IDENTIFYING RESOURCES AND OPTIONS TO MITIGATE THE RISK OF WILDLAND FIRES IN NORTH DAKOTA

Final Report

Prepared for:

North Dakota Forest Service

307 1st Street East
Bottineau, ND 58318-5422

Prepared by:

Darren D. Schmidt
Sheila K. Hanson
Kyle E. Martin

Energy & Environmental Research Center
University of North Dakota
Box 9018
Grand Forks, ND 50202-9018

2003-EERC-06-04 June 2003

DOE DISCLAIMER

ACKNOWLEDGMENT

This report was prepared with the support of the U.S. Department of Energy (DOE) National Energy Technology Laboratory Cooperative Agreement No. DE-FC26-98FT40321. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the authors(s) and do not necessarily reflect the views of DOE.

EERC DISCLAIMER

TABLE OF CONTENTS

Continued...

TABLE OF CONTENTS (continued)

Continued...

TABLE OF CONTENTS (continued)

LIST OF FIGURES

PART I

LIST OF TABLES

PART I

PART II

PART III

PART I – BIOMASS RESOURCES

EXECUTIVE SUMMARY

The North Dakota Forest Service through the Economic Action Program of the U.S. Forest Service National Fire Plan is supporting a study by the University of North Dakota Energy & Environmental Research Center. The goal of the study is to mitigate the risk of fire in North Dakota by identifying the opportunities for biomass utilization through local energy and product markets. Objectives include completing a biomass resource assessment, a market assessment, and outreach for the state of North Dakota. The data supporting the results of the biomass resource assessment are contained in this document.

The results indicate a potential to utilize over 6.5 million tons/yr of biomass material in the state for energy or products. Production from forested land could amount to over 500,000 tons/yr of resource. Quantities are primarily available from private land, although 47,000 tons/yr could be supplied as harvested grass and tree mortality from state and national parks. Municipal sources of wood such as tree trimmings and storm debris account for 156,000 tons/yr. Potential biomass production from Conservation Reserve Program (CRP) land is the largest resource, accounting for 85% of the total potential amount. Production from CRP is possible under federal guidelines if a dedicated biomass energy crop is produced.

Biomass resource data was combined with county fire district data for the annual average number of fire starts over 10 yr. The overlap of fire start data and resource data indicates areas of priority to mitigate fire risk by utilization of biomass. The regional rankings are as follows:

1. Bismarck–Mandan Area
2. Counties Bordering Lake Sakakawea
3. Turtle Mountain–Peace Garden Area
4. Ponderosa Pine Forest in Southwest North Dakota
5. Pembina Valley Region

Significant opportunities to utilize biomass and reduce fire risk occur in the areas listed above. The Bismarck–Mandan area stands out significantly because of a high volume of resource, large population, and considerable fire start history. Counties bordering Lake Sakakawea contain a significant river basin forest and represent a relatively dry area of the state. The Turtle Mountain–Peace Garden Area contains significant forest and municipal sources of wood. The Pembina Valley and Ponderosa Pine Forest are also areas of significant forest cover, with the Ponderosa Pine Forest in Slope and Golden Valley Counties having very low precipitation and a high number of fire starts.

PART I – BIOMASS RESOURCES

INTRODUCTION

Dry conditions and increases in fuel loading in western North Dakota have favored the development of large wild fires. Last year a dramatic rise occurred in the annual number of fires and their average size. Across the country, California, Colorado, and Arizona experienced major fires all summer. These fires were not limited to woodlands, but devastated communities as well. The conditions necessary for large-scale wildfires have prevailed in states with smaller forest resources, as well as in largely forested states. North Dakota, which is sparsely forested, experienced several large fires. The most visible incident occurred in Shields, North Dakota, where a major fire destroyed 85% of the structures in the town.

This study had three main objectives. The first was to quantify the amount and location of the various types of biomass within the state. The second was to identify areas prone to fire and areas that have a predisposition to conditions conducive to fire. The third and final objective was to combine the information collected and make recommendations as to target areas and best possible uses for biomass within those areas for the purpose of fire risk mitigation.

ANALYSIS PROCEDURE

A county-by-county analysis technique was used and is justified as follows. The state of North Dakota has a population of 642,200 and encompasses an area of over 69,000 square miles (approximately 44,000,000 acres) (see Appendix A for a summary of all data collected in the state). Forested land comprises 1.5% of the total amount of land and is widely distributed. North Dakota has 53 counties, ranging in size from 630 to 2742 m^2 and having populations spanning from 750 to 125,000. Population and forestry are concentrated, but not in the same location. Cass, Burleigh, Grand Forks, and Ward Counties account for 50% of the state's population, while Cavalier, Bottineau, Rolette, Dunn, and McKenzie Counties account for 50% of forested acres. None of the 10 counties contain both significant population and forestry. A study on a county basis provides a focus that is useful to local interests who may benefit from biomass utilization.

The quantification process considered biomass resources of significant impact, location, and quantity. Analysis of the state was completed for five resources:

1. Forest resources (wood)
2. Conservation Reserve Program (CRP – hay)
3. Abandoned buildings
4. Municipal tree waste
5. State and national parks (combination of grass and woodlands)

The results were compared to regions considered high-risk fire areas. Several agencies including the Division of Emergency Management (DEM), the U.S. Forest Service (USFS), and

the National Weather Service were contacted to determine areas of high fire risk. Their suggestions were used to focus the study. These agencies recommended quantifying fire risk and fire occurrence using two methods. The first method includes an examination of the 10-year fire occurrence statistics. These data represent areas that have a high rate of fire occurrence over long periods. The second method involves the determination of areas that are at risk of fire, a difficult criterion to quantify since no single way exists to predict that an area will experience fires. High-risk zones may be defined by high fuel loading, high recreational use, or low annual precipitation. The consensus recommended by the North Dakota Forest Service (NDFS), DEM, and the USFS was to consider areas of low annual rainfall as the highest risk. The recommendation was based on the lack of data currently available to correctly assess fire risk.

FOREST-BASED RESOURCE ASSESSMENT

North Dakota is predominantly a farming state with approximately 90% of its land being used for agriculture. This is slowly changing. The state has actively pursued reforestation practices for soil conservation, windbreaks, and recreation. The process has included many projects to restore riparian forests and the increased plantings of windrows. Figure 1 provides an indication of where significant forest resources are located in North Dakota.

North Dakota's forestry resources have been quantified in the following literature:

- Jakes, P.J.; Smith, B.W. *A Second Look at North Dakota's Timberlands*; U.S. Department of Agriculture Forest Service Bulletin NC-58 (1), 1980.

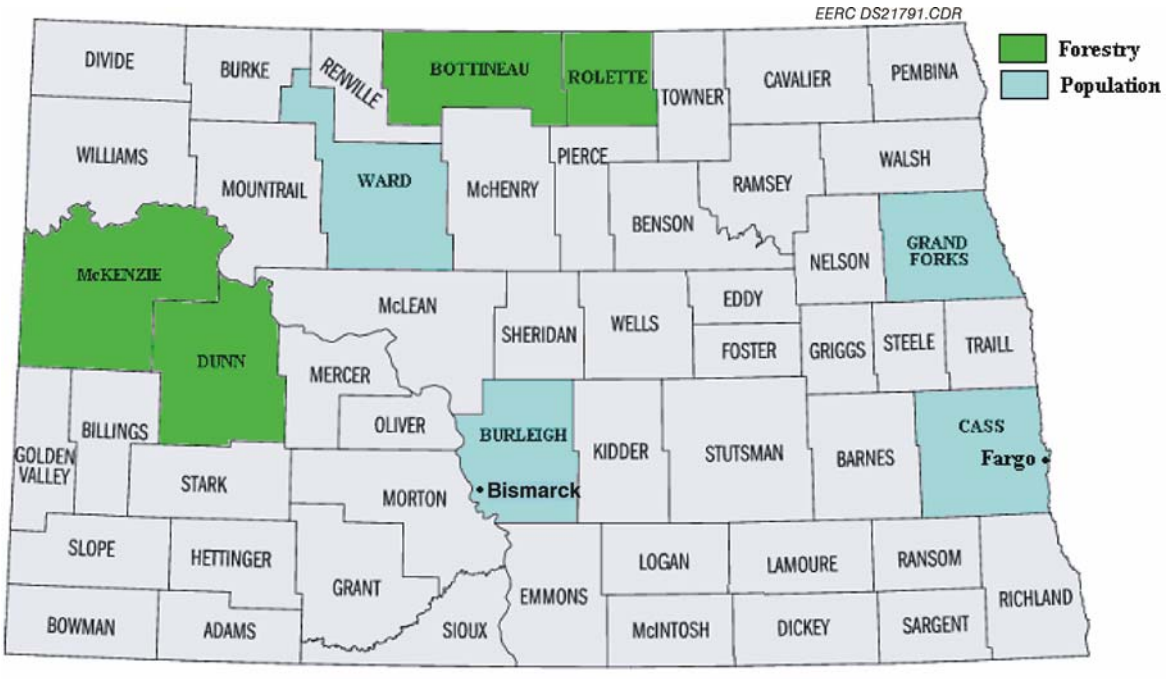


Figure 1. North Dakota counties and location of significant forest resources and population.

- Haugen, D.E.; Harsel, R.A. *North Dakota's Forest Resources*, U.S. Department of Agriculture Forest Service Bulletin NC-336 (2), 1994.

The above studies represent the most accurate and up-to-date analysis of North Dakota's forestry resources. Both reports were developed using a combination of 240,000 aerial photos, 266 ground plots, and computer modeling of 48 forested plots that were left undisturbed between the 1980 and 1994 reports. It should be noted that the Northwest Research Station is currently in the second year of a 5-year cycle in which they are reclassifying and quantifying the state's resources. The results of the new study will utilize the same methodology as the aforementioned reports. The magnitude of coverage will be increased, and the survey will become the most accurate summary of North Dakota's forest resources. Results of the study should be available in 2005 or 2006. The 1994 report provides data on a drainage basin basis (Figure 2) versus a county basis used in the 1980 report. Data from both reports were combined to provide meaningful region-specific data and to estimate resources on a county basis. A combined weighted average method was used. This process entailed using 1980 data to find a percentage of zone for each county, then converting it into 1994 zone data. Table 1 provides data for an example calculation for the Souris River basin.

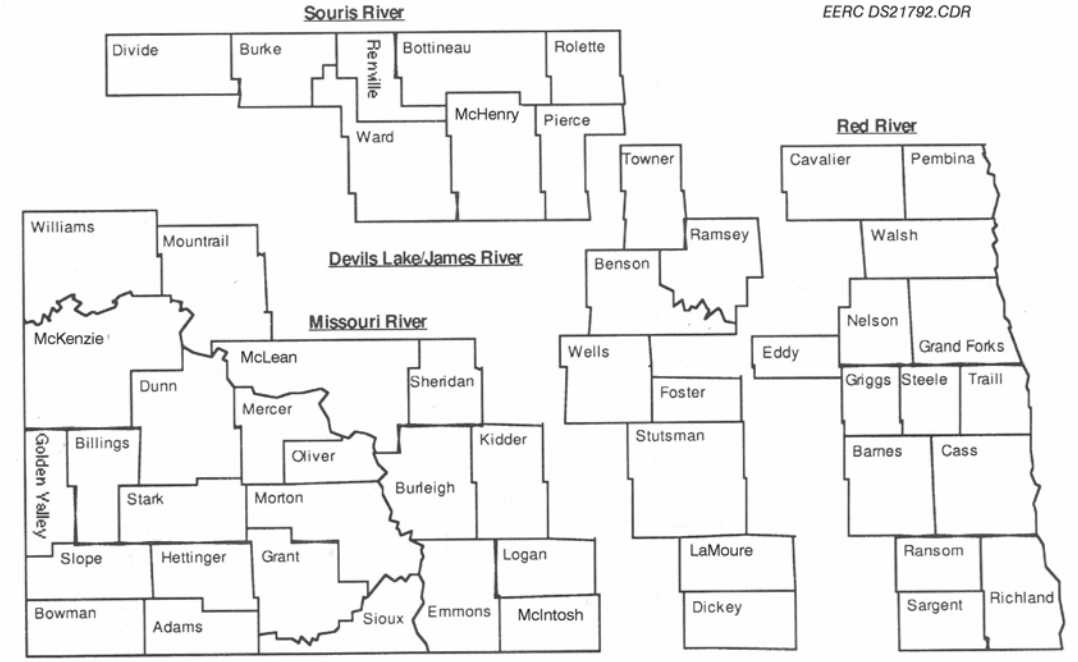


Figure 2. Drainage basins in North Dakota (Bulletin NC-336).

Table 1. Example Method and Calculation of Data Adjustments

County	Zone 1980	Acres of Trees 1980	Zone 1994	Acres of Trees 1984	% of zone 1994	Acres of Trees in Each County 1994
Bottineau	East	44,300	Souris	138,500	33.54%	46,446
Burke	West	700			0.53%	734
Divide	West	300			0.23%	315
McHenry	East	14,300			10.83%	14,993
Pierce	East	2,100			1.59%	2,202
Renville	West	900			0.68%	944
Rolette	East	64,100			48.52%	67,206
Ward	West	5,400			4.09%	5,662
Total		132,100				138,500

Step 1: Find the overall percentage of total forest coverage of each county for a specific river basin:

$$\frac{44{,}300}{132{,}100} = 33.54\%$$

Step 2: Because the relative distribution of forestry remains nearly constant, extrapolate the percentage from 1980 directly to the 1994 zone

$$33.54\% \times 138{,}500 = 46{,}446$$

The method results in a reasonable correlation between data sets and represents the most accurate current data. It is recommended that when the next data set becomes available (2005–2006), an update should be made to this analysis method.

Two assumptions were made in converting the data. First, it was assumed that areas as large as a county experience the same average annual growth, so the distribution that existed in 1980 would be the same in 1994. It was also assumed that no individual plantings or large projects were undertaken that would shift the averages. In addition to the aforementioned assumptions, no attempt was made to estimate growth between 1994 and 2002. The following is an excerpt from the 1994 Forestry Service report and states the data accuracy:

> The estimated growing stock in 1994 was 329.7 million cubic feet, with a sampling error of ±8.8% (±29 million cubic feet). The growing stock volume from a 100% inventory would be expected to fall between 300.7 and 358.7 million cubic feet, with there being a 1 in 3 chance that this is not the case.

Assuming that the combination of the data introduced no significant error, it is reasonable to predict that the accuracy is on the same order as the Forestry Service report.

The total forest cover in North Dakota is 673,200 acres. The major species include ash, elm, aspen, oak, cottonwood, and pine. Table 2 shows the relative amounts of material that could

Table 2. Acres of Forest in North Dakota by County

County	Acres Forest	Mortality, tons/year	Average Forest Production, tons/year	Maximum Forest Production Tons/Year	County	Acres Forest	Mortality Tons/Year	Average Forest Production, tons/year	Maximum Forest Production, tons/year
Adams	180	35	95	158	McLean	13,346	2,569	7,007	11,678
Barnes	7,049	1,357	3,701	6,168	Mercer	5,411	1,042	2,841	4,734
Benson	25,760	4,959	13,524	22,540	Morton	11,001	2,118	5,776	9,626
Billings	31,020	5,971	16,286	27,143	Mountrail	15,691	3,020	8,238	13,729
Bottineau	46,446	8,941	24,384	40,640	Nelson	5,639	1,086	2,960	4,934
Bowman	902	174	473	789	Oliver	6,673	1,285	3,503	5,839
Burke	734	141	385	642	Pembina	33,617	6,471	17,649	29,415
Burleigh	14,067	2,708	7,385	12,309	Pierce	2,202	424	1,156	1,927
Cass	12,362	2,380	6,490	10,817	Ramsey	2,297	442	1,206	2,010
Cavalier	43,594	8,392	22,887	38,145	Ransom	17,242	3,319	9,052	15,087
Dickey	984	190	517	861	Renville	944	182	495	826
Divide	315	61	165	275	Richland	9,760	1,879	5,124	8,540
Dunn	68,353	13,158	35,885	59,809	Rolette	67,206	12,937	35,283	58,805
Eddy	4,012	772	2,106	3,511	Sargent	1,410	271	740	1,234
Emmons	9,198	1,771	4,829	8,048	Sheridan	13,526	2,604	7,101	11,836
Foster	164	32	86	144	Sioux	721	139	379	631
Golden Valley	4,328	833	2,272	3,787	Slope	3,968	764	2,083	3,472
Grand Forks	11,929	2,296	6,263	10,438	Stark	7,575	1,458	3,977	6,628
Grant	5,230	1,007	2,746	4,576	Steele	3,904	752	2,050	3,416
Griggs	3,687	710	1,936	3,226	Stutsman	2,297	442	1,206	2,010
Hettinger	721	139	379	631	Towner	82	16	43	72
Kidder	0	0	0	0	Traill	9,109	1,754	4,782	7,971
LaMoure	1,067	205	560	933	Walsh	19,086	3,674	10,020	16,700
Logan	361	69	189	316	Ward	5,662	1,090	2,972	4,954
McHenry	14,993	2,886	7,871	13,119	Wells	1,149	221	603	1,005
McIntosh	721	139	379	631	Williams	6,132	1,180	3,219	5,365
McKenzie	99,373	19,129	52,171	269,656	Total acres	673,200			
					Total, tons/year		129,591	353,430	589,050

* Mortality refers to the amount of tree material that dies every year. State average is 11 ft^3/year.
The production represents the amount of wood that a given forest stand can produce. The median production is based on 30 ft^3/year while the maximum production is based on an estimate of 50 ft^3/year.

be available within the state by county and in total. Analyses determined that mortality alone could result in up to 129,591 tons of biomass annually. Production is defined as the expected amount of material that could be harvested annually using sustainable management techniques. Based on average to maximum estimated production rates, North Dakota forests have the potential to produce between 353,430 and 589,050 tons/yr.

CONSERVATION RESERVE PROGRAM

The CRP is a voluntary program that allows agricultural landowners to receive annual rental payments and cost-share assistance to establish long-term, resource-conserving covers on eligible farmland placed into the program. Due to the wide variety in soil quality across the state, the downturn in the agricultural economy, and the average age of farmers, a slow and steady increase has occurred in the number of acres being placed into CRP. More than 3.3 million acres of CRP exist (approximately 10% of the total land), with an ability to produce an average of 1.7 tons of hay/acre across the state.

The 1985 farm bill provided for some ability to enroll CRP land for the purpose of energy crop or biomass energy production. The Conservation Reserve Program Biomass Pilot Projects was a program to stimulate growth in rural areas and was administered by the Farm Service Agency of the U.S. Department of Agriculture (USDA). This program was announced in November 2000 and had a statutory limit of six biomass pilot projects. The six energy-based projects enrolled in the program included:

- Switchgrass development in Iowa.
- Hybrid poplar trees in Minnesota.
- Willow crops in New York.
- Switchgrass for sale to a local cooperative's coal-fired fluid-bed combustor in Pennsylvania.
- A switchgrass project in Illinois.
- A project in Oklahoma using old world bluestem native grass for power.

The first four projects were approved March 21, 2001, and the latter two were approved March 26, 2002.

