources (Suppliers) and licensed municipal waste disposal facilities in the state. Contact information was acquired using lists provided by the KFS. An initial database was tabulated by business type, name, mailing address, physical location, zip code and county. All supplier locations and waste disposal facilities were geo-coded in order to record their physical location for subsequent analysis. The physical locations of all supply sources and municipal waste disposal sites are also illustrated on the following pages.

The identified types and sources of wood waste were separated into two major categories and further sub-divided into six supply source groups:

Wood Processing Businesses

1. Primary Wood Products Manufacturing Businesses
2. Secondary Wood Products Manufacturing Businesses

Urban Tree Waste

3. Utility Companies/Arborists
4. Commercial Arborists (Private Tree Care Businesses)
5. Municipal Arborists (operated by city government departments)
6. Waste Disposal Sites

The initial dataset totaled 833 sources which included 716 "Wood Waste Supply Sources" (410 individual businesses, 105 counties, 201 cities (population 1,000 or greater). KFS also provided Camas Creek with a listing of the members of Tree City USA, city foresters, and additional Kansas Arborist Association (KAA) members. Thus, the initial contact list also included 117 members and/or individuals connected to urban forests and/or possessing information regarding urban forests and tree waste. These included members of Tree City USA, the Kansas Arborist Association and city foresters.

Mailed questionnaires were the primary tool for data collection in this study. Four variations of the questionnaire were developed by Camas Creek, and endorsed by the KFS, to allow for appropriate data collection from the six different supply groups. The Dillman survey method was adopted for this phase of the data collection. A written introductory letter prepared by KFS State Forester Larry Biles was first mailed to all contacts two weeks before the actual survey was distributed. The survey form package was distributed by Camas Creek and included an addressed envelope with pre-paid postage and a toll-free option to fax the completed survey form to Camas Creek. One week after the requested deadline for the first survey, Camas Creek mailed a second identical questionnaire form to all non-respondents. The utility companies and utility company arborists were surveyed by phone. Numerous phone conversations were conducted to clarify responses and obtain additional information.

Survey responses revealed a number of supply sources that were no longer in business, secondary wood processors that do not utilize wood products, and waste disposal sites that do not accept tree waste. The survey response rates and the number of respondents for each supply source category are illustrated in Table 1.

Table 1: Wood Waste Response Rates by Supply Group

GROUP	SOURCE	SUPPLIERS SURVEYED	SURVEYS RETURNED	TOTAL RESPONSE RATE
1	Primary Processor	56	30	53.6%
2	Secondary Processor	235	99	42.1%
3	Utility Tree Waste	5	2	40.0%
4	Commercial Arborist	113	49	43.4%
5	Municipal Arborist	201	104	51.7%
6	Waste Disposal Facilities	105	75	71.4%
7	Other*	1	1	100.0%
	TOTALS	716	360	50.3%

* Researchers received one response from a grinder/logging operator

3.2 Supply Characteristics

The below narrative characterizes each of the six major supply groups based on the survey responses received by Camas Creek.

3.2.1 Wood Processing Businesses

- **Primary Processors**

Primary wood processors are businesses that manufacture wood products using logs or other roundwood as raw material. Those products commonly include rough and/or finished lumber, veneer and plywood. The by-products of primary wood processing are a common raw material feedstock for pulp & paper manufacturing, engineered wood products such as particleboard and fiberboard, wood pellets and bio-energy production facilities in areas of Canada and the US where forests and forest product manufacturing infrastructure are more prevalent.

A major advantage of utilizing this type of wood waste is that additional materials-processing steps are minimal or not required to create suitable feedstock. For instance, sawdust produced as a result of sawing lumber can be utilized without additional processing. However, value-added utilization of wood waste is a market-driven phenomenon. Since many of the primary wood processors in Kansas burn, give away, or otherwise dispose of their wood waste, an efficient bio-energy market could provide a suitable incentive for these suppliers to sell their wood waste as bio-energy feedstock material.

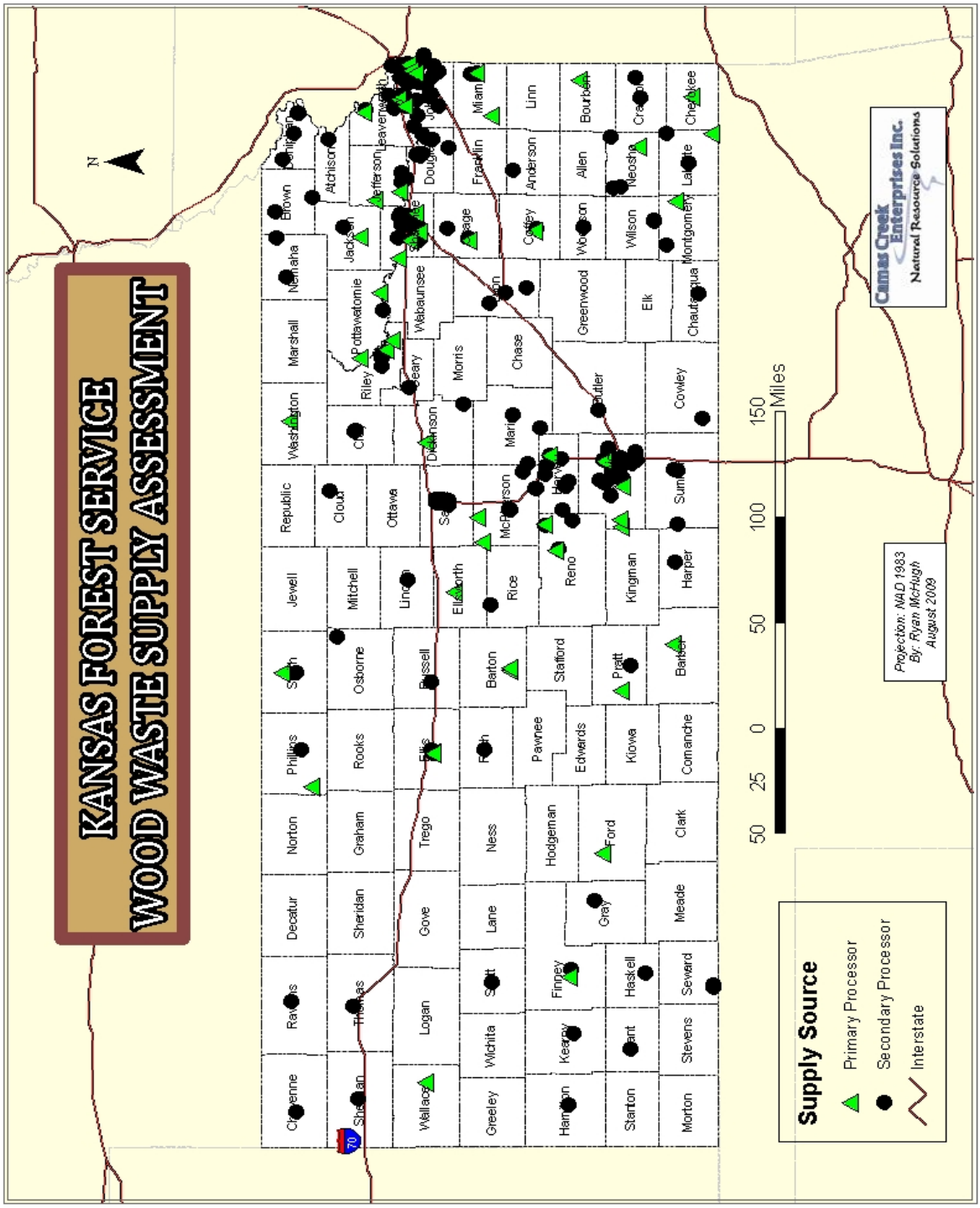
Typically, four types of wood waste are generated as a result of manufacturing solid wood products from logs. These are bark, sawdust, chips and shavings. In many situations tree bark is removed prior to initial processing, which results in the generation of bark as a by-product. The wood products manufacturing by-product "sawdust" is produced during the initial log break-down phase and as lumber is edged and trimmed. Slabs produced during the initial log break-down phase can be further processed into chips and/or wood mulch, or can be pulled off the production line and later burned or used as firewood. Shavings are produced by planing lumber to produce a smooth surface – sometimes green lumber is surfaced and other times only dried lumber is surfaced, which affects the moisture content of that by-product. Our survey results indicated that over 92% of the reported wood waste was already in processed form by primary processors in Kansas.

There are a total of 53 primary processors in the state of Kansas (Figure 1). Twenty-eight of these processors operate their business in permanent locations, 19 businesses are designated as portable operations, and the status of the remaining 6 primary processing businesses is unknown. There is one facility that processes more than 1 million board feet annually and two facilities that process between 100,000 and 1 million board feet annually[8]. The remaining primary processors produce less than 100,000 board feet per year.

According to survey respondents, the majority of primary processing businesses operate small mills at permanent or portable sites that run intermittently or at low production levels due to several factors. Aside from the few larger production mills, most mill operators referred to themselves as retired, hobbyists, or part-time millers; suggesting that the majority of the small and portable mill operations in Kansas may not produce sufficient wood waste to be considered as reliable sources for wood waste at this time.