The 2002 farm bill now has provisions for harvesting of biomass on CRP lands. The bill was signed into law May 13, 2002, and legislation has been published as of May 8, 2003, in the Federal Register under 7 CFR Part 1410, titled "Part IV Department of Agriculture, Commodity Credit Corporation, 2002 Farm Bill, Conservation Reserve Program, Long Term Policy; Interim Rule." Prior to the 2002 act amendments, the 1985 farm bill generally provided that no commercial use could be made of land enrolled in CRP but permitted haying or grazing during droughts or similar weather-related emergencies. The 2002 act amended that provision by adding an exception for managed harvesting and grazing, including the managed harvesting of biomass and installation of wind turbines. Managed haying and grazing will be limited to no more than once every 3 years, depending on conservation plan guidelines, with additional restrictions in environmentally sensitive areas or practices. All haying and grazing activities will be conducted only after a detailed conservation plan is developed for haying or grazing management according to the National Resources Conservation Service Field Office Technical Guide (FOTG) on haying and grazing standards. The FOTG standards can be found at http://www.nrcs.usda.gov/technical/efotg. Under Section 1410.63, permissive uses are defined. The pertinent definitions are as follows:

- Managed haying and grazing, including the harvest of biomass, is permitted in exchange for a reduction of the annual payment in an amount determined by the deputy administrator in accordance with FOTG standards.
- Forestry maintenance such as pruning, thinning, and timber stand improvement is permitted on lands converted to forestry use in accordance with a conservation plan and

in exchange for an applicable reduction in the annual rental payment determined by the deputy administrator.

- The sale of carbon and other environmental credits will be permitted.

Other requirements for CRP enrollment under the 2002 farm bill are as follows. Owners must have operated the lands 12 months prior to signup, which also applies to tenants of lands. Land eligible for CRP enrollment includes the following:

- Cropland subject to a conservation plan and which has been planted in four of the six crop years from 1996 to 2001.

- Marginal pasture land that meets CRP criteria specified in section 1410.6.

- Previously enrolled CRP lands.

Contracts will extend over a period of 10 years. Rental payments cannot exceed $50,000/yr.

CRP lands should be considered in a high-risk fire assessment based on the following:

- An enormous amount of land is involved in the program.

- The land has the potential to produce a significant supply of biomass.

- The land occurs in large unbroken tracks, which pose the potential of giant, fast-moving wild fires, specifically along the I-94 corridor between Valley City and Bismarck.

- The land has the potential to be economically beneficial to areas experiencing economic depression.

Biomass production from CRP land was determined by consulting the USDA Census of Agriculture and the North Dakota State University Extension Service. The census provided the average hay land production on a county basis, while the Extension Service provided average yield for CRP land. These data were compared and determined to be on average within ±3% of each other. The average yield for each county from the census was used to approximate the total amount of hay production each year by county. Table 3 shows the average annual production for each county.

Table 3 shows the total amount of production for an average year. An important factor to consider is that under the conservation program only 25% of a district may be harvested each year, and that area can only be harvested biannually. Because there are nine districts within North Dakota and boundaries were not available, Table 2 approximates the production each county would be permitted. It is important to note that a biomass energy project could conceivably draw from multiple counties.

Table 3. Acres of CRP and Theoretical Production by County

EERC DS21895.CDR

County	CRP Acres	Hay, tons/year	County	CRP Acres	Hay, tons/year
Adams	73,967	91,719	McLean	77,997	120,115
Barnes	103,125	177,375	Mercer	16,024	21,793
Benson	53,115	81,266	Morton	34,395	81,860
Billings	18,205	21,846	Mountrail	53,134	82,889
Bottineau	115,277	176,374	Nelson	125,757	242,711
Bowman	62,929	74,256	Oliver	4,793	10,545
Burke	50,327	102,164	Pembina	33,470	53,552
Burleigh	100,809	181,456	Pierce	80,953	97,144
Cass	32,049	59,932	Ramsey	74,651	124,667
Cavalier	50,973	95,829	Ransom	81,776	173,365
Dickey	74,777	165,257	Renville	19,798	38,408
Divide	73,131	143,337	Richland	34,566	67,404
Dunn	21,004	36,547	Rolette	72,052	122,488
Eddy	72,067	108,101	Sargent	41,223	75,438
Emmons	71,783	138,541	Sheridan	66,470	117,652
Foster	28,194	51,313	Sioux	9,060	16,942
Golden Valley	35,899	34,822	Slope	24,725	46,978
Grand Forks	94,709	189,418	Stark	91,146	157,683
Grant	54,747	109,494	Steele	25,596	40,186
Griggs	85,002	127,503	Stutsman	182,156	326,059
Hettinger	114,164	230,611	Towner	66,615	113,246
Kidder	111,413	174,918	Traill	7,739	13,930
LaMoure	68,607	139,958	Walsh	112,872	207,684
Logan	61,277	128,069	Ward	41,964	84,767
McHenry	116,305	163,990	Wells	71,197	119,611
McIntosh	59,037	100,953	Williams	55,456	100,930
McKenzie	20,872	31,725			
Total Acres of CRP in North Dakota		3,329,344			
Total Tons/Year of CRP Hay in North Dakota		5,794,822			

ABANDONED BUILDINGS

The population in North Dakota declined 1% from 1990 to 2000. This change is misleading. The true demographics show a steady migration from rural to urban centers. Examination of the 53 counties within the state shows that only five counties have experienced growth from 1990 to 2000, while the other 48 lost population. Of the 48 counties with declines, 13 experienced population losses greater than 20% over a 10-year period.

One result of this migration is that many houses, sheds, and other structures are no longer used or maintained. Yards are becoming overgrown and dead material is accumulating in close proximity. In areas where there has been a large population migration, these unused structures present a fire risk to neighboring structures, grasslands, and forests. A recent wildfire in the town of Shields, North Dakota, destroyed 85% of the structures. Occupied buildings may have been saved had unoccupied structures been removed prior to the event.

Determination of an average number of abandoned buildings was difficult. Due to state laws on tax exempt structures and other complications, no agency has an accurate count for how many abandoned buildings exist. A two-step process was used to determine the approximate number of structures that may have been abandoned in each county. With U.S. census data, family size and total number of families that have left each county over the last ten years was calculated. It was assumed that each family owned one house and one garage or shed. It was assumed that 10% of these structures were actually abandoned and left in place. The results of the calculation were examined, and some results were noted as being erroneous. Figure 3 shows abandoned buildings vs. population. A locus of points between 25 and 100 buildings was discovered. A constant factor of 50 buildings per county was determined to be the best representation of the data. A visual count was performed on a drive through Traill, Steele, and Griggs Counties along Highway 200 to verify the approximation. A count of 50 buildings per county resulted. It is most likely that the number is greater per county since only a straight-line path was surveyed. However, for the purposes of this study a conservative estimate of 50 was used. Figure 3 summarizes the data.

Communication with Carrington House Movers of North Dakota provided an estimate of approximately 6.25 tons of wood in an average 1400-square-foot house with a single garage. The demolition of 50 houses per county would result in a total of 16,562 tons of material statewide. The DEM's Hazard Mitigation Grant Program has been involved in the purchase and demolition of flood-prone structures of which a large number have occurred in the counties of Barnes, Walsh, Benson, and Ramsey because of high water tables.

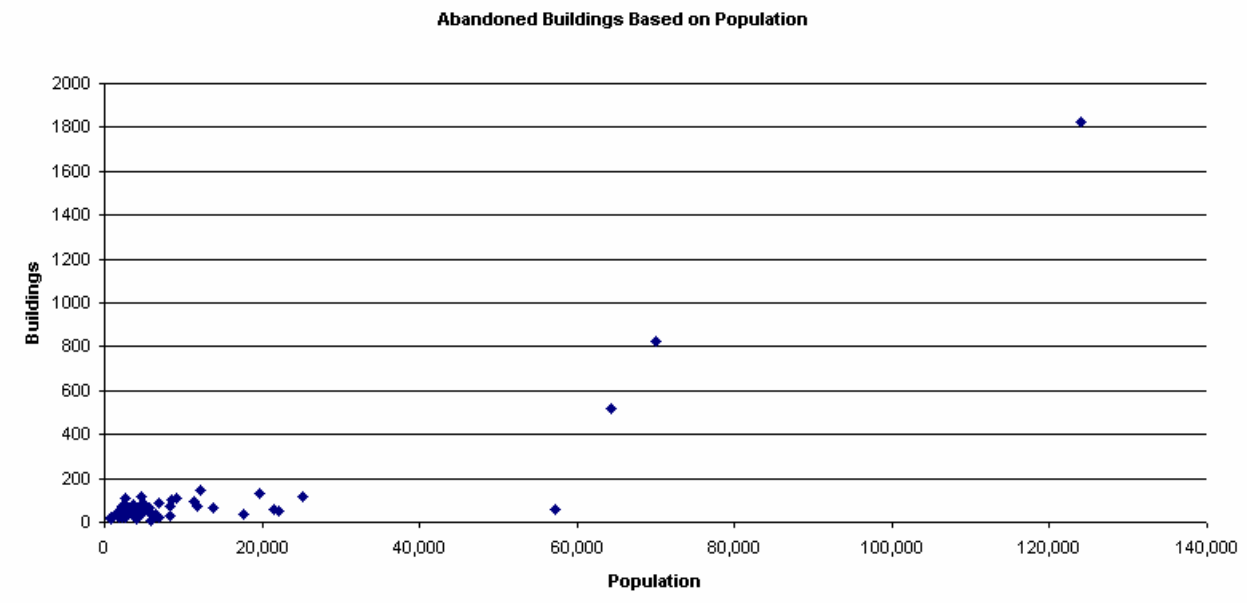


Figure 3. Census data results for approximation of abandoned buildings.

MUNICIPAL TREE WASTE

Municipal tree waste is a highly concentrated and useful source of biomass. Municipal wood is easily accessible because of location and is typically available on a consistent basis. The North Dakota Department of Health (NDDH) provided a set of annual reports by various city landfills. These reports summarized quantification of waste and in some cases included subcategorization. Data reduction resulted in inconsistencies. Twelve locations yielded consistent and accurate data. These sites generally were larger communities where funding for equipment and scales was available or where the managers of the landfill kept accurate records. Figure 4 shows the results of the data obtained from the landfills.

Approximately 0.28 tons/person of tree waste is produced each year. Table 4 shows a compilation of the data. Nearly 156,000 tons of tree waste can be collected annually across the state. Recently, NDDH has been denying permits for open pit burning in larger communities. This trend is expected to continue and will be conducive to the availability of municipal wood for alternative uses.

STATE AND NATIONAL PARKS

Parks are managed separately from private lands. Locations are shown in Figure 5. These areas tend to contain large quantities of older forests. Coupled with the amount of human interaction a park experiences, it is at a much higher risk for fire than are private lands. The combination of fire risk and probability that a fire would cause property damage or threaten

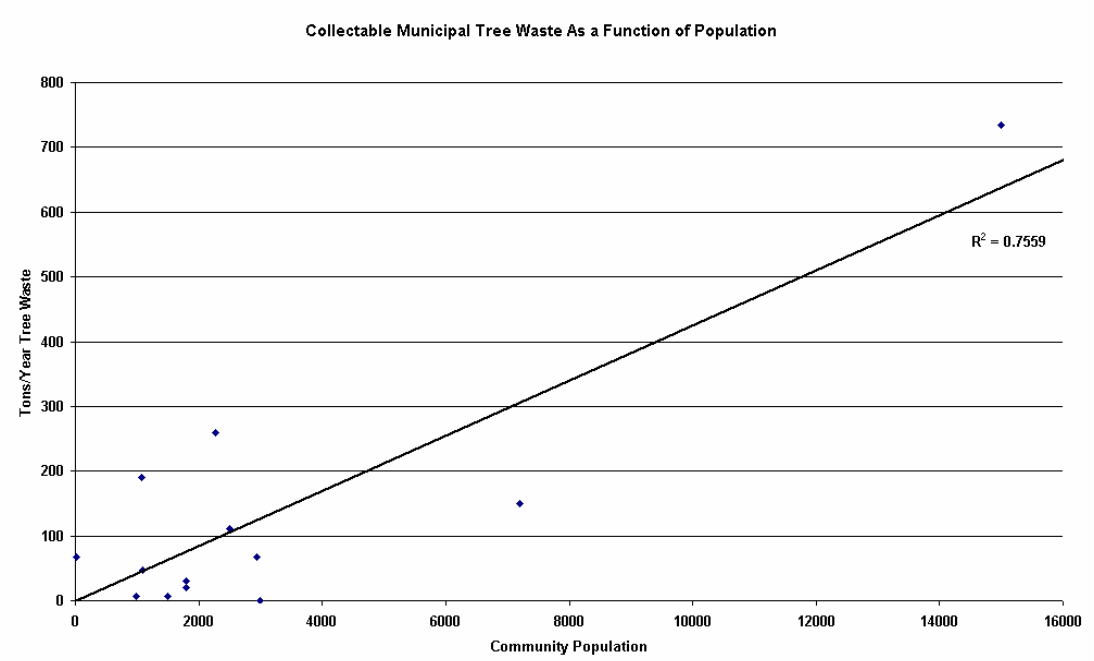


Figure 4. Municipal tree waste from landfills.

Table 4. Municipal Tree Waste

County	Municipal Tree Waste, tons/yr	County	Municipal Tree Waste, tons/yr
Adams	456	McLean	1,875
Barnes	2,658	Mercer	2,006
Benson	1,348	Morton	6,436
Billings	59	Mountrail	1,233
Bottineau	1,374	Nelson	662
Bowman	630	Oliver	285
Burke	293	Pembina	1,871
Burleigh	19,341	Pierce	926
Cass	34,430	Ramsey	2,939
Cavalier	709	Ransom	1,320
Dickey	1,193	Renville	419
Divide	255	Richland	4,249
Dunn	477	Rolette	3,453
Eddy	551	Sargent	846
Emmons	608	Sheridan	147
Foster	492	Sioux	918
Golden Valley	347	Slope	6
Grand Forks	17,664	Stark	5,737
Grant	339	Steele	347
Griggs	457	Stutsman	5,405
Hettinger	410	Towner	421
Kidder	387	Traill	1,970
LaMoure	812	Walsh	2,800
Logan	281	Ward	15,404
McHenry	982	Wells	950
McIntosh	593	Williams	4,926
McKenzie	1,056		
Theoretical Tons of Municipal Tree Waste Produced Each Year			155,752

people's safety makes parks a prime candidate for the use of biomass for fire mitigation. 13 state parks, one national park, and several recreational areas and historic sites are located in North Dakota. These parks, which are typically held as wilderness areas, contain large tracts of forest and grassland in highly localized areas. Additionally, little has been done to reduce forest fuel loadings in these areas. The forest management practice has been to allow no use of wood from within the park, instead allowing the natural life cycle of growth, death, and decay. In some cases natural methods have worked, but in the dryer areas, the decay has not proceeded at a sufficient pace and an abundance of downed and dried wood has accumulated. As such, the approximately 80,000 total acres of parks within the state have become high-risk fire areas.

The quantity of forest and grassland in North Dakota parks and recreational areas was determined by contacting each park headquarters. Table 5 summarizes the theoretical amount of biomass that could be collected from the various state and national parks. The data contained in Table 4 shows the park and the amount of biomass that each possess from both wood and grass. As shown, a theoretical amount of 41,849 tons of hay could be harvested each year while 5,475 tons of wood from tree mortality could be gathered. Due to the nature of parks and the management of the resources within, it was assumed that no harvesting at higher levels of sustainable forest production (30–50 ft^3/yr) would be implemented.

Figure 5. State and national parks of North Dakota.

Table 5. Acres of Forest and Grassland in National and States Parks

National Park	County*	Park Size, acres	Acres Grass	Hay, tons/year	Acres Forest	Mortality, tons/year
Theodore Roosevelt South	Mckenzie	46,158	4,816	7,320	13,012	2,505
Theodore Roosevelt North	Billings	24,070	24,348	29,218	11,635	2,240
Theodore Roosevelt Elkhorn	Billings	218	168	202	50	10
Total		70,446	29,332	36,740	24,697	4,754

State Parks	County*	Park Size, acres	Acres Grass	Hay, tons/year	Acres Forest	Mortality, tons/year
Sully Creek State Park (satellite)	Billings	80	14	17	23	4
Beaver Lake State Park	Logan	266	166	347	36	7
Cross Ranch State Park	Oliver	589	63	139	447	86
Grahams Island State Park	Ramsey	1,165	277	462	510	98
Doyle memorial State Park	McIntosh	21	14	24	7	1
Fort Abraham Lincoln State Park	Morton	1,106	492	1,171	130	25
Fort Ransom State Park	Ransom	890	471	999	284	55
Fort Stevenson State Park	McLean	549	223	343	80	15
Icelandic State Park	Pembina	912	186	297	381	73
Lake Metigoshe State Park	Bottineau	1,485	47	71	1,050	202
Lake Sakakawea State Park	Mercer	1,071	381	518	189	36
Lewis & Clark State Park	Willaims	490	176	321	62	12
Little Missouri State Park	Dunn	1,080	37	64	103	20
Turtle River State Park	Grand Forks	784	190	380	441	85
Total		10,488	2,735	5,152	3,744	721

Total For National & State Parks	80,934	32,067	41,891	28,441	5,475

* The county in which the park is located.

In addition to the state and national parks, numerous recreational areas and historic sites exist within the state. Although these areas consist of smaller resources, the data may provide useful for local interests. Table 5 shows their respective size and resources. Approximately 1130 tons of hay could be collected from these sites, while up to 178 tons of wood from tree mortality could be collected.

Table 6. Acres of Forest and Grassland in State Historic and Recreation Areas

Recreational Areas or Historic Site	Park Size, Acres	Acres Grass	Hay, tons/year*	Acres Forest	Mortality, tons/year
Butte Saint Paul Historic Site	47.0	3.3	5.7	43.7	8
Crow Flies High Historic Site	253.0	243.7	424.0	9.3	2
Devils Lake – Black Tiger Bay Rec. Area	23.0	0.0	0.0	5.0	1
Devils Lake – Shelvers Grove Rec. Area	20.0	0.0	0.0	11.0	2
Double Ditch Historic Site	116.3	93.0	161.8	4.9	1
Elmwood Natural Area	20.5	1.5	2.6	16.6	3
Head of the Mountain Nature Preserve	100.0	60.0	104.4	40.0	8
Missouri River Natural Area	157.3	18.2	31.7	123.5	24
Pembina Gorge Natural Area	698.3	32.3	56.2	666.0	128
Smokey Lake Natural Area	276.0	197.1	343.0	7.0	1
Total	1,711.5	649.1	1,129.4	926.9	178

*** Using average production of 1.74 tons/acre**

RESOURCE MAPPING

Acrview, a geographic information system software package, was used to create resource maps. The projection settings within Acrview specified a coordinate system of Universal Transverse Mercator 83 (UTM-83) and a localization of Zone 14. Acrview allows for the input of data and color-coding in the creation of coordinate-based data sets. Resource maps include the following:

Figure 6 Total acres of forest land by county.
Figure 7 Total acres of CRP by county.
Figure 8 Potential production from CRP by county.
Figure 9 Amount of collectible municipal tree waste by county.
Figures 10–12 Annual precipitation in North Dakota, 2000–2002.

Figure 6 shows on a countywide basis the relative concentration of forestry. As shown, the highest concentrations occur in the western part of the state and are located in the counties of McKenzie, Billings, and Dunn. Other concentrations are located in the Missouri River Valley, the Red River Valley, north-central North Dakota, and the northeastern counties.

Figure 7 shows the distribution of CRP acres across the state. Two areas are of interest. The first is the county of Grant, where annual precipitation is low and concentration of CRP is high. The second includes Burleigh, Kidder, Stutsman, and Barnes Counties. This band is significant because of its proximity to I-94 and the potential for wildfire to rapidly travel across unbroken tracts of CRP.