[8] Biles, Larry. *Kansas Forest Service 2008 Annual Report*. Kansas State University, April 2009.

Figure 1. Location of Primary and Secondary Wood Processing Facilities in Kansas



- **Secondary Processors**

Secondary wood processors are defined as businesses that manufacture wood products from lumber, partially manufactured logs, or residue from primary wood products manufacturing or logging operations. These businesses are one step removed from the primary processing of logs or other roundwood. For instance, shipping pallet manufacturers use lumber that they acquire from a sawmill or lumber broker to build pallets. In Kansas, secondary manufacturers produce a variety of products including furniture, cabinets, trusses, shipping pallets, crates, countertops, doors, window jambs, picture frames, and hardwood molding.

There are a total of 218 secondary processors in the state of Kansas that manufacture products made from wood (see Figure 1 above). Based on survey respondents and KFS data, secondary processors were assigned to nine subgroups determined by the type of product(s) they manufacture (Table 2). One cabinet company reported producing over 5,000 tons of wood waste annually, eleven companies estimated wood waste production between 1,000 – 5,000 tons per year, and the remaining respondents indicated that they produced less than 1,000 tons annually.

Secondary processors primarily produce sawdust, shavings, and small wood pieces as waste material. Chips and bark are not a common by-product of secondary processing. Like the by-products produced by primary processors, the clean by-products associated with secondary processing are also suitable for bio-energy production. Currently, 81% of the wood waste from this group are either given away, land-filled, or disposed of in some other method

Table 2. Survey Response Rate for Secondary Manufacturers

SUB-GROUP	PRODUCTS	SURVEYED	SURVEYS RETURNED	TOTAL RESPONSE RATE
1	CABINETS & COUNTERTOPS	98	40	40.8%
2	WOOD FURNITURE	21	12	57.1%
3	MODULAR STRUCTURES & LUMBER SALES	32	9	28.1%
4	PALLETS & CRATES	9	7	77.8%
5	PICTURE FRAMES & WOODCRAFTS	37	8	21.6%
6	DOORS, WINDOWS & TRUSSES	13	12	92.3%
7	MILLWORK, CASEWORK & MOULDING	16	6	37.5%
8	FENCING & STAKES	7	3	42.9%
9	MISCELLANEOUS	2	2	100.0%
	TOTAL	235	99	42.1%

3.2.2 Urban Tree Waste

- **Utility Companies**

The disposal of whole trees, tree branches and other wood waste generated as a result of utility distribution line activities represents a potential future supply of bio-energy feedstock. These companies provide urban and rural utility distribution such as residential and industrial electrical and natural gas services. The construction and annual maintenance of above and below-ground utility distribution corridors requires an active vegetation management program. Figure 2 depicts the geographic locations of major utility lines and operating locations for the major utility companies and utility line arborists in Kansas.

- **Commercial Arborists (Private Tree Care Businesses)**

The disposal of whole trees, tree branches and other wood waste generated as a result of urban forest management represents a potential future supply of bio-energy feedstock. Commercial arborists directly provide urban tree maintenance and tree removal services for individual private property owners and often contract similar services for city governments responsible for urban forests.

Many of the respondents from this supply group indicated that they owned one or more chippers and/or a grinder as part of their business. Arborist's accumulation of tree waste through daily activities, coupled with their ability to process the waste material into suitable bio-energy feedstock highlights the importance of these suppliers when developing urban bio-energy facilities. Figure 3 illustrates the locations of all commercial tree care service companies in Kansas.

- **Municipal Arborists**

The disposal of whole trees, tree branches and other wood waste generated as a result of urban forest management represents a potential future supply of bio-energy feedstock. City governments in towns with populations exceeding 1,000 residents were contacted to evaluate current tree wood waste disposal practices (see Fig. 3).

In Kansas, city governments are typically responsible for urban forest management in city parks and other public settings, and many administer a registered open burn site for free tree waste disposal from the city and its residents. At the present time, these sites are typically un-attended and tree waste is neither weighed nor measured when it arrives. The flow of tree waste to these sites can also be highly variable, dependent on seasonality and any recent urban tree damage after severe weather (ice storms, severe winds, etc.). Although accurate volume estimates are unavailable, tree waste received at city burnsites is likely to be an additional significant source of woody material for potential bio-energy facilities. Figure 3 illustrates the locations of the surveyed cities.

Figure 2. Electrical Transmission Line Distribution and Operating Locations for Major Utility Companies and Utility Arborists in Kansas.

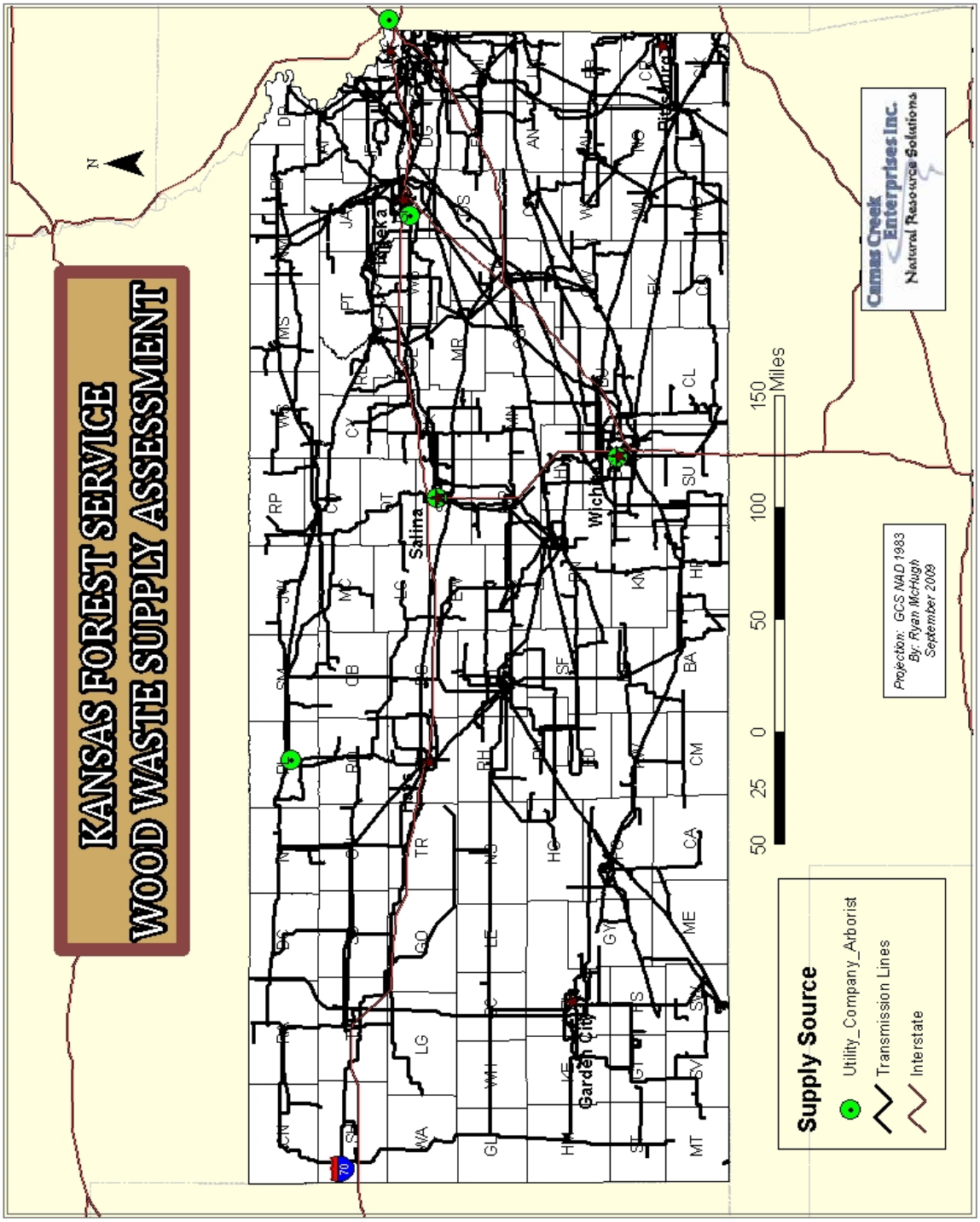
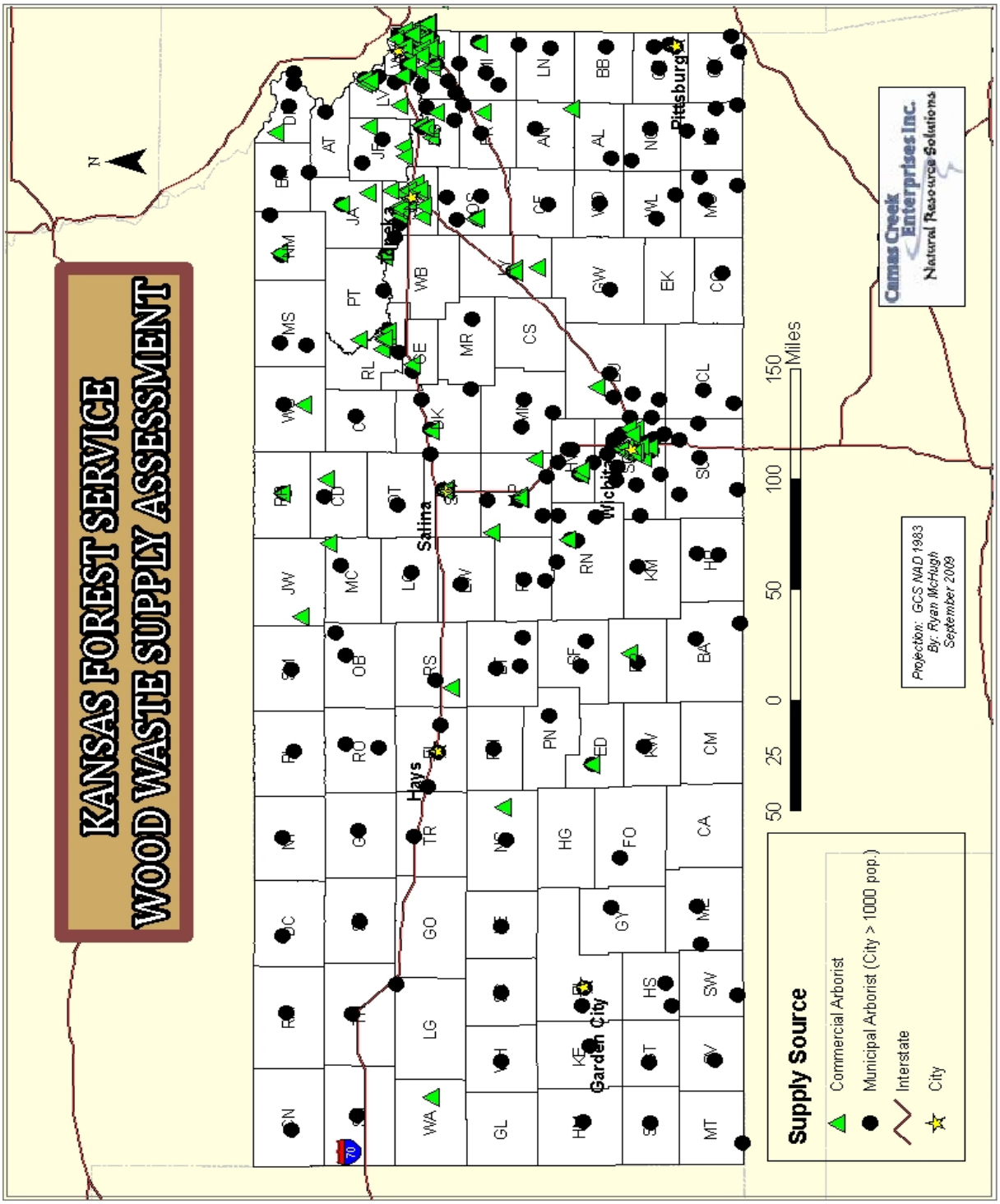