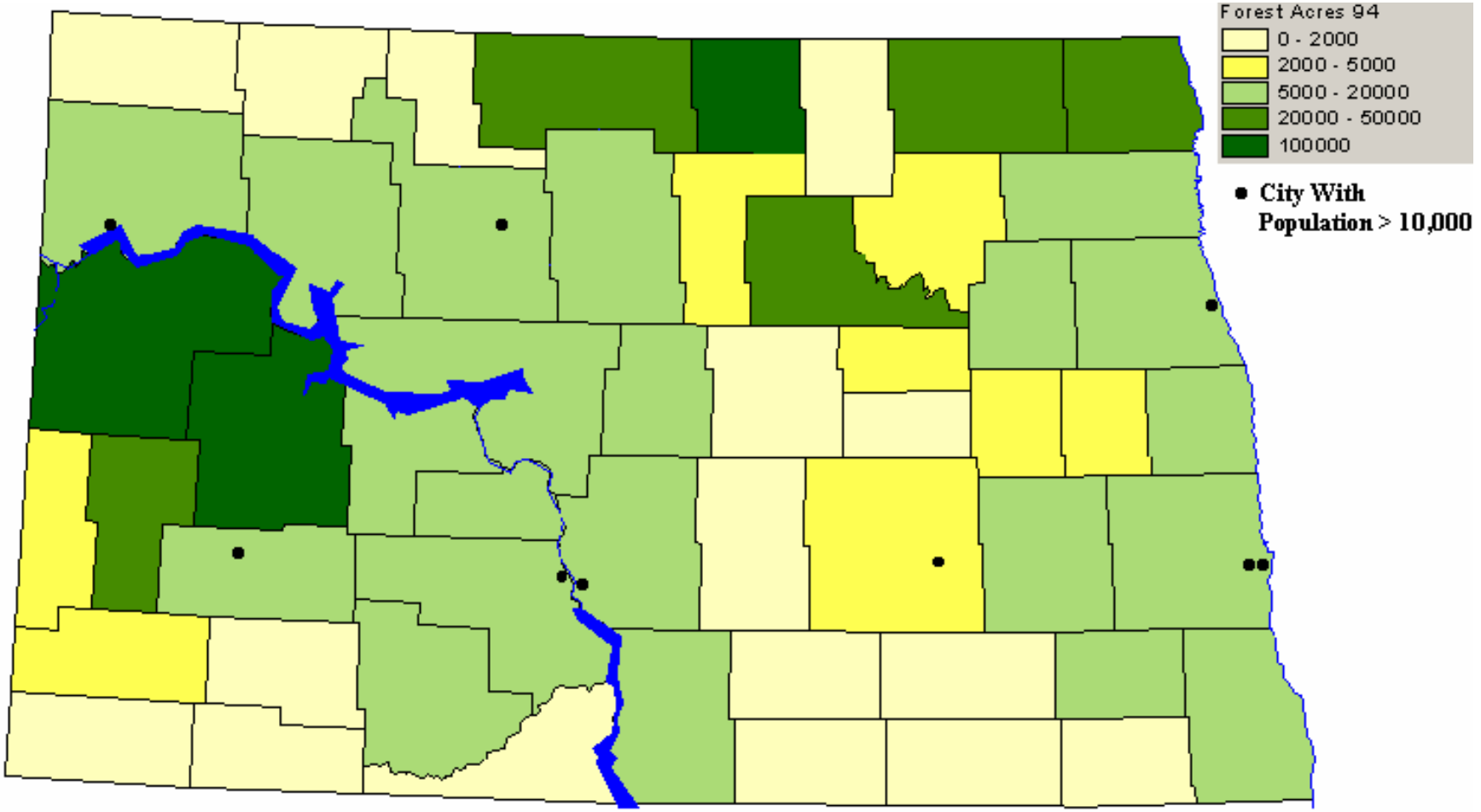


Figure 6. Total acres of forest land by county.

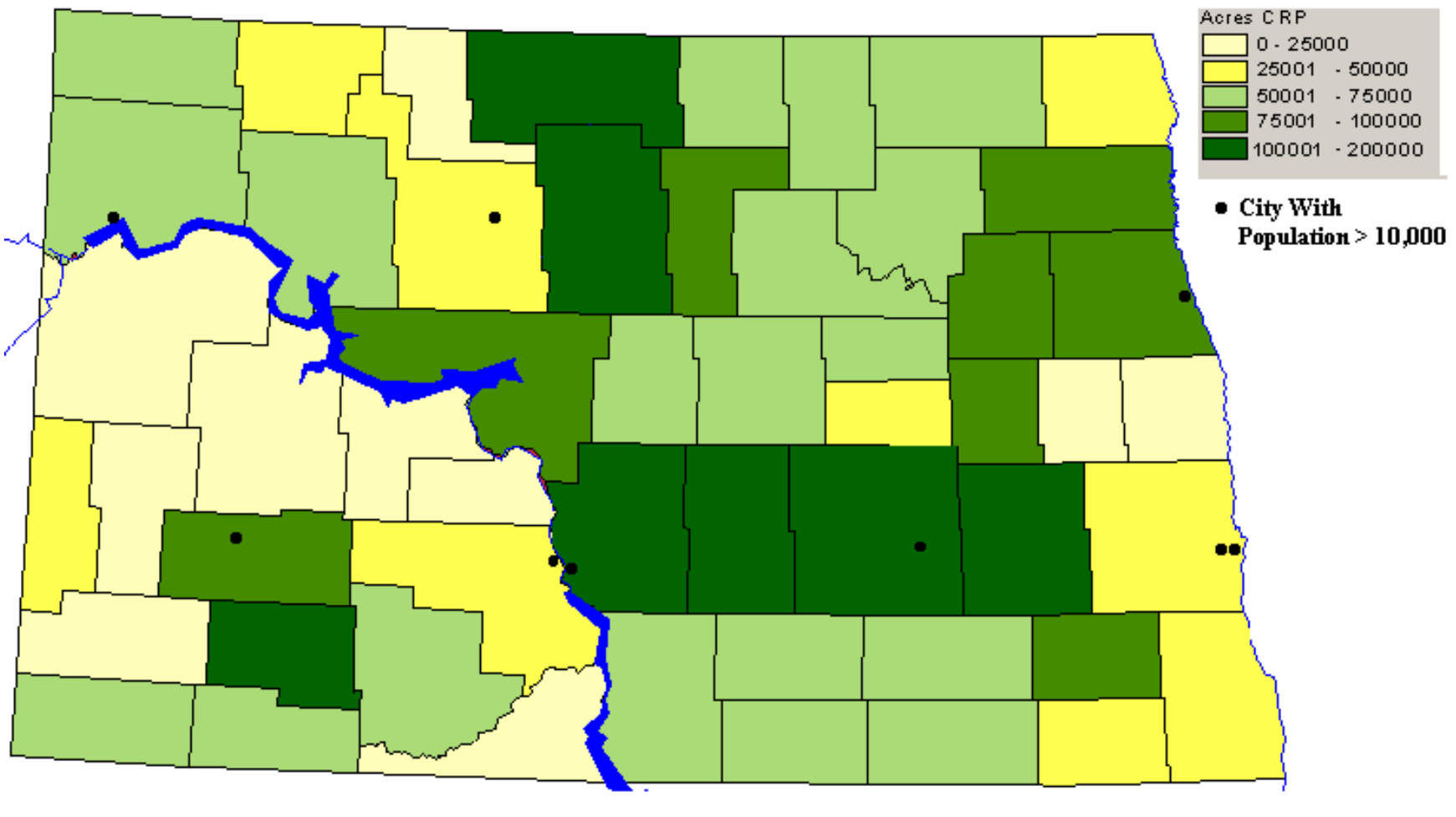


Figure 7. Total acres of CRP by county.

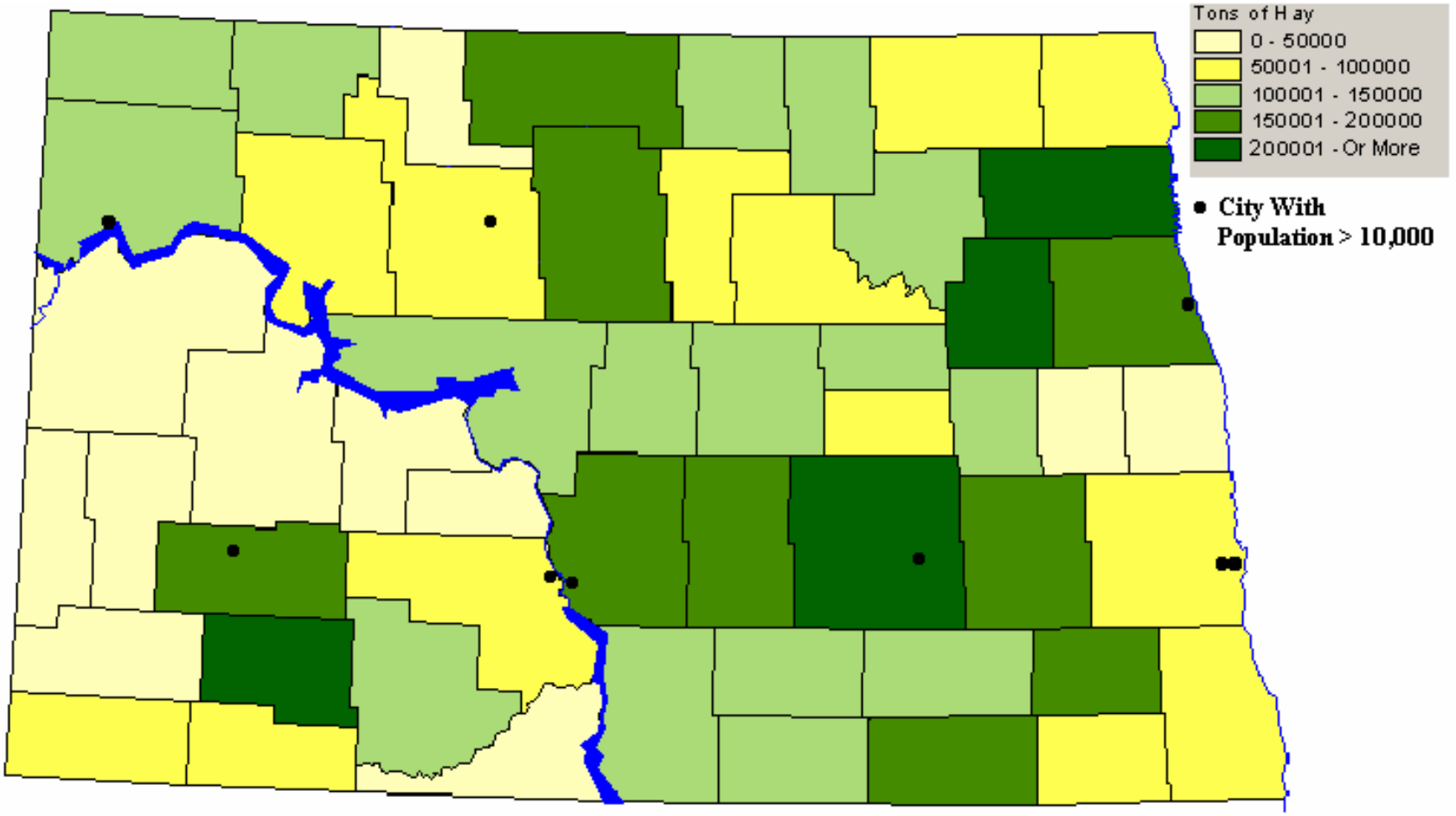


Figure 8. Potential production from CRP by county.

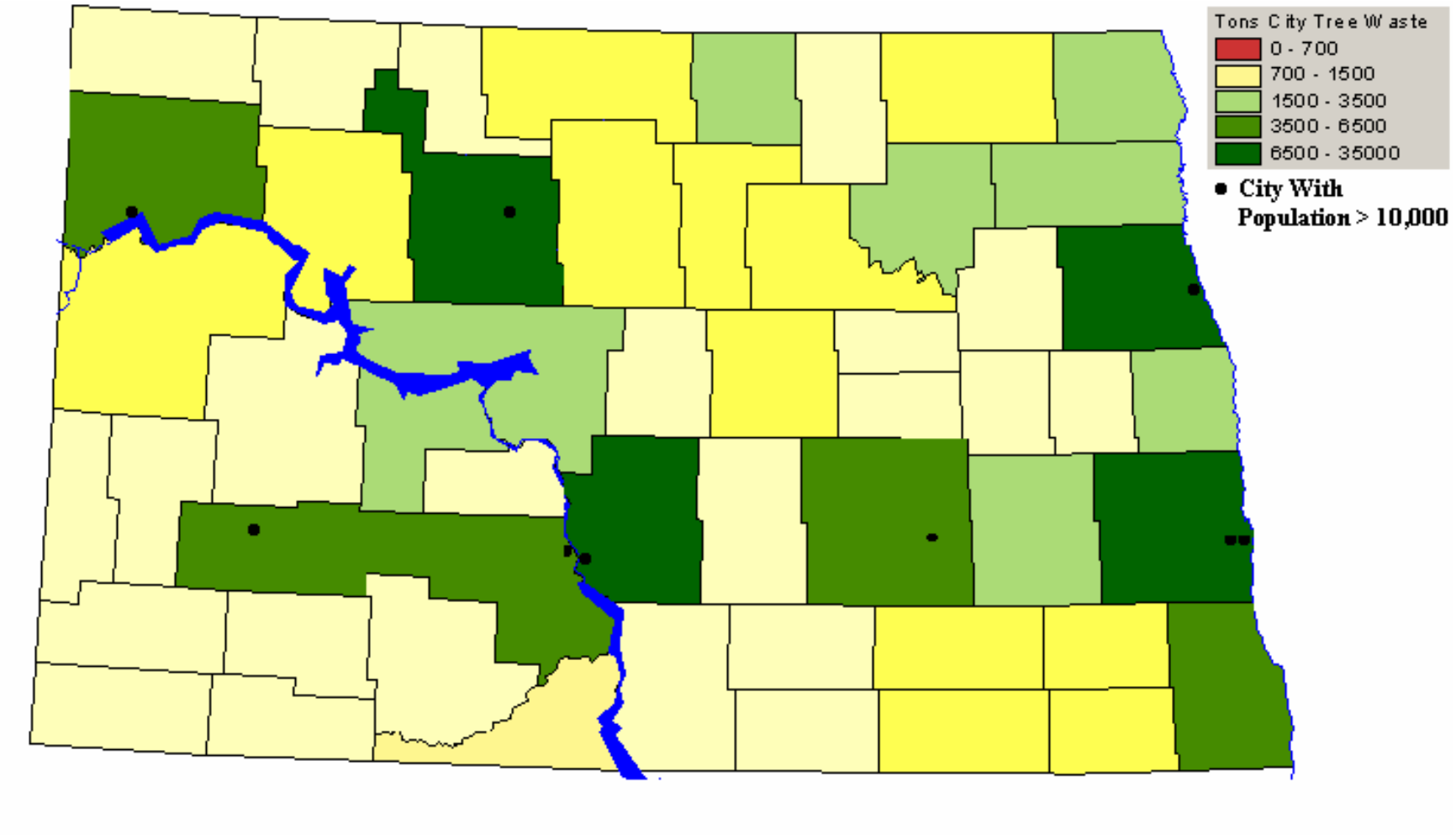


Figure 9. Amount of collectable municipal tree waste by county.

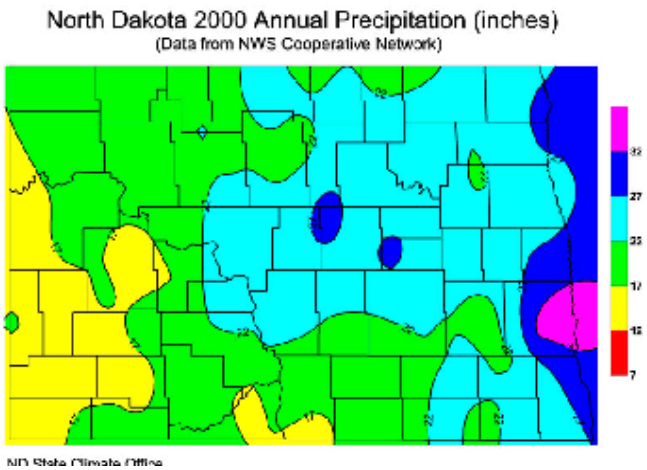


Figure 10. North Dakota 2000 annual precipitation (data from NWS Cooperative Network).

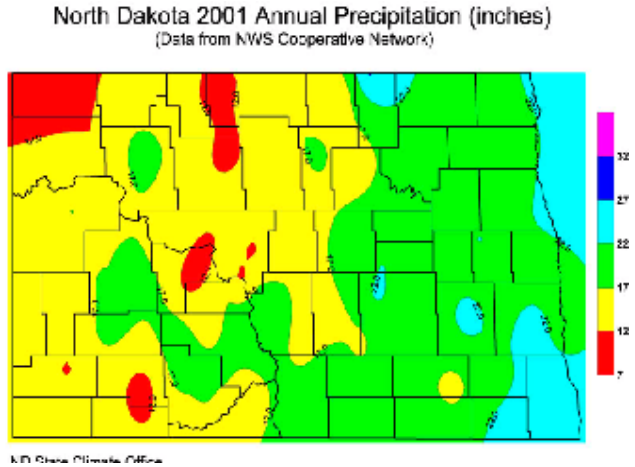


Figure 11. North Dakota 2001 annual precipitation (data from NWS Cooperative Network).

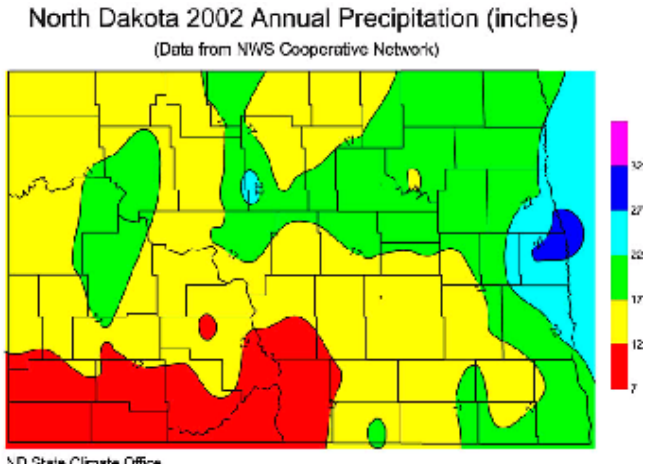


Figure 12. North Dakota 2002 annual precipitation (data from NWS Cooperative Network).

Figure 8 indicates the annual potential production of grasses from CRP lands. Due to differences in soil type and average annual precipitation, production will vary per county and does not necessarily mirror CRP enrollment statistics.

Figure 9 provides municipal tree waste total by county. Municipal tree waste includes all tree material that is typically collected at landfills across the state. Examination of Figure 9 shows that quantity varies directly with population. The population centers such as Grand Forks, Fargo, Bismarck, and Minot all have the highest potential.

Figures 10–12 show the annual precipitation over the past 3 years. The figures show how the western portion of the state is primarily dry, with significantly low precipitation in the northwest and southwest corners of the state. Dry conditions can extend to the central portions of the state, and relatively wet conditions almost always exist within the Red River Valley. As stated by the USFS Fire Assessment System, the fire danger rating level takes into account current and antecedent weather, fuel types, and both live and dead fuel moisture (3). Indices such as the Keetch Byram Drought Index and Palmer Drought Index factor into fire risk assessments. The information in Figures 10–12 was used to highlight consistently dry counties. Figure 13 is used to indicate significant sources of biomass in North Dakota, their location, and type.

RESULTS

An occurrence analysis was performed to highlight counties that can contribute more than one type of biomass resource for utilization. The resources considered were:

- Acres of forest production
- Production from CRP lands
- Tons of municipal wood waste

Counties were listed in order of quantity for the above resources. The 15 highest contributors were selected and are shown in Table 7. The data enable identification of counties that have relatively abundant resources.

Data from Table 7 indicate that Burleigh and Walsh are the only two counties listed in the top 15 counties that contain a significant amount of all three resources—forest, CRP, and municipal tree waste. Areas having both CRP and woody-based resources are the counties of Barnes, Bottineau, Grand Forks, McHenry, Ransom, Rolette, Stark, and Stutsman.