Figure 3. Commercial Arborists and Municipal Arborists (Cities > 1000 population).



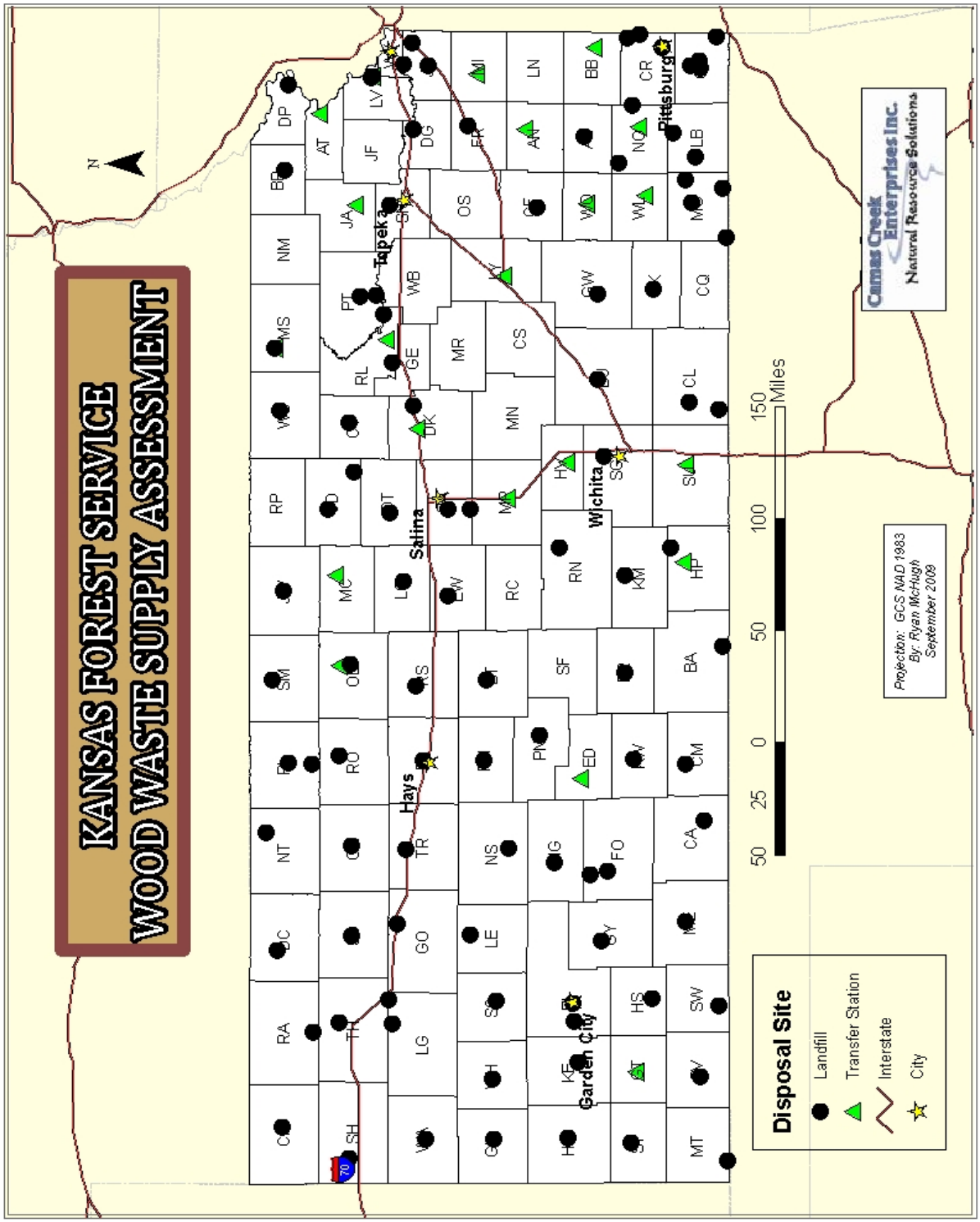
- **Waste Disposal Sites**

All permitted waste disposal facilities in Kansas were contacted to evaluate current wood waste disposal and utilization practices for their respective counties. These facilities included landfills, transfer stations, and Construction & Demolition (C&D) sites. Several of the facilities (landfills and transfer stations) currently separate tree debris and other wood waste at the site – this material is often disposed of by burning or burial rather than being further processed into usable wood waste products. Suitable tree waste was defined as all processed and un-processed branches, stumps, logs, and wood chips from tree removal and maintenance.

For purposes of this wood waste supply study, we specifically excluded "unsuitable urban wood waste" materials, which are those wood waste products not considered suitable for bio-energy utilization. "Unsuitable urban wood waste" is generated from construction & demolition activities and commonly contains wood preservation chemicals, paint and adhesives.

Surveyed waste disposal sites were also not included in our total supply source wood waste tallies for the state to ensure that wood waste reported by suppliers as going to a waste disposal site was not "double-counted". Many of the respondents indicated that a certain percentage of their material went to a licensed landfill, transfer station, or burnsite, however, whether waste wood was delivered to a waste disposal site (landfill or transfer station) or a city burnsite was not indicated. Figure 4 shows the locations of all waste disposal sites in Kansas.

Figure 4. Licensed Waste Disposal Facilities in Kansas.



3.3 Data Conversion

Several of the respondents from the secondary processors and arborists groups provided wood waste data in cubic yards. Data for this research was elected to be reported in green tons, an accepted standard weight unit for the biomass and forest products industry. The following equations were used to convert cubic yard volume measurements into tons.

Equation [1] was used to convert processed wood waste (sawdust) into tons for primary and secondary manufacturers. Equation [2] was used to convert un-processed (wood chunk) waste for the manufacturers and processed wood waste (wood chips) for the arborists and disposal sites into tons[9]. Equation [3] was used to convert un-processed tree waste (branches, trunks) in tons[10].

Equations:

[1] Tons = ($yards^3$) x 0.2050

[2] Tons = ($yards^3$) x 0.2663

[3] Tons = ($yards^3$) x 0.0930

[9] Composting for Municipalities-Planning and Design Considerations. NRAES Cooperative Extension. Ithaca, NY. NRAES-94.

[10] Personal communication: Greg Jones, Research Forester. USDA – Forest Service, Rocky Mountain Research Station. Missoula, MT

4.0 SUPPLY ASSESSMENT FINDINGS

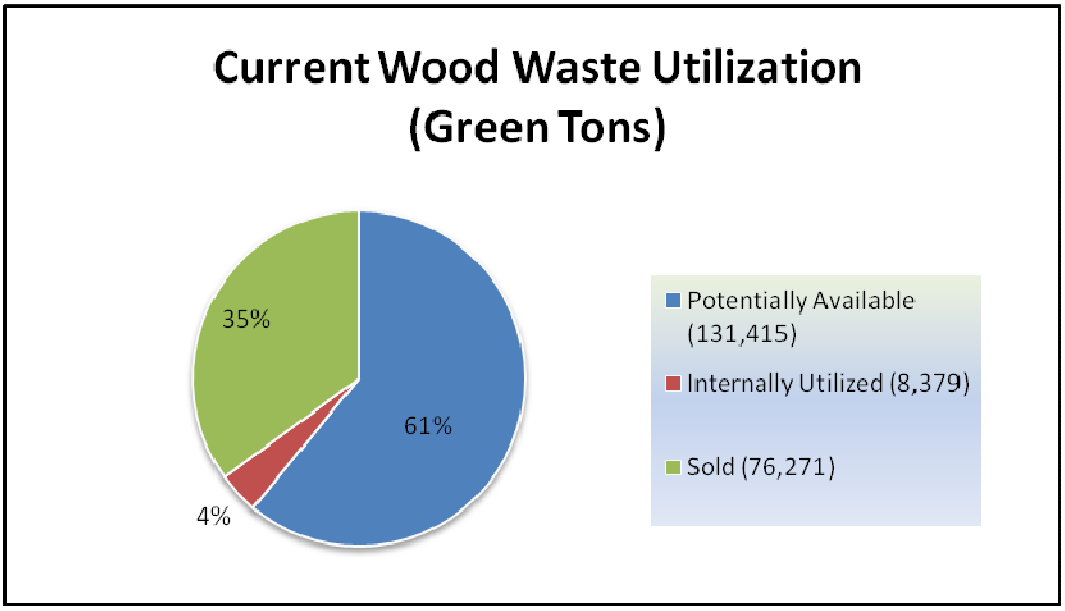
4.1 Reported Wood Waste Production

Camas Creek analyzed respondent data to find that Kansas supply sources (excluding Waste Disposal Sites) reported annual waste wood production of 216,065 green tons (Table 3). Waste Disposal Sites reported receiving an additional 46,047 green tons statewide. Suppliers indicated that nearly 61% (131,415 green tons) of the wood waste currently produced would be potentially available at this time for wood to energy projects based on current utilization practices (Fig. 5). The Waste Disposal Sites indicated that the majority of their tree wood waste (86%) was un-utilized and may be available if a market for the material existed. The majority of respondents who utilized their wood waste consumed the material internally or sold it at current market rates. Increased demand from a bio-energy market in the future may divert some of the currently utilized wood waste to the bio-energy marketplace, increasing the availability of feedstock for bio-energy facilities and boosting market prices, but also potentially affecting currently established businesses.

Table 3. Reported Wood Waste by Supply Group (Green Tons)

GROUP	GREEN TONS	PERCENT OF TOTAL
Primary Processors	15,774	6%
Secondary Processors	33,565	13%
Utility	33,639	13%
Commercial Arborists	30,948	12%
Municipal Arborists	51,090	19%
Waste Disposal Sites	46,047	18%
Other sources	51,048	19%
TOTAL	262,112	100%

Figure 5. Utilization of Current Wood Waste Reported by Suppliers



Potentially available wood waste is considered to be that material that is neither sold nor utilized internally.

Of the total reported wood waste in Kansas, respondents indicated that 67% of their material was already processed (Table 4). A large proportion of that processed wood waste is already in a suitable form of feedstock that could power existing and future wood fired boilers located throughout the state, depending upon feedstock quality standards.

Table 4. Reported Wood Waste Amounts Processed and Un-Processed by Supply Group (Green Tons).

GROUP	PROCESSED	UN-PROCESSED	PERCENT PROCESSED
Primary Processors	14,574	1,200	92%
Secondary Processors	19,102	14,463	57%
Utility	33,639	0	100%
Commercial Arborists	13,236	17,712	43%
Municipal Arborists	23,254	27,836	46%
Waste Disposal Sites	20,628	25,419	45%
Other sources	50,050	998	98%
TOTAL	**174,483**	**87,629**	**67%**

4.2 Tree Waste Processing Infrastructure

A number of respondents from the Utility, Municipal and Commercial Arborists, and Waste Disposal Site groups indicated that they owned or had access to one or more chippers for processing their tree waste. In total, these respondents indicated that they owned, or had access to 293 chippers and 19 grinders. The Kansas City area reported the highest number of processing machines, with 123 chippers operating in the area, primarily owned/operated by one regional utility company. Respondents that reside in Sedgwick, Johnson, and Shawnee counties indicated that they owned 79, 21, and 12 chippers/grinders respectively. The remaining counties had less than 5 chippers/grinders available based on survey responses. Counties that have mechanical processing machinery for tree debris will be better suited for wood to energy conversion because the necessary feedstock is already available as a by-product from current wood processing practices.

4.3 Wood Waste Produced by Non-respondent Groups

Camas Creek was able to extrapolate respondent data to estimate the tonnage of wood waste that one could expect a non-respondent supply source to produce annually. Although sampling data was sufficient for the Wood Processors group (Primary and Secondary), the wide range and high variability in the reported data

created conditions that were not statistically viable for data extrapolation. However, researchers were able to extrapolate data to non-respondents in the Arborist groups and for the Waste Disposal Sites. After data extrapolation, researchers elected to input the more conservative estimates into the database to ensure that wood waste amounts were not over-estimated.

A Municipal Arborist (cities > 1000 population) in the state of Kansas is estimated to produce between 448 – 783 green tons annually, and a Commercial Arborist would produce between 362 – 1,185 green tons of tree waste annually (based on a 75% level of confidence from the mean). Non-respondent Commercial Arborists were estimated to produce, at a minimum, an additional 23,173 green tons per year; while the non-respondent Municipal Arborists would add an additional 43,486 green tons annually (Table. 5).

Table 5. Estimated Total Tree Waste Produced for Non-respondent Commercial and Municipal Arborists in Kansas (Green Tons)

GROUP	LOW ESTIMATE	HIGH ESTIMATE
Commercial Arborist	23,173	75,861
Municipal Arborist	43,486	75,930
TOTAL	**66,659**	**151,791**

Researchers were able to identify a correlation with the amount of tree waste received at Waste Disposal Sites in each county based on population size. Non-respondent counties, with a licensed waste disposal facility and a total population of less than 5,000 people, were estimated to receive between 180 – 237 tons annually (Table 6). Counties with a population between 5,000 – 25,000 residents was estimated to receive 383 – 657 tons per year, and counties with a population greater than 25,000 residents was estimated to receive between 1,436 – 3,793 tons per year of tree waste wood. All together, using the low estimate, non-respondent counties that have Waste Disposal Sites would receive an estimated 21,775 tons in tree waste annually.

Table 6. Estimated Total Tree Waste Wood Received for all Non-respondent Counties at their Waste Disposal Site(s) (Green Tons)

COUNTY POPULATION	LOW ESTIMATE	HIGH ESTIMATE
< 5,000	2,340	4,251
5,000 - 25,000	6,511	11,169
> 25,000	12,924	34,137
TOTAL	**21,775**	**49,557**

After adjusting for non-respondent Arborists and Waste Disposal sites, the total estimated supply of wood waste supply in Kansas is estimated at 350,546 green tons (Table 7).