Figure 14 is a 10-year fire occurrence map from the NDFS. The boundaries are defined by fire district. It should be noted that many fire districts do not report or report inaccurately. However, the data represents a reasonable estimation of areas potentially at risk.

Relative potential for fire was associated with the counties where fires have occurred. For example, a large potentially high-risk area in the southwest covers both Bowman and Slope Counties. Therefore, both counties are indicated as having a high number of fire starts in Figure 15. Plots showing the magnitude of fires for years 2000 and 2001 were supplied by

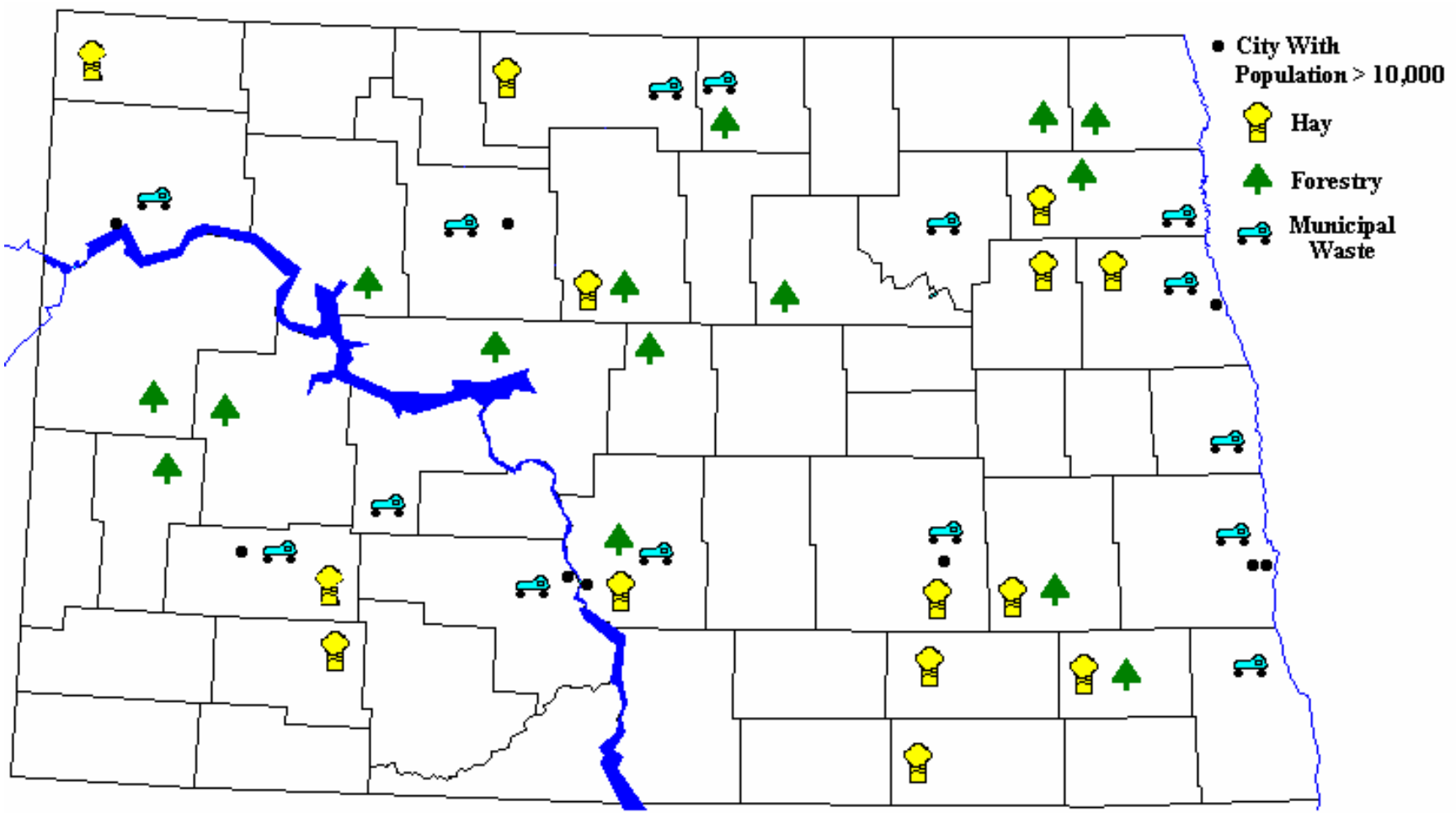


Figure 13. Zones of significant biomass.

Table 7. Top Fifteen Counties and Their Production of Biomass

EERC DS21894.CDR

County	Acres Forest 1994	County	Tons Hay per Year	County	Tons Municipal Tree Waste per Year
McKenzie	99,373	LaMoure	139,958	Cass	34,430
Dunn	68,353	Stutsman	326,059	Burleigh	19,341
Rolette	67,206	Nelson	242,711	Grand Forks	17,664
Bottineau	46,446	Hettinger	230,611	Ward	15,404
Cavalier	43,594	Walsh	207,684	Morton	6,436
Pembina	33,617	Grand Forks	189,418	Stark	5,737
Billings	31,020	Burleigh	181,456	Stutsman	5,405
Benson	25,760	Barnes	177,375	Williams	4,926
Walsh	19,086	Bottineau	176,374	Richland	4,249
Ranson	17,242	Kidder	174,918	Rolette	3,453
Mountrail	15,691	Ranson	173,365	Ramsey	2,939
McHenry	14,993	Dickey	165,257	Walsh	2,800
Burleigh	14,067	McHenry	163,990	Barnes	2,658
Sheridan	13,526	Stark	157,683	Mercer	2,006
McLean	13,346	Divide	143,337	Traill	1,970

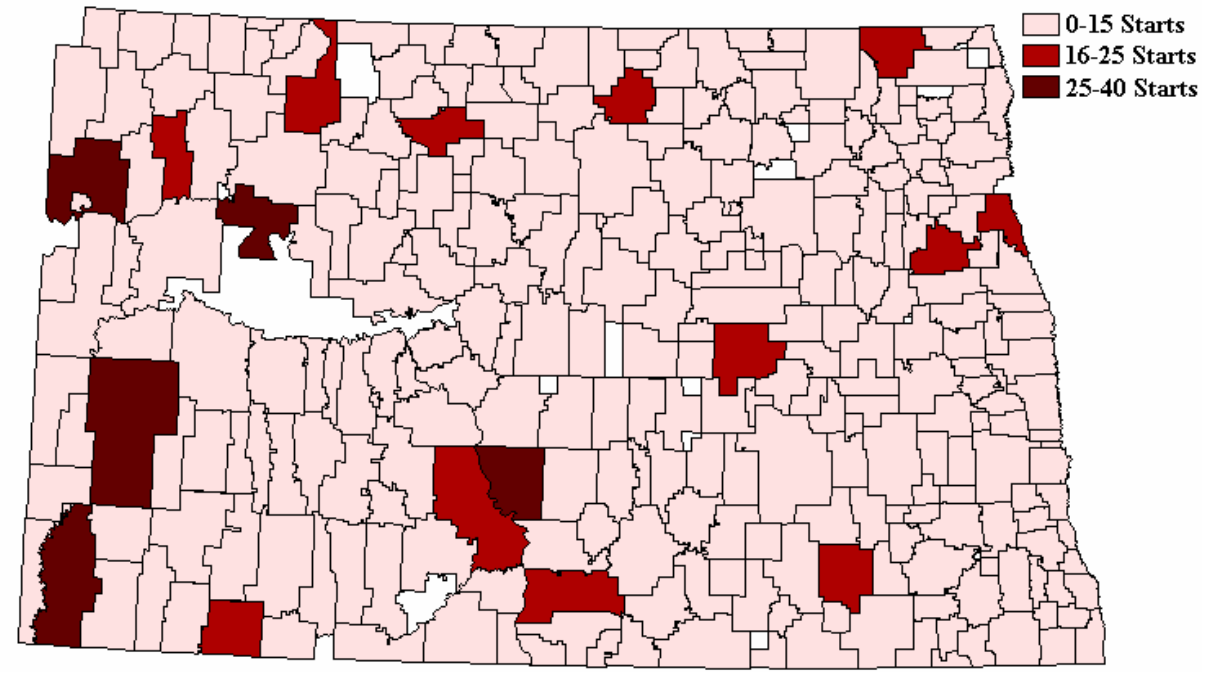
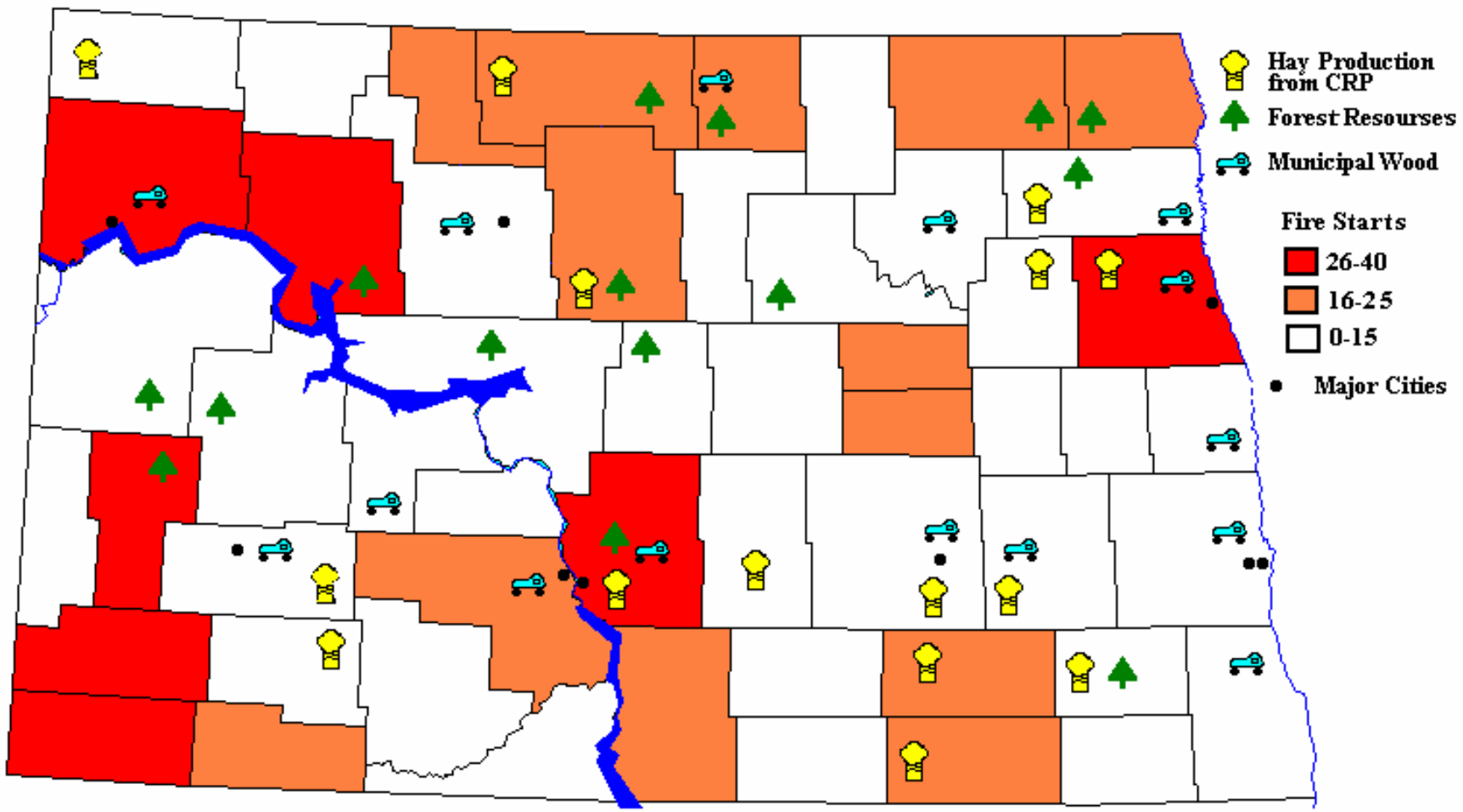


Figure 14. Annual average number of fire starts reported by county fire district over a 10-year period.



* Shading represents the reported number of fire starts per county.
** Symbols represent the most significant sources of biomass within a county.

Figure 15. Summary of biomass and fire risk areas.

Weinerman (4, 5). Although larger fires exist in the western half of the state, no significant differences between fire magnitude and the number of fire starts warranted an adjustment of the data. Therefore, Figure 14 was chosen as the basis for indicating areas that have a potential for a high number of fires. Figure 15 combines both biomass resource data and the 10-year fire occurrence from Figure 14. The result summarizes the areas most prone to fire and the most significant biomass resources that exist relative to areas experiencing a high number of fires.

Counties that experience low precipitation and a high number of fires and have a significant source of biomass are likely to benefit most from a managed approach to biomass utilization that could decrease the potential for fire. Counties that appear to be at risk of fire are listed in Table 8. These counties have had low precipitation over the past 3 years, as shown in Figures 10–12, and, from Figure 15, have had a large number of fires. The rankings for annual biomass utilization potential are defined as follows. The woody resource ranking is based on the total quantity of woody debris from municipal and forest resources. The total biomass ranking is the potential from CRP lands in addition to the woody resources. Since for most counties CRP accounts for over 80% of the total biomass, "total biomass" is indicative of the potential from CRP lands. A ranking of 1 indicates that the county has the greatest quantity of the biomass resource out of the 53 total counties in North Dakota. Table 9 includes a list of counties that either have experienced a large number of fires from figure 15 or have had low precipitation over the past 3 years. Counties shown in Table 10 have a significant biomass resource base. Counties listed in Table 10 rank 1–15 for either a high quantity of woody biomass or total biomass. Counties that can be taken from Tables 8–10 that show an excellent opportunity to mitigate the risk of fire combined with an available biomass resource are as follows and are listed in order of estimated priority.

1. Burleigh
2. Grand Forks
3. Bottineau
4. Rolette
5. Stark
6. Emmons
7. Walsh
8. McHenry
9. Stutsman
10. Ransom
11. Williams
12. McKenzie
13. Hettinger
14. Cavalier
15. Nelson

Averaging the listed order of Tables 8–10 with the biomass rankings created the above list. The result was an average ranking for each of the listed counties, and is intended to show the combined opportunity of both areas under the threat of fire and areas that have significant biomass resources. A visual summary is presented in Figure 16.

Table 8. High-Priority Counties (low precipitation and high number of reported fires)

County		Annual Biomass Utilization Potential	
		Woody Resource Ranking	Total Biomass Ranking
1	Bowman	43	41
2	Slope	36	45
3	Adams	49	37
4	Billings	11	48
5	Emmons	26	15
6	Renville	45	47
7	Williams	21	28

Table 9. Secondary-Priority Counties (either low precipitation or high number of fires)

County		Annual Biomass Utilization Potential	
		Woody Resource Ranking	Total Biomass Ranking
8	Burleigh	5	6
9	Hettinger	46	3
10	Grand Forks	7	5
11	Divide	52	16
12	Golden Valley	33	49
13	Mountrail	17	36
14	Morton	14	35
15	Sioux	42	52
16	Stark	16	12
17	McKenzie	1	38
18	Burke	47	30
19	Grant	31	26
20	McHenry	20	11
21	Bottineau	6	7
22	Rolette	3	14
23	Eddy	32	27
24	Foster	48	44
25	LaMoure	41	17
26	Dickey	38	13
27	Cavalier	8	24
28	Pembina	9	42

Table 10. Counties Not Listed Above That Have Significant Sources of Biomass

		Annual Biomass Utilization Potential	
		Woody Resource Ranking	Total Biomass Ranking
29	Stutsman	24	1
30	Nelson	30	2
31	Walsh	13	4
32	Ransom	15	8
33	Barnes	25	9
34	Kidder	53	10
35	Cass	2	32
36	Dunn	4	43
37	Ward	10	29
38	Benson	12	34

CONCLUSION

North Dakota has 38 counties out of 53 that have an opportunity to mitigate the risk of wildfires through biomass utilization. Burleigh County presents the most significant potential in the state, combining many resources and experiencing a large number of fires in a relatively dry area of the state. Priority counties are shown in Figure 16. In the southwest, counties that have significant resources include Stark, Hettinger, Grant, and Emmons. Priority counties in the northwest include Williams and McKenzie. The Turtle Mountain area and counties of McHenry, Bottineau, and Rolette could benefit from biomass and fire management efforts. In the eastern half of the state, Cavalier, Walsh, Grand Forks, Nelson, Stutsman, and Ransom Counties contain significant biomass resources and present some danger in regard to fire. In addition to the above counties, an area known as the Ponderosa Pine Forest, located in Slope County and part of Golden Valley County, contains approximately 4000 acres of forest in an area of frequent fires and low precipitation. The state of North Dakota has the potential to utilize over 6.5 million tons each year of biomass. The majority of this resource could be supplied from energy crops grown on CRP land, where vast interconnected tracts present a high fire risk along the I-94 corridor between Valley City and Bismarck. Wood-based resources have the potential to supply 500,000 tons per year statewide, and municipal sources can supply 156,000 tons per year. Assuming a value of $15/ton, revenues of over $100 million could be generated annually from currently unused biomass resources, and a significant reduction in the risk of fire in North Dakota could be achieved.

Appendix A contains detailed data utilized in support of the figures and tables in this report.

REFERENCES

1. Jakes, P.J.; Smith, B.W. *A Second Look at North Dakota's Timberlands*; USDA Forest Service Bulletin NC-58; 1980.

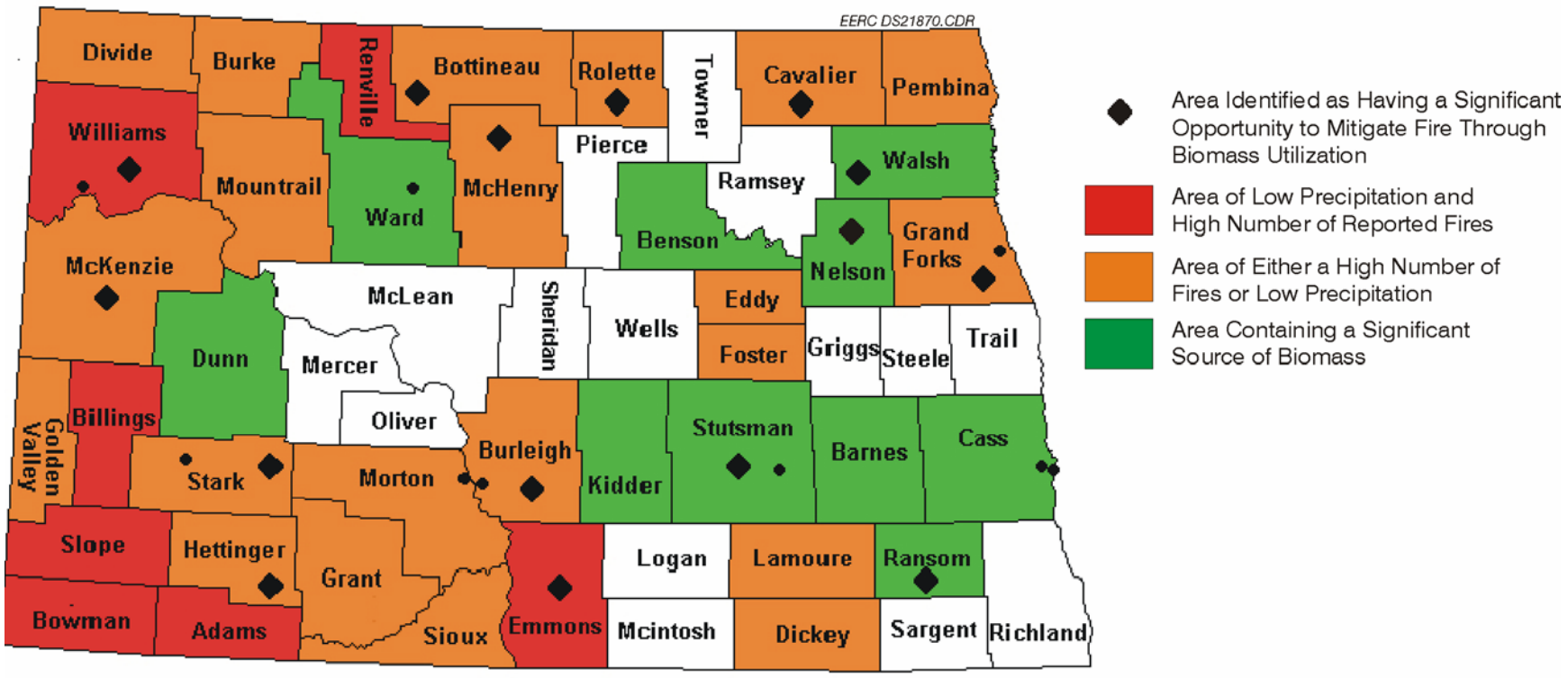


Figure 16. Counties identified as a priority for fire mitigation and biomass utilization.

2. Haugen, D.E.; Harsel, R.A. *North Dakota's Forest Resources*; USDA Forest Service Bulletin NC-336; 1994.

3. USDA Forest Service Wildland Fire Assessment System. http://www.fs.fed.us/land/wfas/wfas23.html (accessed May 2003).

4. Weinerman, J. *Location of Fires That Occurred in 2001 by Maximum Fire Size*. North Dakota Forest Service, May 1, 2002.

5. North Dakota Forest Service. Location of Large (100+ acres or larger) Fires from January 1, 2000, through December 31, 2000; map based on fire protection districts.

PART I – BIOMASS RESOURCES
Appendix A – Complete Data Set of Biomass Resources by County

County	Square Miles[1]	Acres[1]	Acres Forest 1994[2]	Non-Commecial Forest 1980	Commecial Forest 1980	AcresTrees 80	Acres CRP[3]	Population 1990[1]	Population 2000[1]	10 Year Δ Pop	Familys Lost	Farm Employment[1]	Non Farm Employment[1]	Total Employed	Unemployment[1]	Total Labor Force[1]	Housholds[1]	Person / house[1]	Farms 1997[3]	Farm Population[1,3]	Urban Population[1]	Tons Municipal Tree Waste	Hay ton / acre[3]	Hay total
Adams	988	632,320	180	100		100	73,967	3,174	2,523	-20.5%	-291	400	1,342	1,742	2.5%	1,787	1,121	2.24	410	918	1,605	456	1.24	91,719
Barnes	1,492	954,880	7,049	1,900	4,600	6,500	103,125	12,545	11,463	-8.6%	-472	982	6,642	7,624	3.0%	7,860	4,884	2.29	917	2,100	9,363	2,658	1.72	177,375
Benson	1,381	883,840	25,760	3,400	28,000	31,400	53,115	7,198	6,879	-4.4%	-107	725	2,707	3,432	5.9%	3,647	2,328	2.97	717	2,129	4,750	1,348	1.53	81,266
Billings	1,151	736,640	31,020	13,700	3,500	17,200	18,205	1,108	957	-22.7%	-103	285	490	775	3.5%	803	366	2.43	267	649	208	59	1.20	21,846
Bottineau	1,669	1,068,160	46,446	2,300	42,000	44,300	115,277	8,011	6,975	-12.9%	-450	998	3,494	4,492	3.5%	4,655	2,962	2.30	929	2,137	4,838	1,374	1.53	176,374
Bowman	1,162	743,680	902	300	200	500	62,929	3,596	3,124	-13.1%	-203	431	1,950	2,381	1.3%	2,412	1,358	2.32	390	905	2,219	630	1.18	74,256
Burke	1,104	706,560	734	200	500	700	50,327	3,002	2,191	-27.0%	-367	506	1,182	1,688	2.7%	1,735	1,013	2.21	525	1,160	1,031	293	2.03	102,164
Burleigh	1,633	1,045,120	14,067	2,700	5,100	7,800	100,809	60,131	70,069	16.5%	4,107	961	53,082	54,043	2.2%	55,259	27,670	2.42	803	1,943	68,126	19,341	1.80	181,456
Cass	1,765	1,129,600	12,362	2,900	8,500	11,400	32,049	102,874	124,021	20.6%	9,115	1,349	102,015	103,364	1.8%	105,259	51,315	2.32	1,183	2,745	121,276	34,430	1.87	59,932
Cavalier	1,488	952,320	43,594	6,300	33,900	40,200	50,973	6,064	4,655	-23.2%	-602	868	2,657	3,525	3.1%	3,638	2,017	2.34	922	2,157	2,498	709	1.88	95,829
Dickey	1,131	723,840	984	400	800	1,200	74,777	6,107	5,612	-8.1%	-210	676	3,066	3,742	1.5%	3,799	2,283	2.36	597	1,409	4,203	1,193	2.21	165,257
Divide	1,260	806,400	315	100	200	300	73,131	2,899	2,203	-24.0%	-319	575	1,113	1,688	2.3%	1,728	1,005	2.18	599	1,306	897	255	1.96	143,337
Dunn	2,010	1,286,400	68,353	26,400	11,500	37,900	21,004	4,005	3,563	-11.0%	-172	658	1,238	1,896	3.0%	1,955	1,378	2.57	733	1,884	1,679	477	1.74	36,547
Eddy	630	403,200	4,012	900	2,800	3,700	72,067	2,951	2,691	-8.8%	-113	382	1,123	1,505	4.8%	1,581	1,164	2.30	326	750	1,941	551	1.50	108,101
Emmons	1,510	966,400	9,198	2,200	2,900	5,100	71,783	4,830	4,209	-12.9%	-261	836	1,852	2,688	5.4%	2,841	1,786	2.38	868	2,066	2,143	608	1.93	138,541
Foster	635	406,400	164	100	100	200	28,194	3,983	2,634	-33.9%	-564	369	2,252	2,621	3.0%	2,702	1,540	2.39	377	901	1,733	492	1.82	51,313
Golden Valley	1,002	641,280	4,328	1,100	1,300	2,400	35,899	2,108	1,845	-12.5%	-111	281	937	1,218	1.6%	1,238	761	2.38	261	621	1,224	347	0.97	34,822
Grand Forks	1,438	920,320	11,929	2,600	8,400	11,000	94,709	70,683	64,390	-8.9%	-2,590	1,129	47,217	48,346	3.4%	50,048	25,435	2.43	893	2,170	62,220	17,664	2.00	189,418
Grant	1,659	1,061,760	5,230	1,900	1,000	2,900	54,747	3,549	2,775	-21.8%	-337	699	1,157	1,856	2.5%	1,904	1,195	2.30	688	1,582	1,193	339	2.00	109,494
Griggs	709	453,760	3,687	800	2,600	3,400	85,002	3,303	2,628	-20.4%	-295	442	1,538	1,980	1.8%	2,016	1,178	2.29	444	1,017	1,611	457	1.50	127,503
Hettinger	1,132	724,480	721	200	200	400	114,164	3,445	2,650	-23.1%	-346	577	1,219	1,796	2.2%	1,836	1,152	2.30	525	1,208	1,443	410	2.02	230,611
Kidder	1,351	864,640	0			0	111,413	3,332	2,666	-20.0%	-285	602	1,092	1,694	5.3%	1,789	1,158	2.34	557	1,303	1,363	387	1.57	174,918
LaMoure	1,147	734,080	1,067	400	900	1,300	68,607	5,383	4,616	-14.2%	-322	764	1,856	2,620	2.1%	2,676	1,942	2.38	738	1,756	2,860	812	2.04	139,958
Logan	993	635,520	361	100	100	200	61,277	2,847	2,221	-22.0%	-270	432	1,134	1,566	1.6%	1,591	963	2.32	531	1,232	989	281	2.09	128,069
McHenry	1,874	1,199,360	14,993	2,900	11,400	14,300	116,305	6,528	5,724	-12.3%	-342	995	1,877	2,872	4.4%	3,004	2,526	2.35	964	2,265	3,459	982	1.41	163,990
McIntosh	975	624,000	721	200	200	400	59,037	4,021	3,306	-17.8%	-326	543	1,660	2,203	1.3%	2,232	1,467	2.19	556	1,218	2,088	593	1.71	100,953
McKenzie	2,742	1,754,880	99,373	50,400	4,700	55,100	20,872	6,383	5,705	-10.6%	-257	804	3,307	4,111	3.0%	4,238	2,151	2.64	752	1,985	3,720	1,056	1.52	31,725
McLean	2,210	1,414,400	13,346	2,600	4,800	7,400	77,997	10,457	9,144	-12.6%	-547	1,080	4,082	5,162	4.7%	5,417	3,815	2.40	1,058	2,539	6,605	1,875	1.54	120,115
Mercer	1,045	668,800	5,411	1,400	1,600	3,000	16,024	9,808	8,531	-13.0%	-501	507	5,652	6,159	3.4%	6,376	3,346	2.55	575	1,466	7,065	2,006	1.36	21,793
Morton	1,926	1,232,640	11,001	3,200	2,900	6,100	34,395	23,700	25,149	6.1%	577	1,052	11,887	12,939	2.8%	13,312	9,889	2.51	988	2,480	22,669	6,436	2.38	81,860
Mountrail	1,824	1,167,360	15,691	2,900	5,800	8,700	53,134	7,021	6,553	-6.7%	-185	841	2,954	3,795	4.7%	3,982	2,560	2.53	873	2,209	4,344	1,233	1.56	82,889
Nelson	962	628,480	5,639	1,300	3,900	5,200	125,757	4,410	3,563	-19.2%	-389	580	1,599	2,179	4.1%	2,272	1,628	2.18	564	1,230	2,333	662	1.93	242,711
Oliver	724	463,360	6,673	2,300	1,400	3,700	4,793	2,381	1,960	-17.7%	-161	396	773	1,169	2.6%	1,200	791	2.61	367	958	1,002	285	2.20	10,545
Pembina	1,119	716,160	33,617	5,700	25,300	31,000	33,470	9,238	8,408	-9.0%	-349	1,055	5,190	6,245	6.1%	6,651	3,535	2.38	763	1,816	6,592	1,871	1.60	53,552
Pierce	1,018	651,520	2,202	600	1,500	2,100	80,953	5,052	4,597	-9.0%	-197	538	2,802	3,340	3.1%	3,447	1,964	2.31	578	1,335	3,262	926	1.20	97,144
Ramsey	1,185	758,400	2,297	400	2,400	2,800	74,651	12,681	11,833	-6.7%	-362	651	7,845	8,496	3.4%	8,795	4,957	2.34	633	1,481	10,352	2,939	1.67	124,667
Ransom	863	552,320	17,242	4,000	11,900	15,900	81,776	5,921	5,841	-1.4%	-33	626	2,930	3,556	1.6%	3,614	2,350	2.39	498	1,190	4,651	1,320	2.12	173,365
Renville	875	559,872	944	400	500	900	19,798	3,160	2,542	-19.6%	-263	417	1,115	1,532	2.5%	1,571	1,085	2.35	454	1,067	1,475	419	1.94	38,408
Richland	1,437	919,680	9,760	1,600	7,400	9,000	34,566	18,148	17,701	-2.5%	-184	1,181	10,257	11,438	2.8%	11,767	6,885	2.43	1,126	2,736	14,965	4,249	1.95	67,404
Rolette	902	577,280	67,206	4,100	60,000	64,100	72,052	12,772	13,754	7.7%	331	593	5,770	6,363	11.6%	7,198	4,556	2.97	536	1,592	12,162	3,453	1.70	122,488
Sargent	859	549,760	1,410	500	800	1,300	41,223	4,549	4,296	-5.6%	-104	572	2,833	3,405	2.2%	3,482	1,786	2.43	541	1,315	2,981	846	1.83	75,438
Sheridan	972	622,080	13,526	5,000	2,500	7,500	66,470	2,148	1,605	-25.3%	-235	441	644	1,085	6.3%	1,158	731	2.31	470	1,086	519	147	1.77	117,652
Sioux	1,094	700,160	721	200	200	400	9,060	3,761	4,066	8.1%	84	205	1,658	1,863	4.0%	1,941	1,095	3.63	229	831	3,235	918	1.87	16,942
Slope	1,218	779,520	3,968	600	1,600	2,200	24,725	907	754	-16.9%	-62	288	158	446	1.0%	451	313	2.45	299	733	21	6	1.90	46,978
Stark	1,338	856,320	7,575	1,400	2,800	4,200	91,146	22,832	22,213	-2.7%	-254	965	14,287	15,252	2.8%	15,691	8,932	2.44	822	2,006	20,207	5,737	1.73	157,683
Steele	712	455,680	3,904	1,100	2,500	3,600	25,596	2,420	2,191	-9.5%	-93	386	856	1,242	1.6%	1,262	923	2.45	396	970	1,221	347	1.57	40,186
Stutsman	2,221	1,421,440	2,297	900	1,900	2,800	182,156	22,241	21,575	-3.0%	-292	1,160	13,239	14,399	2.0%	14,693	8,954	2.28	1,113	2,538	19,037	5,405	1.79	326,059
Towner	1,025	656,000	82	0	100	100	66,615	3,627	2,770	-23.6%	-371	475	1,525	2,000	3.6%	2,075	1,218	2.31	557	1,287	1,483	421	1.70	113,246
Traill	862	551,680	9,109	2,400	6,000	8,400	7,739	8,752	8,392	-4.1%	-149	657	3,952	4,609	4.1%	4,806	3,341	2.41	603	1,453	6,939	1,970	1.80	13,930
Walsh	1,282	820,480	19,086	2,800	14,800	17,600	112,872	13,840	12,081	-12.7%	-736	1,119	6,614	7,733	3.9%	8,047	5,029	2.39	928	2,218	9,863	2,800	1.84	207,684
Ward	2,013	1,288,320	5,662	2,000	3,400	5,400	41,964	57,921	57,247	-1.2%	-274	1,355	39,452	40,807	2.9%	42,026	23,041	2.46	1,215	2,989	54,258	15,404	2.02	84,767
Wells	1,271	813,440	1,149	500	900	1,400	71,197	5,864	4,882	-16.7%	-436	723	2,633	3,356	3.3%	3,471	2,215	2.25	683	1,537	3,345	950	1.68	119,611
Williams	2,070	1,324,800	6,132	2,500	900	3,400	55,456	21,129	19,606	-7.2%	-640	981	11,937	12,918	2.8%	13,290	8,095	2.38	948	2,256	17,350	4,926	1.82	100,930
Totals and Averages	69,078	44,209,790	673,200 1.52%	174,900	343,200	518,100	3,329,349 8.64%	638,800	633,449			37,113	411,843	448,956		462,225		2.417 Average	35,289	84,833	548,616	155,752	1.744 Average	5,794,822

1 http://www.census.gov/

2 North Dakota's Forest Resources, 1994, David E. Haugen, Ronald P Kingley, Robert Harsel

3 http://www.nass.usda.gov/census/

The following is an explanation of the data in Appendix A:

Square Miles[1]	Area of each county in square miles.
Acres[1]	Area of each county in acres.
Acres Forest 1994[2]	The total number of acres of each county as forest.
Noncommercial Forest 1980	This is the total area as classified by USFS that is not utilized for commercial practice.
Commercial Forest 1980	The total area as classified by the USDA Forest Service that is classified as being utilized for commercial production of wood material.
Acres Trees 1980	The total acreage of trees in North Dakota and the sum of commercial and noncommercial lands.
Acres CRP[3]	The total amount of land currently enrolled in the CRP.
Population 1990[1]	The total population base that resided within a given county.
Population 2000[1]	The total population base that resided within a given county.
10 Year Δ Pop	The change in population from 1990 to 2000.
Families Lost	Calculated by dividing the 10-year population change by the number of persons per family.
Farm Employment[1]	Population in a county whose major source of income is from primary farming practices.
Nonfarm Employment[1]	Population of workers whose major income is derived from sources other than primary farming practices.
Total Employed	Total number of jobs within a county.
Unemployment[1]	The number of people of employable age who at the time of the census were unemployed.
Total Labor Force[1]	Population of employable people.
Households[1]	Number of housing units in a county. Based on the population and persons per household data.
Person/House[1]	Number of persons residing in a housing unit.

Farms 1997[3]	The total number of farms within a given county.
Farm Population[1, 3]	The total population base that resides on farms within a given county.
Urban Population[1]	The total population that resides within a given county.
Tons Municipal Tree Waste	This column was calculated based on data taken from a survey of municipal landfills. Utilizing the population base served by landfills and their reported collection rates, the average waste collected per person was calculated. Then using census numbers, the total urban population that exists within each county was calculated and a total collectible amount was determined.
Hay, tons/acre[3]	Average recorded production of hay per acre in a county.
Hay Total	The theoretical collectible amount of hay biomass within each county.

PART II – NORTH DAKOTA'S ENERGY INFRASTRUCTURE OF REGISTERED BOILERS

EXECUTIVE SUMMARY

The North Dakota Forest Service through the Economic Action Program of the U.S. Forest Service's National Fire Plan is supporting a study by the University of North Dakota Energy & Environmental Research Center. The goal of the study is to mitigate the risk of fire in North Dakota by identifying the opportunities for biomass utilization through local energy and product markets. Objectives include completing a biomass resource assessment, a market assessment, and outreach for the state of North Dakota. The information contained in this document outlines the infrastructure of state regulated boilers, which represent the potential end use market for consumption of biomass as an energy fuel.

Based on data provided by the state boiler inspector, statistics of the energy infrastructure are as follows. Active boilers total 8441: 2.5% are coal-fired, 82% are gas-fired, 9.7% are oil-fired, 1.8% are propane-fired, 3.6% are electric, and 0.4% use other fuels. Coal-fired utilities and oil-refining operations in the state consume the majority of energy. The large numbers of natural gas-fired units exist mostly at commercial enterprises. The potential for firing biomass is significant at coal-, gas-, and oil-fired facilities, with quantities as much as 1,845,368 tons/yr, 1,621,755 tons/yr, and 263,516 tons/yr, respectively. Propane and electric furnaces offer little opportunity to fire biomass.

Many reasons exist for why large, medium, and small boiler operators should focus on firing biomass fuels. Coal-fired utilities could make capital investments to allow fuel flexibility at their operations and potentially decrease costs. The utilities may realistically consider cofiring biomass at 10% of the heat-value input to a boiler. This small cofiring percentage represents a significant potential for biomass use at approximately 1,000,000 tons/yr in North Dakota. Another huge potential for biomass includes the many institutional and industrial boilers in the state that represent the potential to fire approximately 1,800,000 tons/yr of biomass. These systems could benefit from biomass fuels supplied at lower costs than coal and natural gas. Medium-sized boiler systems pay double for stoker-grade coal than what utilities pay for minemouth coal, and biomass is typically one-third the price of natural gas. These medium-sized boilers would typically cofire biomass at 25% to 85% of capacity. Small coal-fired furnaces could offset coal by firing 100% with biomass resources and could consume approximately 50,000 tons/yr throughout the state. At least 250 opportunities exist to replace fossil fuels with biomass in large and medium boilers at 3,000,000 tons/yr, and at least 172 opportunities exist to replace coal with wood in small furnaces at about 50,000 tons/yr. These estimates provide a good match with available biomass resources, comprising approximately 900,000 tons/yr of forest and municipal wood and 5.8 million tons/yr of grasslands.