Table 7. Total Processed and Un-Processed Wood Waste by Group

GROUP	GREEN TONS	PERCENT OF TOTAL
Primary Processors	15,774	4%
Secondary Processors	33,565	10%
Utility	33,639	10%
Commercial Arborists	54,121	15%
Municipal Arborists	94,576	27%
Waste Disposal Sites	67,822	19%
Other sources	51,048	15%
TOTAL	**350,546**	**100%**

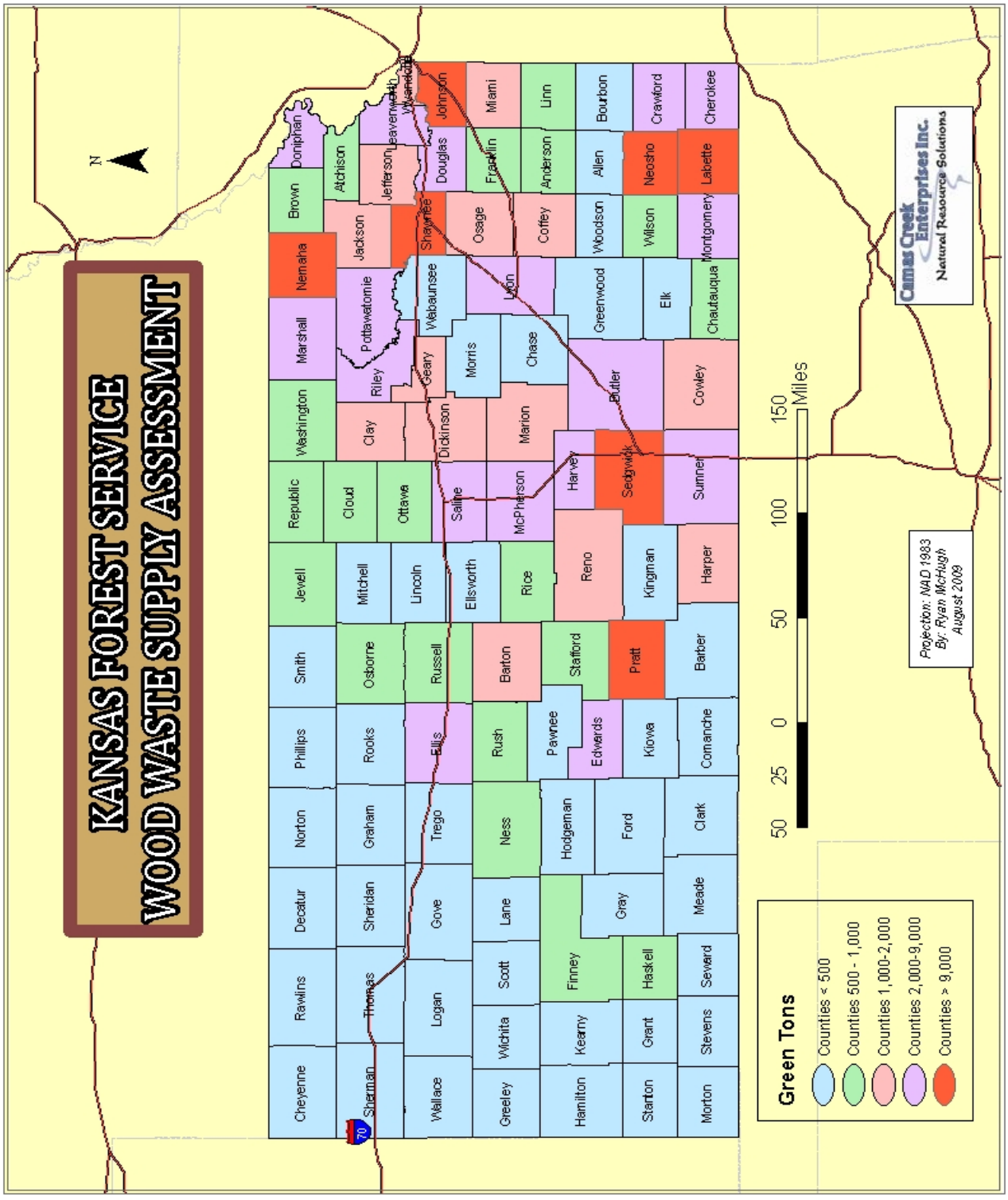
4.4 County Level Supply Ranking

The county level was the smallest geographic unit available to geo-spatially analyze a combination of all categories of wood waste supply data. Geo-spatial analyses displayed that seven counties in Kansas have suppliers producing wood waste in excess of 9,000 tons annually, and there are thirty-eight counties with wood waste supply of over 1,000 tons (Fig. 6). Counties with wood waste supply greater than 1,000 green tons are listed in Table 8. The table also illustrates potentially available material and the amount of wood waste received at the disposal sites in the county. Potentially available wood waste is considered to be that material that is neither sold nor utilized internally.

Table 8. Counties with Wood Waste Production in Excess of 1,000 tons

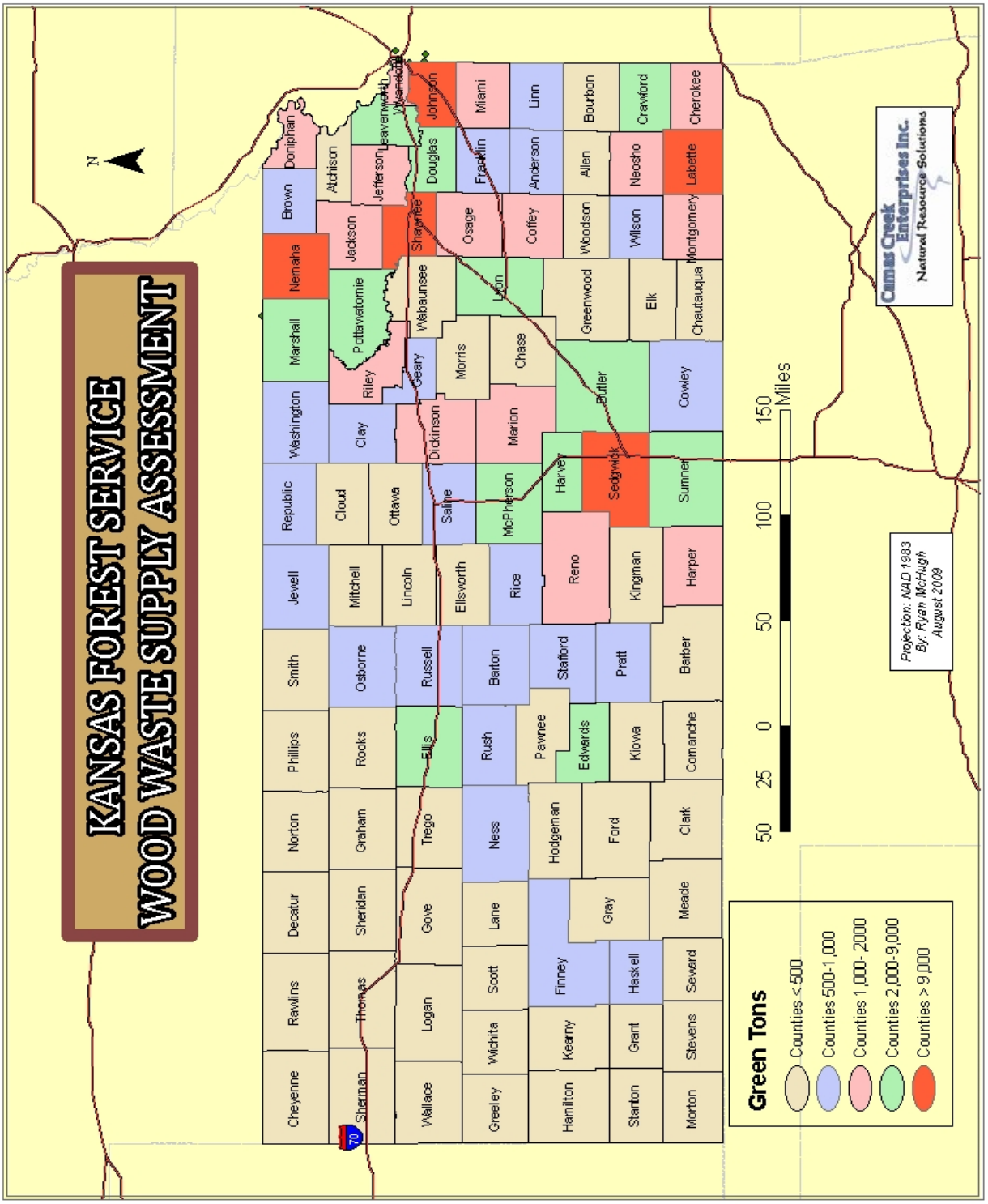
	(GREEN TONS)				(GREEN TONS)		
COUNTY	TOTAL	POTENTIALLY AVAILABLE	DISPOSAL SITES	COUNTY	TOTAL	POTENTIALLY AVAILABLE	DISPOSAL SITES
PRATT	50,810	677	383	RILEY	2,861	1,967	9,160
SEDGWICK	48,469	43,154	1,436	ELLIS	2,821	2,641	1,198
NEMAHA	19,626	18,416	0	EDWARDS	2,742	2,469	500
JOHNSON	18,529	16,104	6,200	MONTGOMERY	2,344	1,575	1,436
SHAWNEE	15,433	9,292	1,436	SALINE	2,074	833	300
LABETTE	11,484	11,194	383	RENO	1,879	1,592	1,436
NEOSHO	11,264	1,174	20	JEFFERSON	1,805	1,585	0
BUTLER	5,450	4,932	1,436	COFFEY	1,796	1,785	180
DONIPHAN	5,323	1,864	180	WYANDOTTE	1,765	1,416	0
SUMNER	4,728	4,174	383	MARION	1,663	1,394	0
CHEROKEE	4,253	1,390	416	OSAGE	1,646	1,463	383
LEAVENWORTH	3,935	3,439	7,989	DICKINSON	1,458	1,235	1,100
LYON	3,934	3,277	1,436	HARPER	1,344	1,075	383
MARSHALL	3,640	3,550	383	JACKSON	1,277	1,012	383
HARVEY	3,610	3,248	1,500	MIAMI	1,268	1,042	1,436
CRAWFORD	3,521	3,159	100	BARTON	1,208	966	0
POTTAWATOMIE	3,112	2,788	100	COWLEY	1,087	934	450
MCPHERSON	3,031	2,653	4,000	CLAY	1,069	966	180
DOUGLAS	2,934	2,318	1,436	GEARY	1,006	814	0

Figure 6. Total Wood Waste Produced by Suppliers



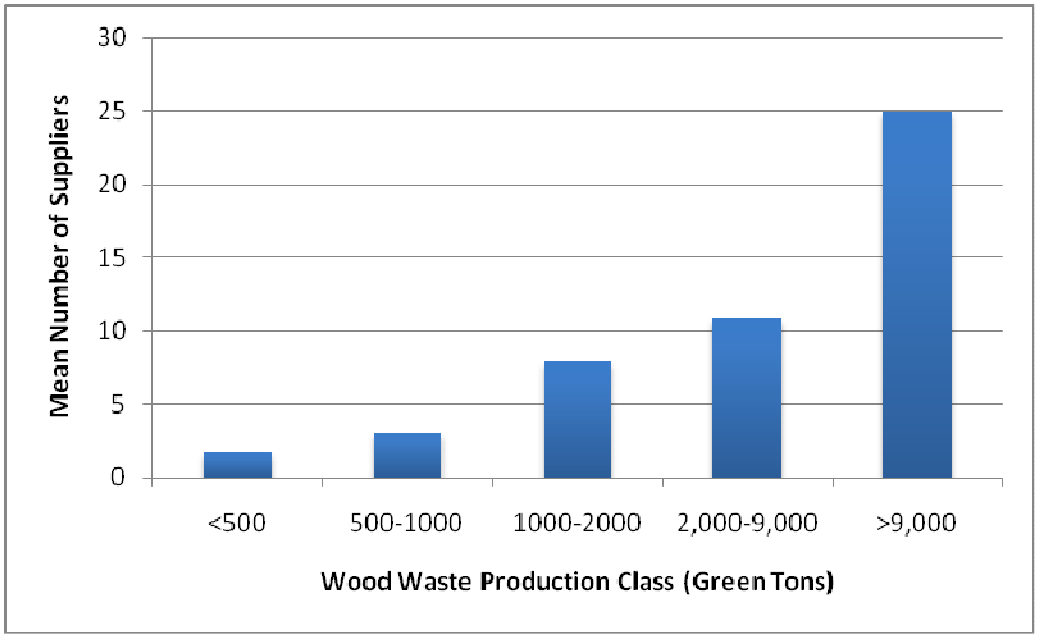
To define geographic areas where bio-energy feedstock supply currently exits researchers analyzed and mapped wood waste that is potentially available (currently not utilized or sold) by suppliers (Fig. 7). Thirty-one of Kansas's 105 counties have a potentially available wood waste supply that exceeds 1,000 tons annually. Of this group, wood waste supply in 5 counties exceeded 9,000 tons annually. In descending order, they are Sedgwick, Nemaha, Johnson, Labette, and Shawnee. Pratt and Neosho counties also produce more than 9,000 tons annually, primarily from a large supplier in each of the counties, but at this time all material is sold into another market. Except for just a few large wood waste suppliers, most Kansas producers indicated that they utilize very little of their wood waste at this time because there are no suitable markets for the material in their area.

Figure 7. Wood Waste Potentially Available for Bio-energy Supply



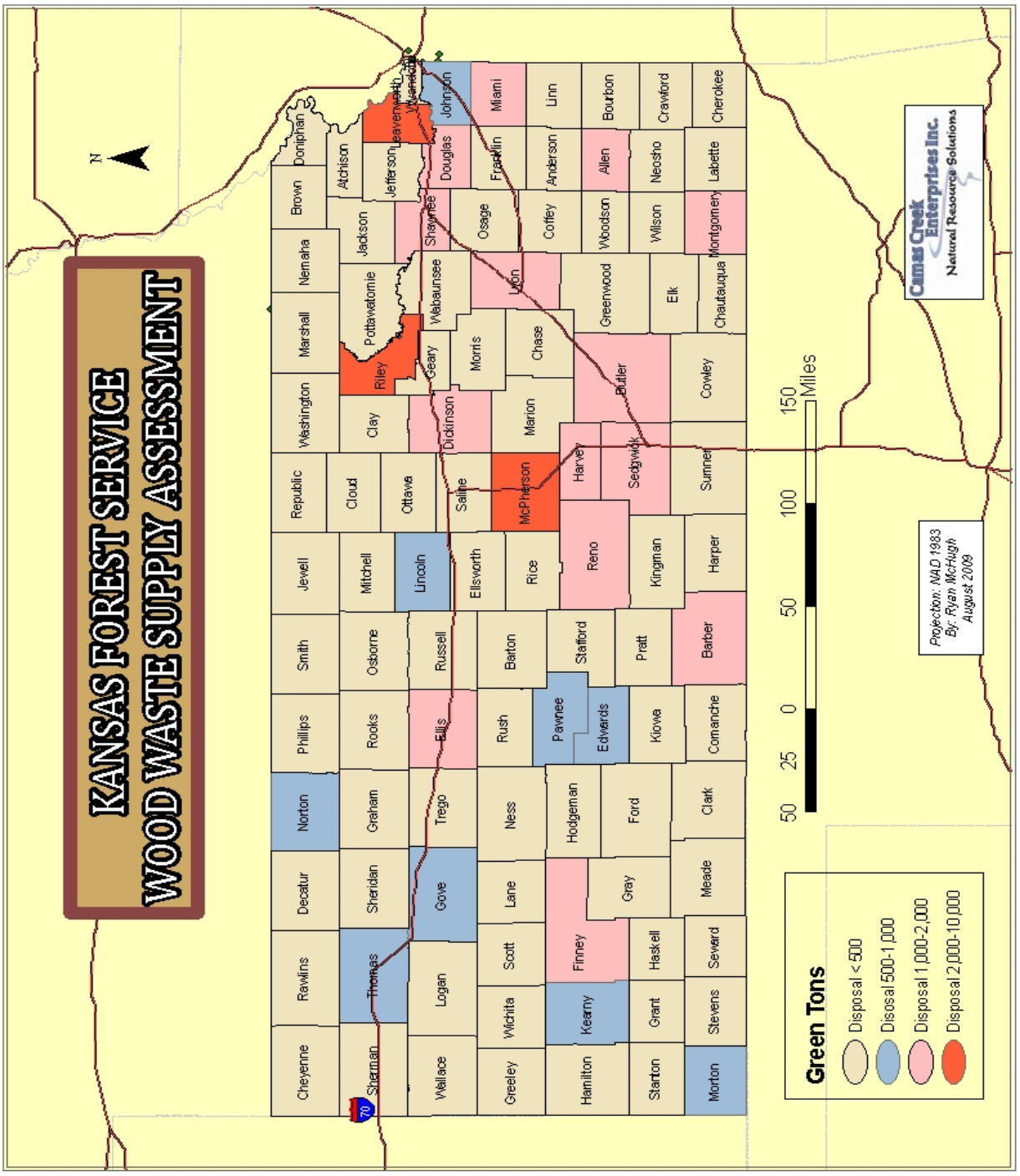
Results of the survey also conveyed that, on average, counties producing large amounts of wood waste were also host to high numbers of supply sources located within the county (Fig. 8). For instance, counties that produced less than 500 green tons of wood waste annually were home to an average of only three suppliers, where counties that produced between 1000-2000 tons annually showed an average of about 8 suppliers in their county. Although this notion is relatively intuitive, it will be important to assess the number of suppliers operating in a county being considered for bio-energy facilities.

Figure 8. Average Number of Suppliers in a County Compared to Annual Wood Waste Production Class



There are 58,476 green tons of potentially available tree waste wood received at Waste Disposal Sites in Kansas. Results indicated that seventeen counties receive more than 1,000 green tons of tree waste annually, and three counties exceed 4,000 green tons annually (Fig. 9). These counties are Riley, Leavenworth, and McPherson. Interestingly, the disposal sites receiving the largest amount of tree waste wood were located in different counties than those that ranked high in wood waste production from suppliers. However, these counties are adjacent to areas of high population centers and are potentially available sources of woody biomass for these areas.

Figure 9. Potentially Available Wood Waste Received at Licensed Waste Disposal Site by County



4.5 Supply Suitability Assessment

Raw material feedstock supply suitability is a major factor affecting bio-energy projects. Bio-energy project proponents must recognize that numerous economic and operational factors need to be resolved in order to increase the utilization of wood waste in Kansas. The following discussion provides insight into each of these challenges. It is also important that each potential wood energy producer assess the regional and global competitive advantages/disadvantages associated with wood waste supply and utilization for their individual product and location.