PART II – NORTH DAKOTA'S ENERGY INFRASTRUCTURE OF REGISTERED BOILERS

INTRODUCTION

The types of biomass that contribute to fire risk in North Dakota include grasslands and forest. Consuming biomass in existing energy systems across the state of North Dakota could potentially create a marketable end use for materials that contribute to fuel loading and fire risk. The North Dakota Department of Insurance maintains records on registered boilers and the state boiler inspector periodically updates the information. The data presented in this report is an analysis preformed by the University of North Dakota Energy & Environmental Research Center of North Dakota state records to indicate the potential for incorporating sources of biomass into existing boiler systems. The analysis does not take into account consumption of biomass by processing industries such as ethanol production, which could discover innovative ways to use biomass in the future.

BACKGROUND AND ORGANIZATION OF DATA

Data were obtained from the North Dakota Department of Insurance and is available as public record. The boiler inspection division maintains a Foxpro database of every active and inactive boiler in the state. State law requires systems greater than 15 psig to be registered. An excel spreadsheet, which is typically provided to insurance agents, was obtained. The spreadsheet contains adequate information for locating boilers and estimating the potential for biomass consumption, and it provides an effective means to summarize information versus a time-consuming search of the Foxpro database.

Data sets provided by the boiler inspector included the following: all active and inactive boilers in North Dakota, city, user name, owner name, address, county code, insurance code, last inspection date, re-inspection date, expiration date, type of steam pressure, boiler manufacturer, year built, relief valve pressure setting, vessel type, fuel type, heating surface area, relief valve design capacity, contact person, phone number, and locator code.

Data analysis, reduction, and summary were required to reduce the 8441 listed boilers to a form that is useful for public information relating to biomass utilization. The results of this study are intended to be used by private businesses, municipal and state governments, and developers to realize opportunities for firing biomass fuels that would alleviate fire risk. Several maps are provided to show location of boilers and the relative proximity to biomass resources. Local enterprises and institutions may use the tables provided in this document to specifically identify systems that have the potential for using biomass. Because of the shear volume of information, not all registered boilers are listed in the appendices; however, systems that present significant opportunity for biomass utilization are included.

DATA ANALYSIS

The analysis presented in this section is organized based on several factors. The first factor is whether the boiler is active or inactive. Active boilers are currently operating inspected units within the state. Inactive boilers may include mothballed boilers, units designated for salvage, or enterprises that have ceased operation. There are 4372 inactive boilers on record. Due to the shear volume of boilers, only active boilers were analyzed. Active boilers were broken down by fuel type: solid fuel, natural gas, oil, propane, electricity, and miscellaneous. The analysis considered features relative to the fuel type. Subcategories under fuel types are based on scale such as utility, type of furnace, and firing rate. Biomass resources typically exist in magnitudes of 100 tons/yr to 10,000 tons/yr from single sources. These quantities would be expected from specific forest resources and single farm-based grassland resources. In light of resource quantities, medium and small boiler fuel consumption rates provide a good match and justify the subcategory breakdown based on size.

The methods applied to data reduction are as follows. Locations are tabulated by county, owner, and city in this report. The rated capacity of the relief valve was used to determine the annual fuel consumption of the boiler. Each data point was analyzed to determine an appropriate annual capacity and availability factor. The assumptions for factors are shown in Appendix A. Various boilers were surveyed to determine appropriate capacity and availability factors based on actual annual fuel use. The calculation of annual tonnage of biomass use is determined based on a 7000-Btu/lb heating value. Cofiring of 10% biomass is assumed for utility-scale applications, and 100% replacement is assumed for medium and small boilers.

RESULTS

The general statistics of boilers in North Dakota are listed in Table 1. The potential to use biomass is presented in a breakdown of boilers based on fuel type in Table 2. Although a majority of boilers in North Dakota are natural gas-fired, significant opportunities exist with both gas- and coal-fired units. Table 3 shows the number of opportunities in the state. The majority of fuel fired in North Dakota is coal due to the coal-based electric utilities. Cofiring biomass at 10% of the heating value was considered for utility applications since resources would likely limit the ability to fire higher quantities. Coal-fired water-tube boilers represent a significant opportunity for biomass firing. Typically, these boilers are well-suited for feed system modifications since they already fire solid fuel and can cofire fuels in conjunction with coal. It is noted from the table that approximately 4000 tons/yr of wood is fired within North Dakota. Small coal furnaces are also a good opportunity. Small coal furnaces can be modified relatively simply to fire wood and take advantage of smaller, localized biomass resources that would not be significant for larger boilers. Natural gas, oil, and propane are more than double the price of coal on a heating-value basis. When prices for natural gas peak in the winter, both biomass and coal can be eight times less expensive. Price and supply are economic drivers for energy consumers to consider firing biomass. As shown in Table 2, significant opportunities for large gas boilers similar in size to the water-tube coal-fired boilers exist in North Dakota. A secondary opportunity to replace natural gas, based on quantity, is found with small gas furnaces. However, the users must consider the challenges of handling solid fuels. The oil-fired units are generally smaller in size than natural

Table 1. Boiler Statistics for North Dakota

Boiler Type	Units
Active Boilers	8441
Solid Fuel-Fired	211
Gas-Fired	6900
Oil-Fired	816
Propane-Fired	152
Electric	303
Other	59

Table 2. Potential to Fire Biomass to Replace Coal, Natural Gas, Oil, Propane, and Electricity in Active Registered Boilers

Type	Tons/yr
Utility Cofire with Coal	997,813
Water-Tube Boilers (coal)	796,697
Existing Wood-Fired Burners	1980
Small Furnaces	48,878
Potential to Cofire with Coal and Other Solid Fuels	1,845,368
Large Gas Boilers (>20 MMBtu/hr)	1,026,102
Medium Gas Boilers (10–20 MMBtu/hr)	78,411
Small Gas Furnaces (<10 MMBtu/hr)	517,241
Potential to Replace Natural Gas	1,621,755
Large Oil-Fired Boilers (>10 MMBtu/hr)	161,777
Small Oil-Fired Boilers (<10 MMBtu/hr)	101,739
Potential to Replace Oil	263,516
Propane Boilers (>1 MMBtu/hr)	3881
Potential to Replace All Propane	8388
Electric Boilers (5–30 MMBtu/hr)	8401
Potential to Replace All Electric Boilers	40,000

Table 3. Summary of the Number of Opportunities to Replace Fossil Fuels with Biomass in Active Registered Boilers in North Dakota

Type	Units
Utility Cofire with Coal	14
Water-Tube Boilers (coal)	19
Existing Wood-Fired Furnaces	6
Small Furnaces	172
Potential to Cofire with Coal and Other Solid Fuels	211
Large Gas Boilers (>20 MMBtu/hr)	85
Medium Gas Boilers (10–20 MMBtu/hr)	95
Small Gas Furnaces (<10 MMBtu/hr)	6720
Potential to Replace Natural Gas	6900
Large Oil-Fired Boilers (>10 MMBtu/hr)	48
Small Oil-Fired Boilers (<10 MMBtu/hr)	768
Potential to Replace Oil	816
Propane Boilers (>1 MMBtu/hr)	27
Potential to Replace all Propane	152
Electric Boilers (5–30 MMBtu/hr)	17
Potential to Replace All Electric Boilers	303

gas-fired units, but present some opportunity. Propane- and electric-fired furnaces are typically too small to present any real opportunity for biomass use.

OPPORTUNITY DISCUSSION

Appendix A provides a detailed listing of boilers by county, indicating opportunities for utilization of biomass. The appendix is in order of fuel type and includes coal, natural gas, oil, propane, and electric boilers. A discussion of each fuel type is presented.

Coal

211 facilities consume coal in the state of North Dakota, and an opportunity exists to consume 1,845,368 tons/yr of biomass at these facilities. The benefit of a coal-fired facility is that it is already designed to fire solid fuels, so minimal investment may be required to add the capability to fire biomass. This enables a relatively low capital investment that may be recovered by using lower-cost fuels. The vast majority of coal is consumed at electric utilities. If cofiring biomass at 10% is considered at utilities, it would represent 53% of the total potential for firing biomass at coal-fired boilers in the state. 14 coal-fired utilities are located in the western half of North Dakota.

Water-tube boilers offer similar advantages. These systems exist largely in the Red River Valley at processing plants and universities. These water-tube boilers typically pay double what the electric utilities pay for coal and can economically justify retrofits to fire biomass easier than utilities, based on fuel price. Water-tube boilers could consume 796,697 tons/yr of biomass, and 19 such facilities exist in the state.

Fire-tube and cast iron furnaces are small coal-fired units distributed throughout the state, but with greater concentration in the western half. Although representing only a 48,878-tons/yr potential to fire biomass, these small units have the advantage of being well-suited for retrofit and may match up to localized biomass resources that would otherwise be unattractive to boilers with a large fuel diet.

Natural Gas

The benefit of natural gas-fired boilers to biomass utilization is the relative cost of gas versus biomass. Facilities firing natural gas would require a complete retrofit to change to a solid fuel. Since natural gas prices have risen and price histories over the past 10 years are showing 3% to 7% annual escalation factors, significant savings can be produced by firing biomass. The savings can produce an attractive return for complete retrofit investments. Naturally, the larger boilers that operate continuously will produce greater savings.

44 natural gas process boilers exist in North Dakota. In general, the location of all natural gas boilers varies directly with population. However, a trend of location can be seen along Interstate 94 with a larger number of boilers located in the eastern half of North Dakota. The process boilers are defined as units rated greater than 20 MMBtu/hr and typically support a process resulting in high availability factors. These boilers consume fuel in similar magnitude to the water-tube coal-fired units in the state. Some of the boilers shown on the list of process boilers in Appendix A were not considered to contribute to the total potential for biomass use due to implausible business factors. The facilities include the Civic Center in Bismarck, RDO Foods in Grand Forks, Dakota Gasification Great Plains Synfuels Plant in Beulah's Northern Sun in Enderlin (already uses biomass), and Cargill in Wahpeton. Process boilers could consume 750,765 tons/yr of biomass or account for 46% of the total potential to replace natural gas with biomass fuel.

41 natural gas heating plants are rated greater than 20 MMBtu/hr located at institutions and universities, and 95 boilers sized between 10–20 MMBtu/hr are located at schools, churches, and other similar-sized facilities in North Dakota. The most significant opportunities are with boilers >20 MMBtu/hr, which account for 1,026,102 tons/yr. Smaller boilers comprise an opportunity of 595,652 tons/yr.

Oil

Oil prices typically follow natural gas prices, but are usually higher. Order of magnitude varies, but can be double. Therefore, greater economic returns can be realized from oil-fired facilities switching to biomass rather than to gas or coal. The data in Appendix A for oil-fired facilities was categorized into utility-owned systems, boilers greater than 20 MMBtu/hr, and

boilers from 10 to 20 MMBtu/hr. The total potential for biomass to replace oil is 263,516 tons/yr, which is approximately 25% of the potential for either natural gas or coal replacement. Regardless of size, each category possesses the same potential for quantity of biomass utilization. 10 oil-fired units are utility-owned, 13 units are over 20 MMBtu/hr, and 23 units are between 10–20 MMBtu/hr. Boiler location is primarily concentrated at or near areas of population.

Propane and Electricity

Propane and electric boilers offer little opportunity for biomass use. However, if used, a total of 48,388 tons/yr of biomass could be consumed. Only 27 propane boilers are larger than 1 MMBtu/hr, typically too small to be worth retrofitting. 17 electric boilers are sized between 5–30 MMBtu/hr, which would be worth investigation.

CONCLUSION

Significant opportunity exists to mitigate fire risk from forest and grassland resources in the state of North Dakota by investigating opportunities for biomass energy use. Appendix B contains three overlaid figures showing the location and magnitude of coal-, gas-, and oil-fired boilers relative to forest-based resources. Forest resources provide the best match to energy infrastructure in terms of quantity. At total of approximately 800,000 tons/yr of forest production from fire risk areas could be used as energy in an infrastructure that is capable of consuming approximately 4,000,000 tons/yr. If only 20% of the energy infrastructure market enabled biomass utilization, 100% of available resources could be consumed. This would greatly reduce the conditions that contribute to wild fires in North Dakota.

PART II – NORTH DAKOTA ENERGY INFRASTRUCTURE OF REGISTERED BOILERS

Appendix A – Boiler Listings Based on Fuel Type and Summary Statistics

Solid Fuel Boiler Statistics

# of Utility Boilers	14	
Combined Generation Capacity (MW)	4077	
Potential for Cofiring Wood (10%)	997,813	tons/yr
# of Water-Tube Boilers	19	
Firing Potential for Wood (7000 Btu/lb)	796,697	tons/yr
# of Wood/Pellet-Fired Furnaces	6	
Current Annual Wood Consumption	1,980	tons/yr
# of Cast Iron Furnaces	27	
Firing Potential for Wood (7000 Btu/lb)	2,039	tons/yr
# of Fire Tube Furnaces	145	
Firing Potential for Wood (7000 Btu/lb)	46,839	tons/yr
Total # of Solid Fuel-Fired Units	211	
Total Firing Potential	1,845,368	tons/yr

Major Coal-Consuming Utilities

#	County	Owner	City	Relief Valve Rating (lbs/hr steam)	Est. Fuel Use MMBtu/yr	Capacity MW	10% Cofiring Potential (tons/yr of wood)	
1	McLean	COAL CREEK STATION	UNDERWOOD	4,399,944	19,271,755	550	137,655	
2	McLean	COAL CREEK STATION	UNDERWOOD	3,849,182	16,859,417	550	120,424	
3	McLean	COAL CREEK STATION	UNDERWOOD	166,125	727,628		5,197	
4	Mercer	ANTELOPE VALLEY STATION	BEULAH	3,474,154	15,216,795	450	108,691	
5	Mercer	ANTELOPE VALLEY STATION	BEULAH	3,473,164	15,212,458	450	108,660	
6	Mercer	COYOTE STATION	BEULAH	3,460,878	15,158,646	414	108,276	
7	Mercer	GREAT RIVER ENERGY	STANTON	1,386,035	6,070,833	202	43,363	
8	Mercer	GREAT RIVER ENERGY	STANTON	452,091	1,980,159		14,144	
9	Mercer	LELAND OLDS STATION	STANTON	3,188,560	13,965,893	440	99,756	
10	Mercer	LELAND OLDS STATION	STANTON	1,632,422	7,150,008	216	51,071	
11	Morton	HESKETT STATION	MANDAN	326,500	1,430,070	25	10,215	
12	Morton	HESKETT STATION	MANDAN	779,972	3,416,277	75	24,402	
13	Oliver	MILTON R YOUNG STATION	CENTER	1,758,180	7,700,828	250	55,006	
14	Oliver	MILTON R YOUNG STATION	CENTER	3,546,359	15,533,052	455	110,950	
							997,813	**total**

Major Coal Consumers Using Water-Tube Boilers Note: Northern Sun fires sunflower hulls

#	County	Owner	City	Relief Valve Rating (lbs/hr steam)	Capacity Factor	Availability Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Barnes	VALLEY CITY STATE UNIV	VALLEY CITY	38,692	0.2	0.2	13,558	968	
2	Burleigh	ND STATE PENITENTIARY	BISMARCK	47,467	0.2	0.5	41,581	2,970	
3	Cass	NDSU PHYSICAL PLANT	FARGO	88,730	0.6	0.5	233,182	16,656	
4	Cass	NDSU PHYSICAL PLANT	FARGO	130,721	0.6	0.5	343,535	24,538	
5	Grand Forks	UND PLANT SERVICES	GRAND FORKS	101,923	0.6	0.5	267,854	19,132	
6	Grand Forks	UND PLANT SERVICES	GRAND FORKS	104,890	0.6	0.5	275,651	19,689	
7	Grand Forks	UND PLANT SERVICES	GRAND FORKS	127,332	0.6	0.5	334,628	23,902	
8	Pembina	AMERICAN CRYSTAL SUGAR	DRAYTON	33,638	0.8	0.85	200,375	14,312	
9	Pembina	AMERICAN CRYSTAL SUGAR	DRAYTON	362,581	0.8	0.85	2,159,823	154,273	
10	Pembina	ARCHER DANIELS MIDLAND	WALHALLA	170,746	0.8	0.85	1,017,100	72,650	
11	Ransom	NORTHERN SUN - ADM	ENDERLIN	452,640	0.8	0.85	2,696,286	192,592	
12	Renville	MOHALL MEDICAL CENTER	MOHALL	3,161	0.6	0.5	8,307	593	
13	Richland	STATE COLLEGE OF SCIENCE	WAHPETON	91,539	0.3	0.5	120,282	8,592	
14	Richland	MINN-DAK FARMERS COOP	WAHPETON	177,178	0.6	0.5	465,624	33,259	
15	Richland	MINN-DAK FARMERS COOP	WAHPETON	183,021	0.6	0.5	480,979	34,356	
16	Stutsman	STATE HOSPITAL	JAMESTOWN	65,759	0.6	0.5	172,815	12,344	
17	Traill	AMERICAN CRYSTAL SUGAR	HILLSBORO	185,263	0.8	0.85	1,103,575	78,827	
18	Traill	AMERICAN CRYSTAL SUGAR	HILLSBORO	185,263	0.8	0.85	1,103,575	78,827	
19	Ward	MINOT STATE UNIVERSITY	MINOT	43,772	0.6	0.5	115,033	8,217	
								796,697	**total**

Wood and Pellet Fired Furnaces (Thom Linen Service fires medical waste)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Grand Forks	AMERICAN WOODS INC	GRAND FORKS	5,250,000	0.1	4,599	329	
2	Grand Forks	AMERICAN WOODS INC	GRAND FORKS	8,844,000	0.1	7,747	553	
3	Ransom	LISBON STREET DEPARTMENT	LISBON	585,000	0.1	512	37	
4	Cass	THOM LINEN SERVICE	FARGO	8,472,000	0.1	7,421	530	
5	Cass	SHANLEY HIGH SCHOOL	FARGO	5,000,000	0.1	4,380	313	
6	Cass	WASHINGTON ELEMENTARY	FARGO	3,485,000	0.1	3,053	218	
							1,980	**total**

Coal-Consuming Cast Iron Furnaces (100,000 – 3,000,000 Btu/hr)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr
1	Benson	BENSON COUNTY COURTHOUSE	MINNEWAUKAN	1,900,000	0.1	1,664	119
2	Bottineau	TENNYSON BROTHERS	ANTLER	1,900,000	0.1	1,664	119
3	Bottineau	NORTH SIDE REPAIR	BOTTINEAU	800,000	0.1	701	50
4	Burke	KNUTSON AUTO REPAIR	BOWBELLS	1,125,000	0.1	986	70
5	Divide	CONCORDIA LUTHERAN CHURCH	CROSBY	3,300,000	0.1	2,891	206
6	Golden Valley	DAKOTA FARM EQUIPMENT	BEACH	790,000	0.1	692	49
7	Golden Valley	WALZ TRUCK REPAIR	BEACH	510,000	0.1	447	32
8	Grant	DITTUS INC	ELGIN	790,000	0.1	692	49
9	Grant	DITTUS INC	ELGIN	1,139,000	0.1	998	71
10	Grant	NEW LEIPZIG SCHOOL	NEW LEIPZIG	1,200,000	0.1	1,051	75
11	LaMoure	GONE FISHIN	KULM	650,000	0.1	569	41
12	McHenry	CONOCO	VELVA	369,000	0.1	323	23
13	McHenry	GERALD MOSTAD	VELVA	510,000	0.1	447	32
14	Mercer	MOHL DRILLING	BEULAH	1,139,000	0.1	998	71
15	Mercer	SPIER SALES & SERVICE	BEULAH	790,000	0.1	692	49