In 2006, Camas Creek developed a "Preferred Supplier Matrix" format to rank suppliers of various types of small-diameter roundwood, based on each potential supplier's raw material supply system, plant production capabilities, customer relations, technology, production equipment, marketing system and location.[11] A systematic assessment of wood waste supply should be performed for individual suppliers of bio-energy feedstock in relation to each contemplated wood-to-energy project, to include the following topics:

Seasonality – Seasonality pertains to the timely availability of wood waste supply. Irregular availability will influence delivered raw material cost structures, working capital requirements and inventory space requirements. A variety of factors affect the seasonality of each type of wood waste. For instance, municipal waste facilities experience variations in the delivery of tree debris over the course of a normal year, as tree debris delivery normally is less in the winter than during the spring/fall period. Private and government tree maintenance activities do not generally occur year-round. Severe storms may result in irregular periodic increases of tree debris. Weather conditions and storms will also affect field operations associated with utility line maintenance requirements. Secondary processors are normally not affected by weather conditions, but may be affected by seasonal market demand for their products. The larger primary wood processing companies typically operate year-round, while the smaller sawmills in Kansas do not operate on a consistent basis.

Reliable Access – Access to supply sources is affected by road access and weather that affects the roads needed to transport products generated by supply sources. Truck access to secondary wood processors may be affected by available space needed to load wood waste products, especially in situations where wood waste loading was not anticipated.

[11] Lane, Rich. 2006. Project Poles-Small-Diameter Roundwood Commercialization Project.

Processing – Wood waste generated by secondary processing is typically in a form that does not require further mechanical processing. In general, primary wood processors have equipment in-place to chip or grind slabs, and the sawdust and shavings they produce are already in suitable form. Most tree service and utility companies mechanically process tree debris using chippers or grinders. To generate suitable woody biomass feedstock at municipal waste facilities, mechanical processing must occur for tree waste to be converted to a usable form. The capital investment required to purchase wood processing equipment, and the associated operating budget, are often a barrier for small municipal waste sites unless a suitable market first exists.

Freight – Resolution of freight challenges is critical for utility companies and commercial arborists working outside of town. Typically, it is difficult to maximize legal net weights when hauling wood waste due to its low density/high bulk characteristics. Specialized equipment, such as chip vans, may be needed to transport processed wood waste from rural settings to market locations in order to minimize freight costs. This type of equipment is also needed to efficiently haul material generated at locations such as sawmills, which are sometimes many miles from market.

Quality Conformity – Product quality is often overlooked in the initial stages of procuring raw material feedstock. Product quality, which is specified by the purchaser and dependent on the technology platform used to produce bio-energy, refers to moisture content, size distribution, presence of undesirable material such as tree needles, leaves, bark content, over-sized or un-chipped material and contaminants, such as metal or plastic. There are numerous examples of new small-scale bio-energy plants that initially operated at lower than expected productivity levels due to struggles with feedstock quality.

Materials Separation – Wood waste is often co-mingled with other non-combustible or unsuitable material. The processes necessary to segregate suitable tree waste from typical house-hold trash, and their associated costs, are a primary reason why some landfills do not readily embrace wood recycling unless landfill space is limited or an economical incentive or legislative mandate exists. Proper materials separation is also required for other sources of wood waste generated during urban tree maintenance and utility line maintenance. Primary and secondary wood processing operations generally require a lower degree of material separation if sawdust can be mixed with other residual wood products.

Sustainability – The issues of sustainability pertain to ecological factors and long-term supply availability. The amount of wood waste generated directly from trees in the forest or an urban setting is a function of biological growth rates and the level of management intensity required to obtain desired conditions. Municipal wood waste supply is unlikely to be affected by sustainability issues. Many secondary wood processors obtain raw material from sources outside Kansas – this wood waste supply category is unlikely to be affected by sustainability issues.

Competition – Current and planned future uses of wood waste supply must be considered for all site-specific wood energy analyses. Several wood-fired boilers already exist in Kansas. For example, alfalfa dehydration facilities consume 1,137 tons/year in Larned and 1,837 tons/year in Abilene. The wood waste already used or expected to be consumed by those operations and the undocumented amounts consumed by other known users in Kansas should be factored into every analysis exploring increased wood waste utilization. It is also evident that significant amounts of wood waste from certain Wood Processing companies are already processed and sold into another marketplace. For instance, the range improvement contractor in Pratt county sells all 50,000 tons of estimated wood waste produced, and a large sawmill in Neosho county currently sells their 10,000 tons of wood waste.

5.0 WOOD WASTE UTILIZATION

As noted above, about one-third of woody biomass supply in Kansas is currently utilized, a situation that in numerous locations represents an opportunity to produce bio-energy products using wood waste as a renewable feedstock. The following section describes several opportunities to increase the utilization of Kansas's wood waste.

5.1 Emerging Opportunities for Wood Energy

Electricity and Heat Energy

In addition to wood-fired boiler conversion projects, other potential opportunities exist to utilize wood waste for bio-energy production. Direct combustion and gasification technology platforms are available that use wood waste to produce steam for the generation of electricity. Wood waste can be utilized as the sole feedstock to generate electricity or can be used to co-fire facilities that produce electricity from coal. A company in Lucerne Valley, CA co-fires woody biomass with coal for its cement kilns. Except in cases where there are other primary uses of steam (such as the Eagle Studs sawmill and lumber dry kiln in Hall Montana that uses exhaust steam to power piston generators that produce 700 KW of internally-used electricity) investments in wood-fired boiler facilities that generate less than 1MW of electricity are usually not economical. A 1MW wood waste electrical generation plant was recently built in Carson City, Nevada, which will consume 12,000 to 15,000 tons of wood waste annually. A 5MW electrical generation plant will require up to 75,000 tons of wood waste annually. Given the available wood waste supply in Kansas, the only area where electrical generation may be potentially feasible is in the three urban counties containing the cities of Wichita, Topeka, and Kansas City. Electrical generation using woody biomass may also be feasible in areas of the southeast portion of the state given the high concentration of wood waste suppliers. A complete site-specific supply analysis should be conducted if this type of wood waste utilization is contemplated.

Additionally, counties that exceed 1,000 tons of wood waste annually have the potential to power converted or new small wood boilers to produce heat or steam. Seven of the ten public schools in Montana that utilize wood for heat energy, established through the Fuels for Schools and Beyond initiative, utilize less than 1,000 tons of processed wood to power these facilities on an annual basis. Replacing fuel oil, propane, or natural gas heating systems with woody biomass

boilers has not only diverted this waste wood from landfills and burn-piles, but it has created annually cost savings for these seven facilities ranging from $12,500 – $103,000 dollars.

Thermo-chemical processes have been developed that use wood to produce bio-fuels such as cellulosic ethanol and bio-diesel. Abengoa Bio-energy Corporation is currently operating a site in Colwich that produces ethanol mostly from grain, and has plans for another site in Hugoton. Although this company has no plans for wood waste utilization, such energy intensive facilities present some waste-wood energy potential. Waste-wood can be utilized to produce heat and steam for the corn ethanol production process.

Wood Pellets

Wood pellet demand is continually increasing from North American and international markets. Policy changes to combat climate change and the desire for nations to diversify fuel supply and increase renewable energy utilization has ignited the recent expansion in this sector. Wood pellets are usually made from dry, untreated, industrial wood waste such as sawdust, shavings or ground wood chips. This material under high pressure and temperature is compressed into small pellets, cylindrical in shape. Both softwood (e.g. conifers, pines) and hardwood (e.g. oak) species may be used as a raw material.

Pellet mills produce two grades of fuel – Premium and Standard. Standard pellets are derived from materials that produce more residual ash, such as tree bark or agricultural residues. Premium pellets are usually produced from hardwood or softwood sawdust containing no tree bark. Premium pellets make up 95 percent of current pellet production and can be burned in all appliances.

Currently there are 800,000 homes in the U.S. using wood pellets to heat their homes.[12] The highest demand for this product is in Europe where they consume over 6 million tons annually. U.S. consumers use 2 million tons annually and the demand is projected to increase as the social and political climates are increasingly shifting towards renewable energy consumption.

Prairie Fire Bioenergy Cooperative in Healy currently manufactures pellets from wood and agricultural wastes in Kansas and Colorado. The process of converting wood into pellets is simply done by loading the fine chips or sawdust into a hopper

[12] Pellet Fuels Institute. www.pelletheat.org

and pressurizing the material into a pellet. However, to produce pellets on a commercial level requires a large initial expenditure of capital to acquire the machinery, facilities, and feedstocks. Growth in the wood pellet market is expected to increase in the future making investment in the technology attractive at this time. It will be important to research feedstock supply and quality availability before any future pellet manufacturing plant is constructed.

5.2 Geo-Spatial Buffer Analyses

5.2.1 City Level Analyses

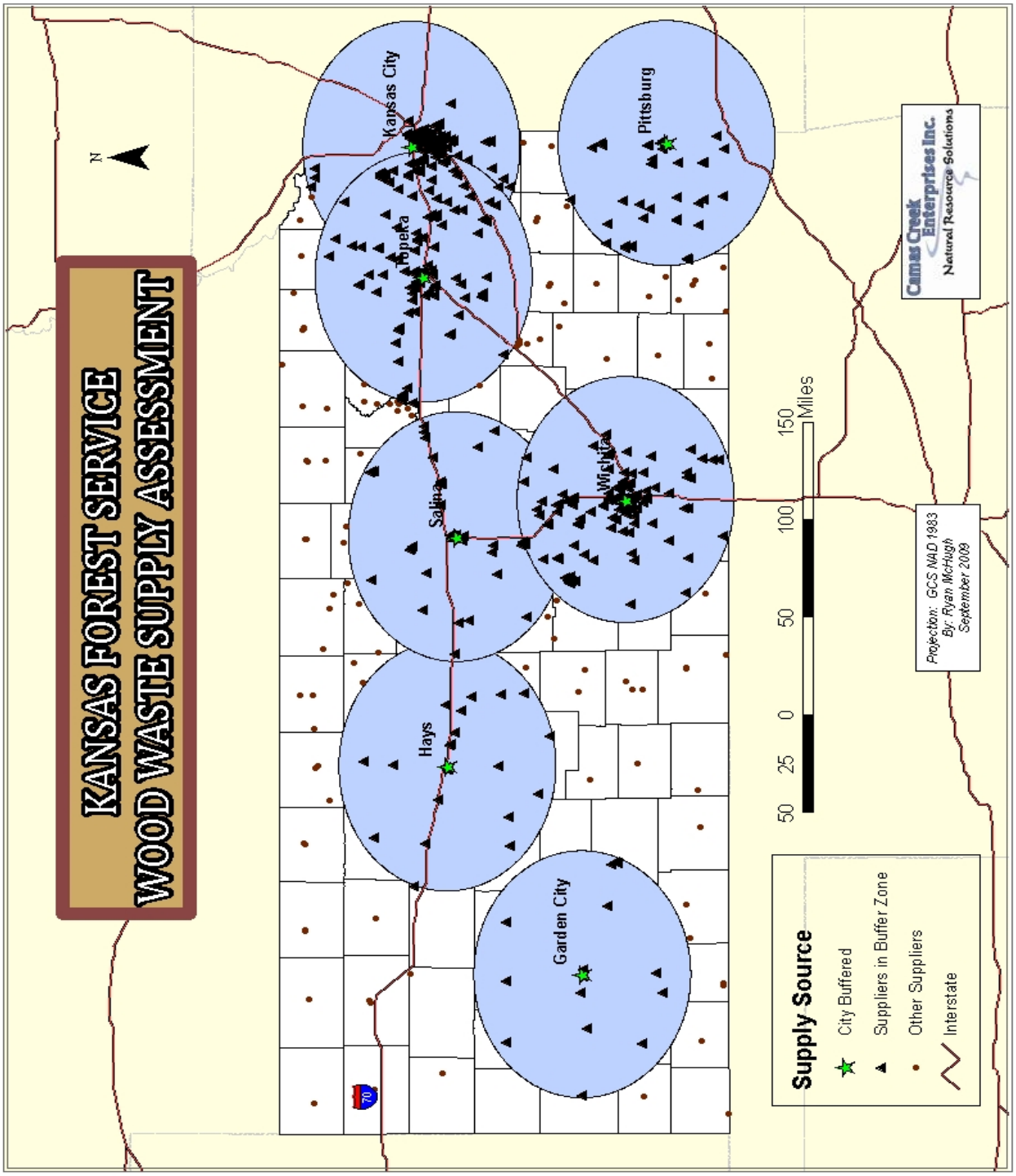
Wood waste supply was examined in a fifty (50) mile radius around seven select cities in Kansas that displayed potential as being centrally located to a significant amount of wood waste supply sources. Some of the buffer zones overlap, but most of the selected cities occupy spatially diverse areas across the state.

Kansas City and Wichita have the largest supply of wood waste within the buffer zone annually totaling 79,222 and 70,594 green tons respectively (Table 9). These two large cities, along with Topeka, have access to a hefty pool of supply sources that have concentrated their businesses around these metropolitan areas (Fig 10). Based on this wood waste supply assessment, these areas may be most suited for any large-scale wood to energy facilities that plan to produce heat or electricity. There is a significant concentration of secondary wood processors, and the vast majority of commercial and utility arborists in Kansas, operating around these major cities (see Figs 1-3). Results indicate that the buffered cities each have access to more than 10 Waste Disposal Sites within a fifty mile radius that could potentially supply more waste wood for bio-energy utilization projects.

Table 9. Wood Waste Produced by Suppliers within a Fifty Mile Radius of Selected Cities (Green Tons)

CITY	TOTAL WOOD WASTE	POTENTIALLY AVAILABLE	SUPPLIER COUNT	DISPOSAL SITES
KANSAS CITY	79,222	70,785	162	11
WICHITA	70,594	62,534	129	10
TOPEKA	39,624	29,388	137	14
PITTSBURG	29,783	16,177	39	15
SALINA	10,948	8,435	57	11
HAYS	7,223	6,086	28	10
GARDEN CITY	4,078	3,351	15	13

Figure 10. Suppliers Located within a Fifty-mile Radius of Seven Selected Cities in Kansas



5.2.2 Rural Area Analysis

The wood waste supply analysis revealed that thirty-eight of Kansas's 105 counties have wood waste supply that exceeds 1,000 tons annually. These counties are depicted in Figure 6 and should be considered as potential locations for small-scale wood-to-energy production. Information obtained via personal communication with David Atkins (USDA-Forest Service Wood Biomass Coordinator – Region One) confirmed that feedstock requirements for small scale wood boilers varies from 800 – 1,200 tons per year depending on boiler type, the amount of heat or steam required, and the number of calendar days each year that heat was required. This calculation, based on actual amounts of biomass feedstock required for various successful "Fuels for Schools" projects in Montana, assumes that between 5,000 – 5,400 BTUs are produced from each pound of biomass feedstock. For example, the Darby Montana 3.3 MMBTU wood biomass boiler when operated about 200 days per year consumes between 800 to 1,000 tons of biomass feedstock annually.

There are a handful of rural counties that produce wood waste in excess of 1,000 tons that may be suitable candidates for small-scale woody biomass boilers. Harper, Marion, Edwards, Marshall, Doniphan, and Coffey counties all reside either on the perimeter, or outside the fifty mile buffer zones from the large cities and have population levels below 15,000 residents.

6.0 CONCLUSIONS

6.1 Supply Summary

The state of Kansas currently has an available supply of wood waste that would allow for expansion of wood to energy facilities in site specific areas of the state. The following bullets highlight some of the key findings from the study that indicate the possibility for Kansas bio-energy development:

- There is an estimated 282,724 green tons of woody biomass produced annually in Kansas by the wood processing, utility, and commercial and municipal arborist supply sector.
- 67, 822 green tons of wood waste is annually received at municipal waste sites in Kansas. Fifteen counties have disposal sites that receive tree waste wood in amounts that exceed 1,000 green tons.
- Thirty-eight counties in the state have suppliers that produce total wood waste that exceeds 1,000 green tons annually, with seven of these counties producing wood waste in excess of 9,000 green tons annually
- A large proportion of total woody biomass supply is concentrated around the major cities in central and eastern Kansas (Kansas City, Topeka, Wichita, and Pittsburg)
- A relatively small amount of wood waste is currently utilized in Kansas. Statewide, 66% of all processed and un-processed waste wood material is available at this time (approximately 187,000 tons). Respondents indicated that currently this material is either given away or disposed of some manner, and would be potentially available if a wood waste market developed.
- 67% of all wood waste material generated in the state is already in a processed form by mechanized chipping or grinding practices and may be suitable as feedstock to produce renewable energy.
- Site specific supply information and a detailed feasibility study is necessary for all potential wood to energy projects. For each project level analysis, supply source suitability should be examined and supplier selection criteria developed.

6.2. Further Research

- The locations and supply of other sources non-woody biomass (such as agricultural crops and animal husbandry by-products) should be examined to complement recently assessed woody biomass feedstock supply sources.

- Comprehensive collaboration with the existing bio-ethanol plants and other bio-energy industries may also be effective to help identify potentially-available supply, efficient logistical systems and optimal locations of new bio-energy locations, as feedstock transportation is often the most costly expenditure of biomass utilization. Long haul distances and inefficient transportation practices can quickly make the delivery of feedstock un-economical, even when the raw material costs are relatively inexpensive. Streamlining this process with an integrated infrastructure of transportation and well positioned receiving facilities will be necessary to make the biomass industry in Kansas more successful.

- Monitoring current technology developments for converting wood waste to transportation fuels such as cellulosic ethanol will be an integral step for successful maturity of this industry in Kansas.

- Identification of the federal grant, loan and tax incentives for renewable energy projects will be an important step for project development and operation.