16	Mercer	PEACE LUTHERAN CHURCH	HAZEN	1,352,000	0.1	1,184	85	
17	Mercer	PEACE LUTHERAN CHURCH	HAZEN	925,000	0.1	810	58	
18	Morton	WETCH & SONS DRILLING CO	MANDAN	1,600,000	0.1	1,402	100	
19	Nelson	G & M ENTERPRISES	LAKOTA	510,000	0.1	447	32	
20	Stutsman	SPIRITWOOD SCHOOL	SPIRITWOOD	2,525,000	0.1	2,212	158	
21	Ward	GRATECH COMPANY	BERTHOLD	2,105,000	0.1	1,844	132	
22	Ward	CANDLELIGHT APARTMENTS	KENMARE	643,000	0.1	563	40	
23	Ward	HANSEN HARDWARE	KENMARE	643,000	0.1	563	40	
24	Ward	RALPHS FLOORING	KENMARE	1,188,000	0.1	1,041	74	
25	Ward	RENSCH GARAGE	MAKOTI	1,300,000	0.1	1,139	81	
26	Ward	DAN HIEB CONSTRUCTION	MINOT	743,400	0.1	651	47	
27	Ward	NORTH SHORE SCHOOL	RYDER	2,140,000	0.1	1,875	134	
							2,039	**total**

Coal-Consuming Fire-Tube Boilers (500,000 Btu/hr to 20 MMBtu/hr)

#	County	Owner	City	Relief Valve Rating (Btu/hr)		Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Adams	DAKOTA PRAIRIE ENRICH CTR	REEDER	-	0.1	-	-	
2	Adams	HETTINGER SCHOOL	HETTINGER	3,161,000	0.1	2,769	198	
3	Adams	HETTINGER SCHOOL	HETTINGER	4,070,000	0.1	3,565	255	
4	Adams	HETTINGER SCHOOL	HETTINGER	4,890,000	0.1	4,284	306	
5	Adams	HETTINGER SCHOOL	HETTINGER	4,890,000	0.1	4,284	306	
6	Benson	OBERON SCHOOL	OBERON	3,161,000	0.1	2,769	198	
7	Benson	WARWICK SCHOOL	WARWICK	3,700,000	0.1	3,241	232	
8	Benson	MADDOCK SCHOOL	MADDOCK	7,076,000	0.1	6,199	443	
9	Bottineau	WESTHOPE HOME	WESTHOPE	3,000,000	0.1	2,628	188	
10	Bottineau	CENTRAL SCHOOL	BOTTINEAU	3,800,000	0.1	3,329	238	
11	Bottineau	WESTHOPE SCHOOL	WESTHOPE	4,355,000	0.1	3,815	272	
12	Bottineau	WESTHOPE SCHOOL	WESTHOPE	6,250,000	0.1	5,475	391	
13	Bottineau	BOTTINEAU CITY HALL	BOTTINEAU	6,942,000	0.1	6,081	434	
14	Bottineau	JUNIOR HIGH & HIGH SCHOOL	BOTTINEAU	8,150,000	0.1	7,139	510	
15	Bottineau	MSU BOTTINEAU BRANCH	BOTTINEAU	13,686,000	0.1	11,989	856	
16	Bottineau	MSU BOTTINEAU BRANCH	BOTTINEAU	13,686,000	0.1	11,989	856	
17	Burke	BOWBELLS CITY OF	BOWBELLS	970,000	0.1	850	61	
18	Burke	BOWBELLS HIGH SCHOOL	BOWBELLS	5,000,000	0.1	4,380	313	
19	Burke	BOWBELLS ELEMENTARY	BOWBELLS	6,322,000	0.1	5,538	396	
20	Burleigh	BISMARCK MARBLE & GRANITE	BISMARCK	510,000	0.1	447	32	
21	Burleigh	PORTABLE WELDING SERVICE	BISMARCK	1,300,000	0.1	1,139	81	
22	Burleigh	WERRE SCOTT	BALDWIN	2,105,000	0.1	1,844	132	
23	Burleigh	KING COAL FURNACE CORP	BISMARCK	3,696,000	0.1	3,238	231	
24	Burleigh	ATLAS READY MIX	BISMARCK	4,300,000	0.1	3,767	269	
25	Burleigh	DAKOTA ADVENTIST ACADEMY	BISMARCK	13,448,364	0.1	11,781	841	
26	Cass	FARGO TIRE SERVICE	FARGO	2,650,000	0.1	2,321	166	
27	Cass	FARGO TIRE SERVICE	FARGO	8,335,000	0.1	7,301	522	
28	Divide	WAYNES WELDING	CROSBY	790,000	0.1	692	49	
29	Divide	CROSBY TIRE & BODY SHOP	CROSBY	1,170,000	0.1	1,025	73	
30	Divide	DIVIDE COUNTY COURTHOUSE	CROSBY	3,161,000	0.1	2,769	198	
31	Divide	CROSBY ELEMENTARY SCHOOL	CROSBY	5,700,000	0.1	4,993	357	
32	Divide	ST LUKES HOSPITAL	CROSBY	6,690,000	0.1	5,860	419	
33	Divide	ST LUKES HOSPITAL	CROSBY	6,690,000	0.1	5,860	419	
34	Divide	CROSBY HIGH SCHOOL	CROSBY	9,515,055	0.1	8,335	595	
35	Dunn	DODGE SCHOOL	DODGE	2,500,000	0.1	2,190	156	
36	Dunn	HALLIDAY SCHOOL	HALLIDAY	13,400,000	0.1	11,738	838	
37	Emmons	STRASBURG ELEMENTARY	STRASBURG	2,020,000	0.1	1,770	126	
38	Golden Valley	GOLDEN VALLEY COUNTY SHOP	BEACH	510,000	0.1	447	32	
39	Grant	HERTZ BROTHERS INC	NEW LEIPZIG	510,000	0.1	447	32	
40	Grant	HERTZ BROTHERS INC	NEW LEIPZIG	550,000	0.1	482	34	
41	Grant	GRANT COUNTY COURTHOUSE	CARSON	2,105,000	0.1	1,844	132	
42	Grant	GRANT COUNTY COURTHOUSE	CARSON	2,105,000	0.1	1,844	132	
43	Grant	HERTZ BROTHERS INC	NEW LEIPZIG	2,500,000	0.1	2,190	156	
44	Grant	NEW LEIPZIG SCHOOL	NEW LEIPZIG	2,900,000	0.1	2,540	181	
45	Grant	ELGIN SCHOOL	ELGIN	4,568,000	0.1	4,002	286	
46	Grant	ELGIN SCHOOL	ELGIN	5,602,000	0.1	4,907	351	
47	Grant	PRAIRIE LEARNING CENTER	RALEIGH	6,218,000	0.1	5,447	389	
48	Grant	JACOBSON MEMORIAL HOSP	ELGIN	10,000,000	0.1	8,760	626	
49	Griggs	SHEYENNE TOOLING & MFG	COOPERSTOWN	1,300,000	0.1	1,139	81	
50	Griggs	GRIGGS COUNTY COURTHOUSE	COOPERSTOWN	2,716,000	0.1	2,379	170	
51	Hettinger	ST MARYS CHURCH	NEW ENGLAND	10,500,000	0.1	9,198	657	
52	Kidder	TAPPEN SCHOOL	TAPPEN	2,500,000	0.1	2,190	156	
53	Kidder	TUTTLE SCHOOL	TUTTLE	5,615,000	0.1	4,919	351	
54	LaMoure	LAMOURE SCHOOL	LAMOURE	6,019,000	0.1	5,273	377	
55	McHenry	UPHAM PUBLIC SCHOOL	UPHAM	4,100,000	0.1	3,592	257	
56	McHenry	NEWPORT SCHOOL	TOWNER	4,530,000	0.1	3,968	283	
57	McHenry	NEWPORT SCHOOL	TOWNER	4,530,000	0.1	3,968	283	
58	McHenry	DRAKE SCHOOL	DRAKE	6,020,000	0.1	5,274	377	
59	McHenry	VELVA SCHOOL	VELVA	9,060,000	0.1	7,937	567	
60	McHenry	VELVA SCHOOL	VELVA	9,095,000	0.1	7,967	569	
61	McKenzie	WATFORD CITY HIGH SCHOOL	WATFORD CITY	13,884,000	0.1	12,162	869	
62	McKenzie	WATFORD CITY HIGH SCHOOL	WATFORD CITY	13,884,000	0.1	12,162	869	
63	McLean	NEDLOH LTD	WILTON	5,193,000	0.1	4,549	325	
64	Mercer	HAZEN MOTORS	HAZEN	550,000	0.1	482	34	
65	Mercer	LIGNITE TIRE SERVICE	BEULAH	925,000	0.1	810	58	
66	Mercer	BEULAH DRUG	BEULAH	1,200,000	0.1	1,051	75	
67	Mercer	DAKOTA WESTMORELAND	BEULAH	2,020,000	0.1	1,770	126	
68	Mercer	GOLDEN VALLEY SCHOOL	GOLDEN VALLEY	2,900,000	0.1	2,540	181	

69	Mercer	BEULAH HIGH SCHOOL	BEULAH	2,925,000	0.1	2,562	183	
70	Mercer	BEULAH HIGH SCHOOL	BEULAH	3,130,000	0.1	2,742	196	
71	Mercer	B C FRY COMPANIES	ZAP	3,529,000	0.1	3,091	221	
72	Mercer	BEULAH HIGH SCHOOL	BEULAH	5,250,000	0.1	4,599	329	
73	Mercer	HAZEN HIGH SCHOOL	HAZEN	5,250,000	0.1	4,599	329	
74	Mercer	HAZEN HIGH SCHOOL	HAZEN	5,250,000	0.1	4,599	329	
75	Mercer	HAZEN MIDDLE SCHOOL	HAZEN	5,250,000	0.1	4,599	329	
76	Mercer	HAZEN MIDDLE SCHOOL	HAZEN	5,250,000	0.1	4,599	329	
77	Mercer	HAZEN ELEMENTARY SCHOOL	HAZEN	7,355,000	0.1	6,443	460	
78	Mercer	HAZEN ELEMENTARY SCHOOL	HAZEN	7,355,000	0.1	6,443	460	
79	Morton	HEBRON HERALD	HEBRON	510,000	0.1	447	32	
80	Morton	MIDWAY MACHINING	MANDAN	1,005,000	0.1	880	63	
81	Morton	ST LAWRENCE CHURCH	FLASHER	2,105,000	0.1	1,844	132	
82	Morton	ST LAWRENCE CHURCH	FLASHER	2,105,000	0.1	1,844	132	
83	Morton	FLASHER SCHOOL	FLASHER	3,800,000	0.1	3,329	238	
84	Morton	FLASHER SCHOOL	FLASHER	7,500,000	0.1	6,570	469	
85	Mountrail	PARSHALL CITY AUDITORIUM	PARSHALL	3,500,000	0.1	3,066	219	
86	Mountrail	PARSHALL ELEMENTARY	PARSHALL	5,250,000	0.1	4,599	329	
87	Mountrail	PARSHALL HIGH SCHOOL	PARSHALL	5,250,000	0.1	4,599	329	
88	Mountrail	NEW TOWN HIGH	NEW TOWN	6,843,000	0.1	5,994	428	
89	Mountrail	EDWIN LOE ELEMENTARY	NEW TOWN	7,355,000	0.1	6,443	460	
90	Nelson	NELSON COUNTY COURTHOUSE	LAKOTA	2,500,000	0.1	2,190	156	
91	Nelson	LAKOTA ELEMENTARY	LAKOTA	2,805,000	0.1	2,457	176	
92	Nelson	LAKOTA SCHOOL	LAKOTA	6,600,000	0.1	5,782	413	
93	Oliver	ST PAULS LUTHERAN CHURCH	CENTER	510,000	0.1	447	32	
94	Oliver	ST PAULS LUTHERAN CHURCH	CENTER	650,000	0.1	569	41	
95	Oliver	CENTER CIVIC CENTER	CENTER	925,000	0.1	810	58	
96	Oliver	CENTER SCHOOL	CENTER	5,250,000	0.1	4,599	329	
97	Oliver	CENTER SCHOOL	CENTER	5,250,000	0.1	4,599	329	
98	Pierce	RUGBY EQUIPMENT CO	RUGBY	696,000	0.1	610	44	
99	Pierce	HARTLEYS SCHOOL BUSES	RUGBY	2,900,000	0.1	2,540	181	
100	Ramsey	CAMP GRAFTON	DEVILS LAKE	16,077,000	0.1	14,083	1,006	
101	Ramsey	CAMP GRAFTON	DEVILS LAKE	16,077,000	0.1	14,083	1,006	
102	Ramsey	CAMP GRAFTON	DEVILS LAKE	19,708,000	0.1	17,264	1,233	
103	Ramsey	CAMP GRAFTON	DEVILS LAKE	19,758,000	0.1	17,308	1,236	
104	Ramsey	CAMP GRAFTON	DEVILS LAKE	19,758,000	0.1	17,308	1,236	
105	Ransom	LISBON AREA HEALTH SVCS	LISBON	4,053,000	0.1	3,550	254	
106	Renville	RENVILLE COUNTY OFFICE	MOHALL	-	0.1	-	-	
107	Renville	MOHALL PAINT	MOHALL	510,000	0.1	447	32	
108	Renville	SAVELKOUL FORD	MOHALL	790,000	0.1	692	49	
109	Renville	RENVILLE COUNTY SHOP	MOHALL	1,030,000	0.1	902	64	
110	Renville	SHERWOOD SCHOOL	SHERWOOD	5,200,000	0.1	4,555	325	
111	Renville	MOHALL SCHOOL	MOHALL	6,322,000	0.1	5,538	396	
112	Renville	GLENBURN SCHOOL	GLENBURN	7,500,000	0.1	6,570	469	
113	Rolette	DUNSEITH ELEMENTARY	DUNSEITH	5,900,000	0.1	5,168	369	
114	Rolette	ST JOHN SCHOOL	ST JOHN	6,091,000	0.1	5,336	381	
115	Rolette	ROLLA HIGH SCHOOL	ROLLA	9,152,000	0.1	8,017	573	
116	Sargent	SARGENT COUNTY COURTHOUSE	FORMAN	3,485,000	0.1	3,053	218	
117	Sheridan	SHERIDAN MEMORIAL HOME	MCCLUSKY	925,000	0.1	810	58	
118	Sheridan	GOODRICH SCHOOL	GOODRICH	1,200,000	0.1	1,051	75	
119	Sheridan	MCCLUSKY ELEMENTARY	MCCLUSKY	5,250,000	0.1	4,599	329	
120	Sheridan	MCCLUSKY HIGH SCHOOL	MCCLUSKY	6,029,000	0.1	5,281	377	
121	Stark	ASSUMPTION ABBEY	RICHARDTON	9,626,000	0.1	8,432	602	
122	Stark	SACRED HEART PRIORY	RICHARDTON	22,360,000	0.1	19,587	1,399	
123	Stutsman	SCHERBENSKE & SON INC	JAMESTOWN	1,682,000	0.1	1,473	105	
124	Towner	VONDALS ELECTRIC	CANDO	510,000	0.1	447	32	
125	Towner	BISBEE LUTHERAN CHURCH	BISBEE	743,400	0.1	651	47	
126	Towner	TOWNER COUNTY COURTHOUSE	CANDO	3,850,000	0.1	3,373	241	
127	Towner	BISBEE SCHOOL	BISBEE	5,000,000	0.1	4,380	313	
128	Towner	TOWNER CO MEDICAL CENTER	CANDO	6,552,000	0.1	5,740	410	
129	Towner	CANDO SCHOOL	CANDO	6,942,000	0.1	6,081	434	
130	Towner	CANDO SCHOOL	CANDO	6,945,000	0.1	6,084	435	
131	Ward	ST AGNES CHURCH	KENMARE	-	0.1	-	-	
132	Ward	NAZARETH LUTHERAN CHURCH	KENMARE	1,050,000	0.1	920	66	
133	Ward	MAKOTI THRESHING ASSN	MAKOTI	2,439,000	0.1	2,137	153	
134	Ward	ZION LUTHERAN CHURCH	MINOT	3,000,000	0.1	2,628	188	
135	Ward	PARK SOUTH PARTNERSHIP	MINOT	4,040,000	0.1	3,539	253	
136	Ward	KENMARE HIGH SCHOOL	KENMARE	5,250,000	0.1	4,599	329	
137	Ward	LOWES GARDEN CENTER	MINOT	5,250,000	0.1	4,599	329	
138	Ward	MAKOTI SCHOOL	MAKOTI	6,245,000	0.1	5,471	391	
139	Ward	SAWYER SCHOOL	SAWYER	7,658,000	0.1	6,708	479	
140	Wells	RYAN BUILDING	HARVEY	1,900,000	0.1	1,664	119	
141	Wells	FESSENDEN SCHOOL	FESSENDEN	6,322,000	0.1	5,538	396	
142	Wells	HARVEY SCHOOL DISTRICT	HARVEY	8,322,000	0.1	7,290	521	
143	Wells	HARVEY HIGH SCHOOL	HARVEY	10,500,000	0.1	9,198	657	
144	Williams	BASIN FILTRATION	WILLISTON	1,020,000	0.1	894	64	
145	Williams	TIOGA HIGH SCHOOL	TIOGA	7,500,000	0.1	6,570	469	
							46,839	**total**

Natural Gas Boiler Statistics

# of Process Boilers Over 20 MMBtu/hr	44	
Firing potential for Wood (7000 Btu/lb)	750,765	tons/yr
# of Heating Plant Boilers Over 20 MMBtu/hr	41	
Firing Potential for Wood (7000 Btu/lb)	275,337	tons/yr
# of Gas Boilers from 10 MMBtu/hr to 20 MMBtu/hr	95	
Firing Potential for Wood (7000 Btu/lb)	78,411	tons/yr
Total Firing Potential	1,104,513	tons/yr
Total Number of Gas-Fired Boilers	6,900	
Capacity	12,959	MMBtu/hr
Estimated Quantity of Gas Consumed	22,704,565	MMBtu/yr
Wood Equivalent	1,621,755	tons/yr

Major Natural Gas Process Boilers (20 MMBtu/hr and Greater)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Capacity Factor	Availability Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Billings	PETRO HUNT LLC	KILLDEER	29,493,000	0.8	0.8	165,350	11,811	
2	Billings	PETRO HUNT LLC	KILLDEER	28,112,000	0.8	0.8	157,607	11,258	
3	Billings	PETRO HUNT LLC	KILLDEER	27,578,000	0.8	0.8	154,613	11,044	
4	Billings	PETRO HUNT LLC	KILLDEER	22,503,000	0.8	0.8	126,161	9,011	
5	Burleigh	CIVIC CENTER	BISMARCK	105,000,000	0.8	0.8	588,672	42,048	
6	Cass	CASS CLAY CREAMERY	FARGO	59,796,000	0.8	0.8	335,240	23,946	
7	Cass	CARGILL INC	WEST FARGO	54,735,000	0.8	0.8	306,866	21,919	
8	Cass	CASS CLAY CREAMERY	FARGO	53,538,000	0.8	0.8	300,155	21,440	
9	Cass	CARGILL INC	WEST FARGO	51,831,000	0.8	0.8	290,585	20,756	
10	Cass	FARGO FILTRATION PLANT	FARGO	29,910,000	0.8	0.8	167,687	11,978	
11	Cass	FARGO FILTRATION PLANT	FARGO	29,910,000	0.8	0.8	167,687	11,978	
12	Cass	DRAYTON FOODS	FARGO	22,038,000	0.8	0.8	123,554	8,825	
13	Foster	DAKOTA GROWERS PASTA CO	CARRINGTON	20,356,000	0.8	0.8	114,124	8,152	
14	Foster	DAKOTA GROWERS PASTA CO	CARRINGTON	20,356,000	0.8	0.8	114,124	8,152	
15	Grand Forks	RDO FOODS CO	GRAND FORKS	180,505,000	0.8	0.8	1,011,983	72,285	
16	Grand Forks	J R SIMPLOT COMPANY	GRAND FORKS	68,615,000	0.8	0.8	384,683	27,477	
17	Grand Forks	J R SIMPLOT COMPANY	GRAND FORKS	64,506,000	0.8	0.8	361,646	25,832	
18	Grand Forks	J R SIMPLOT COMPANY	GRAND FORKS	48,652,000	0.8	0.8	272,763	19,483	
19	Grand Forks	CENEX ASPHALT TERMINAL	GRAND FORKS	30,470,000	0.8	0.8	170,827	12,202	
20	McHenry	ARCHER DANIELS MIDLAND CO	VELVA	79,337,000	0.8	0.8	444,795	31,771	
21	Mercer	DAKOTA GASIFICATION CO	BEULAH	604,591,000	0.8	0.8	3,389,579	242,113	
22	Mercer	DAKOTA GASIFICATION CO	BEULAH	604,591,000	0.8	0.8	3,389,579	242,113	
23	Mercer	DAKOTA GASIFICATION CO	BEULAH	604,591,000	0.8	0.8	3,389,579	242,113	
24	Mercer	DAKOTA GASIFICATION CO	BEULAH	105,780,000	0.8	0.8	593,045	42,360	
25	Mercer	DAKOTA GASIFICATION CO	BEULAH	105,780,000	0.8	0.8	593,045	42,360	
26	Morton	DAKOTA COUNTRY CHEESE	MANDAN	25,439,000	0.8	0.8	142,621	10,187	
27	Pembina	ARCHER DANIELS MIDLAND	WALHALLA	93,126,000	0.8	0.8	522,102	37,293	
28	Pembina	ARCHER DANIELS MIDLAND	WALHALLA	86,383,000	0.8	0.8	484,298	34,593	
29	Ransom	NORTHERN SUN - ADM	ENDERLIN	452,640,000	0.8	0.8	2,537,681	181,263	
30	Ransom	NORTHERN SUN - ADM	ENDERLIN	183,826,000	0.8	0.8	1,030,602	73,614	
31	Ransom	NORTHERN SUN - ADM	ENDERLIN	79,470,000	0.8	0.8	445,541	31,824	
32	Richland	CARGILL	WAHPETON	205,140,000	0.8	0.8	1,150,097	82,150	
33	Richland	CARGILL	WAHPETON	154,482,000	0.8	0.8	866,088	61,863	
34	Stutsman	CAVENDISH FARMS	JAMESTOWN	45,399,000	0.8	0.8	254,525	18,180	
35	Stutsman	CAVENDISH FARMS	JAMESTOWN	45,399,000	0.8	0.8	254,525	18,180	
36	Walsh	ALCHEM LIMITED	GRAFTON	30,507,000	0.8	0.8	171,034	12,217	
37	Walsh	ALCHEM LIMITED	GRAFTON	28,096,000	0.8	0.8	157,517	11,251	
38	Walsh	ALCHEM LIMITED	GRAFTON	21,616,000	0.8	0.8	121,188	8,656	
39	Walsh	ALCHEM LIMITED	GRAFTON	20,637,000	0.8	0.8	115,699	8,264	
40	Williams	TIOGA GAS PLANT	TIOGA	88,506,000	0.8	0.8	496,200	35,443	
41	Williams	TIOGA GAS PLANT	TIOGA	88,506,000	0.8	0.8	496,200	35,443	
42	Williams	TIOGA GAS PLANT	TIOGA	88,506,000	0.8	0.8	496,200	35,443	
43	Williams	TIOGA GAS PLANT	TIOGA	35,903,000	0.8	0.8	201,287	14,378	
44	Williams	TIOGA GAS PLANT	TIOGA	24,848,000	0.8	0.8	139,308	9,951	
								1,942,619	**total**

Major Natural Gas Heating Boilers (20 MMBtu/hr and Greater)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Capacity Factor	Availability Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr
1	Barnes	VALLEY CITY STATE UNIV	VALLEY CITY	21,757,000	0.6	0.5	57,177	4,084
2	Burleigh	MEDCENTER ONE	BISMARCK	31,031,000	0.6	0.5	81,549	5,825
3	Burleigh	ST ALEXIUS MEDICAL CENTER	BISMARCK	29,498,000	0.6	0.5	77,521	5,537
4	Burleigh	ST ALEXIUS MEDICAL CENTER	BISMARCK	27,784,000	0.6	0.5	73,016	5,215
5	Burleigh	MEDCENTER ONE	BISMARCK	24,261,000	0.6	0.5	63,758	4,554
6	Burleigh	MEDCENTER ONE	BISMARCK	24,261,000	0.6	0.5	63,758	4,554
7	Burleigh	ST ALEXIUS MEDICAL CENTER	BISMARCK	22,597,000	0.6	0.5	59,385	4,242
8	Cass	NDSU PHYSICAL PLANT	FARGO	159,193,000	0.6	0.5	418,359	29,883
9	Cass	NDSU PHYSICAL PLANT	FARGO	62,730,000	0.6	0.5	164,854	11,775
10	Cass	MERITCARE MEDICAL CENTER	FARGO	31,140,000	0.6	0.5	81,836	5,845
11	Cass	MERITCARE UNIVERSITY HOSP	FARGO	24,077,000	0.6	0.5	63,274	4,520
12	Cass	MERITCARE UNIVERSITY HOSP	FARGO	23,917,000	0.6	0.5	62,854	4,490

13	Cass	MERITCARE UNIVERSITY HOSP	FARGO	23,077,000	0.6	0.5	60,646	4,332	
14	Cass	PRAIRIE AT ST JOHNS	FARGO	22,841,000	0.6	0.5	60,026	4,288	
15	Grand Forks	UND PLANT SERVICES	GRAND FORKS	101,922,000	0.6	0.5	267,851	19,132	
16	Grand Forks	UND PLANT SERVICES	GRAND FORKS	64,207,000	0.6	0.5	168,736	12,053	
17	Grand Forks	UND PLANT SERVICES	GRAND FORKS	64,205,000	0.6	0.5	168,731	12,052	
18	Grand Forks	RDO FOODS CO	GRAND FORKS	63,331,000	0.6	0.5	166,434	11,888	
19	Grand Forks	UND PLANT SERVICES	GRAND FORKS	49,559,000	0.6	0.5	130,241	9,303	
20	Grand Forks	ALERUS CENTER	GRAND FORKS	31,544,337	0.6	0.5	82,899	5,921	
21	Grand Forks	ALERUS CENTER	GRAND FORKS	31,544,337	0.6	0.5	82,899	5,921	
22	Grand Forks	ALTRU HEALTH SYSTEMS	GRAND FORKS	26,830,000	0.6	0.5	70,509	5,036	
23	Grand Forks	ALTRU HEALTH SYSTEMS	GRAND FORKS	26,829,000	0.6	0.5	70,507	5,036	
24	Pembina	MOTOR COACH INDUSTRIES	PEMBINA	20,826,000	0.6	0.5	54,731	3,909	
25	Ramsey	MERCY HOSPITAL	DEVILS LAKE	21,616,000	0.6	0.5	56,807	4,058	
26	Ramsey	STATE SCHOOL FOR THE DEAF	DEVILS LAKE	20,529,000	0.6	0.5	53,950	3,854	
27	Richland	STATE COLLEGE OF SCIENCE	WAHPETON	42,445,000	0.6	0.5	111,545	7,968	
28	Richland	STATE COLLEGE OF SCIENCE	WAHPETON	36,775,000	0.6	0.5	96,645	6,903	
29	Richland	STATE COLLEGE OF SCIENCE	WAHPETON	33,648,000	0.6	0.5	88,427	6,316	
30	Stark	DICKINSON STATE UNIV	DICKINSON	22,647,000	0.6	0.5	59,516	4,251	
31	Stark	DICKINSON STATE UNIV	DICKINSON	22,647,000	0.6	0.5	59,516	4,251	
32	Stark	DICKINSON STATE UNIV	DICKINSON	22,647,000	0.6	0.5	59,516	4,251	
33	Stark	ST JOSEPHS HOSPITAL	DICKINSON	22,135,000	0.6	0.5	58,171	4,155	
34	Stutsman	STATE HOSPITAL	JAMESTOWN	41,984,000	0.6	0.5	110,334	7,881	
35	Stutsman	STATE HOSPITAL	JAMESTOWN	23,785,000	0.6	0.5	62,507	4,465	
36	Walsh	STATE DEVELOPMENTAL CTR	GRAFTON	21,757,000	0.6	0.5	57,177	4,084	
37	Walsh	STATE DEVELOPMENTAL CTR	GRAFTON	21,757,000	0.6	0.5	57,177	4,084	
38	Ward	MINOT STATE UNIVERSITY	MINOT	27,775,000	0.6	0.5	72,993	5,214	
39	Ward	TRINITY - ST JOSEPHS	MINOT	26,206,000	0.6	0.5	68,869	4,919	
40	Ward	MINOT STATE UNIVERSITY	MINOT	25,659,000	0.6	0.5	67,432	4,817	
41	Ward	TRINITY - ST JOSEPHS	MINOT	23,816,000	0.6	0.5	62,588	4,471	
								275,337	**total**

Natural Gas Boilers (10 MMBtu/hr – 20 MMBtu/hr)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr
1	Barnes	SHEYENNE CARE CENTER	VALLEY CITY	19,034,000	0.1	16,674	1,191
2	Barnes	SHEYENNE CARE CENTER	VALLEY CITY	18,803,000	0.1	16,471	1,177
3	Barnes	MARYVALE CONVENT	VALLEY CITY	13,884,000	0.1	12,162	869
4	Barnes	VFW CLUB	VALLEY CITY	12,881,000	0.1	11,284	806
5	Barnes	VALLEY WEST 2	VALLEY CITY	12,593,000	0.1	11,031	788
6	Barnes	VALLEY CITY HIGH SCHOOL	VALLEY CITY	11,994,000	0.1	10,507	750
7	Barnes	VANSCO ELECTRONICS INC	VALLEY CITY	11,734,000	0.1	10,279	734
8	Barnes	MERCY HOSPITAL	VALLEY CITY	11,208,000	0.1	9,818	701
9	Billings	US POST OFFICE	MEDORA	13,973,579	0.1	12,241	874
10	Burleigh	COCA COLA BOTTLING CO	BISMARCK	19,662,000	0.1	17,224	1,230
11	Burleigh	WALKER JACK	BISMARCK	18,277,000	0.1	16,011	1,144
12	Burleigh	BUMAN BUILDING	BISMARCK	18,273,000	0.1	16,007	1,143
13	Burleigh	CALGARY #2	BISMARCK	17,464,000	0.1	15,298	1,093
14	Burleigh	CALGARY #3	BISMARCK	17,464,000	0.1	15,298	1,093
15	Burleigh	CALGARY #2	BISMARCK	15,828,000	0.1	13,865	990
16	Burleigh	DENNYS	BISMARCK	15,300,000	0.1	13,403	957
17	Burleigh	MONTANA DAKOTA UTILITIES	BISMARCK	13,192,000	0.1	11,556	825
18	Burleigh	WALKER JACK	BISMARCK	13,052,000	0.1	11,434	817
19	Burleigh	MEMORIAL BUILDING	BISMARCK	12,304,580	0.1	10,779	770
20	Burleigh	DEPT OF TRANSPORTATION	BISMARCK	11,894,000	0.1	10,419	744
21	Burleigh	STUDENT UNION	BISMARCK	11,519,000	0.1	10,091	721
22	Burleigh	BISMARCK TEMPLE	BISMARCK	11,000,000	0.1	9,636	688
23	Burleigh	NORTH POINTE APARTMENTS	BISMARCK	10,896,000	0.1	9,545	682
24	Burleigh	JEANETTE MYHRE ELEMENTARY	BISMARCK	10,500,000	0.1	9,198	657
25	Cass	MCDONALD APARTMENTS	FARGO	17,434,000	0.1	15,272	1,091
26	Cass	MERITCARE UNIVERSITY HOSP	FARGO	16,866,000	0.1	14,775	1,055
27	Cass	MERITCARE MEDICAL CENTER	FARGO	16,866,000	0.1	14,775	1,055
28	Cass	SOUTH POINTE II	FARGO	14,127,000	0.1	12,375	884
29	Cass	CLARICA TOWER	FARGO	12,513,000	0.1	10,961	783
30	Cass	L E BERGER ELEMENTARY	WEST FARGO	12,384,000	0.1	10,848	775
31	Cass	UNIVERSITY VILLAGE	FARGO	12,196,000	0.1	10,684	763
32	Cass	UNIVERSITY VILLAGE	FARGO	12,196,000	0.1	10,684	763
33	Cass	UNIVERSAL BUILDING	FARGO	12,182,000	0.1	10,671	762
34	Cass	US BANK	FARGO	12,182,000	0.1	10,671	762
35	Cass	33RD STREET APARTMENTS	FARGO	11,994,000	0.1	10,507	750
36	Cass	MERITCARE UNIVERSITY HOSP	FARGO	11,700,000	0.1	10,249	732
37	Cass	ST PARTNERSHIP	FARGO	11,549,000	0.1	10,117	723
38	Cass	STEEN & BERG	FARGO	11,519,000	0.1	10,091	721
39	Cass	CLARICA TOWER	FARGO	11,366,000	0.1	9,957	711
40	Cass	UNIVERSITY PARK APTS	FARGO	10,821,000	0.1	9,479	677
41	Cass	WEST FARGO MIDDLE SCHOOL	WEST FARGO	10,749,000	0.1	9,416	673
42	Cass	NORTH HIGH SCHOOL	FARGO	10,700,000	0.1	9,373	670
43	Cass	OLIVET LUTHERAN CHURCH	FARGO	10,700,000	0.1	9,373	670

44	Cass	OLIVET LUTHERAN CHURCH	FARGO	10,700,000	0.1	9,373	670	
45	Cass	L E BERGER ELEMENTARY	WEST FARGO	10,170,000	0.1	8,909	636	
46	Cass	NORSEMAN APARTMENTS	FARGO	10,000,000	0.1	8,760	626	
47	Divide	BUSHEL 42 PASTA CO	CROSBY	18,790,000	0.1	16,460	1,176	
48	Eddy	BISON LODGE	NEW ROCKFORD	10,808,000	0.1	9,468	676	
49	Eddy	FAIRVIEW APARTMENTS	NEW ROCKFORD	10,808,000	0.1	9,468	676	
50	Eddy	G & R GRAIN & FEED INC	NEW ROCKFORD	10,808,000	0.1	9,468	676	
51	Eddy	HERITAGE HOUSE	NEW ROCKFORD	10,808,000	0.1	9,468	676	
52	Emmons	LINTON HOSPITAL	LINTON	11,389,000	0.1	9,977	713	
53	Golden Valley	BEACH HIGH SCHOOL	BEACH	17,404,000	0.1	15,246	1,089	
54	Golden Valley	BEACH HIGH SCHOOL	BEACH	16,369,000	0.1	14,339	1,024	
55	Golden Valley	BEACH HIGH SCHOOL	BEACH	13,192,000	0.1	11,556	825	
56	Golden Valley	BEACH HIGH SCHOOL	BEACH	13,192,000	0.1	11,556	825	
57	Grand Forks	RYDELL CHEVROLET	GRAND FORKS	18,338,000	0.1	16,064	1,147	
58	Grand Forks	TRANSITIONAL CENTRE	GRAND FORKS	17,464,000	0.1	15,298	1,093	
59	Grand Forks	CARL BEN EILSON ELEM	GRAND FORKS	15,750,000	0.1	13,797	986	
60	Grand Forks	BELMONT APARTMENTS	GRAND FORKS	15,270,000	0.1	13,377	955	
61	Mckenzie	MCKENZIE CO MEM HOSPITAL	WATFORD CITY	13,686,000	0.1	11,989	856	
62	McLean	RIVERDALE SCHOOL	RIVERDALE	13,884,000	0.1	12,162	869	
63	McLean	WASHBURN SCHOOL	WASHBURN	13,686,000	0.1	11,989	856	
64	Morton	GEORGES MIDWEST BAKERY	MANDAN	19,646,000	0.1	17,210	1,229	
65	Morton	MONTANA DAKOTA UTILITIES	MANDAN	13,686,000	0.1	11,989	856	
66	Morton	MANDAN HIGH SCHOOL	MANDAN	13,419,000	0.1	11,755	840	
67	Morton	FORT LINCOLN SCHOOL	MANDAN	13,387,000	0.1	11,727	838	
68	Morton	WELLS FARGO BANK	MANDAN	12,073,000	0.1	10,576	755	
69	Morton	CENEX ASPHALT TERMINAL	MANDAN	11,389,000	0.1	9,977	713	
70	Ramsey	ODD FELLOWS HOME	DEVILS LAKE	18,326,000	0.1	16,054	1,147	
71	Ramsey	COMFORT INN	DEVILS LAKE	11,624,000	0.1	10,183	727	
72	Ramsey	TRAILS WEST MOTEL	DEVILS LAKE	11,426,000	0.1	10,009	715	
73	Ramsey	HEARTLAND II	DEVILS LAKE	10,846,000	0.1	9,501	679	
74	Ransom	NORTH DAKOTA VETERANS HM	LISBON	10,830,000	0.1	9,487	678	
75	Ransom	NORTH DAKOTA VETERANS HM	LISBON	10,830,000	0.1	9,487	678	
76	Richland	QWEST	WAHPETON	13,884,000	0.1	12,162	869	
77	Richland	WCCO BELTING COMPANY	WAHPETON	11,994,000	0.1	10,507	750	
78	Rolette	ROLETTE SCHOOL	ROLETTE	13,884,000	0.1	12,162	869	
79	Sargent	MILNOR I	MILNOR	10,460,000	0.1	9,163	654	
80	Stark	ESP COMPUTERS & SOFTWARE	DICKINSON	12,674,000	0.1	11,102	793	
81	Stark	LOGO MAGIC	DICKINSON	11,994,000	0.1	10,507	750	
82	Stark	ST JOSEPHS HOSPITAL	DICKINSON	11,519,000	0.1	10,091	721	
83	Stark	ESQUIRE CLUB	DICKINSON	11,464,000	0.1	10,042	717	
84	Stutsman	ANNE CARLSEN CENTER	JAMESTOWN	11,994,000	0.1	10,507	750	
85	Stutsman	ANNE CARLSEN CENTER	JAMESTOWN	11,794,000	0.1	10,332	738	
86	Stutsman	LINCOLN ELEMENTARY	JAMESTOWN	11,439,000	0.1	10,021	716	
87	Walsh	SUNSET HOME	GRAFTON	13,884,000	0.1	12,162	869	
88	Ward	INTERNATIONAL INN	MINOT	13,286,000	0.1	11,639	831	
89	Ward	COMFORT INN MINOT	MINOT	13,104,000	0.1	11,479	820	
90	Ward	MINOT STATE UNIVERSITY	MINOT	11,519,000	0.1	10,091	721	
91	Ward	MOTOR SERVICE COMPANY INC	MINOT	10,824,000	0.1	9,482	677	
92	Ward	NORTH HILL LAUNDROMAT	MINOT	10,500,000	0.1	9,198	657	
93	Ward	NORTH PLAINS ELEMENTARY	MINOT	10,500,000	0.1	9,198	657	
94	Ward	WARD COUNTY JAIL	MINOT	10,166,000	0.1	8,905	636	
95	Williams	TRAVEL HOST MOTEL	WILLISTON	13,491,000	0.1	11,818	844	
							78,411	**total**

Oil-Fired Boiler Statistics

# of Oil-Fired Boilers	816	
# of Utility-Owned Oil-Fired Boilers	10	
Potential to Fire Wood at 10%	57,284	tons/yr
# of Process Boilers over 20 MMBtu/hr	13	
Firing Potential for Wood (7000 Btu/lb)	85,148	tons/yr
# of Heating Boilers 10 to 20 MMBtu/hr	23	
Firing potential for Wood (7000 Btu/lb)	19,345	tons/yr
# of Oil-Fired Boilers under 10 MMBtu/hr	768	
Firing Potential for Wood (7000 Btu/lb)	101,739	tons/yr
Total for Units Over 10 MMBtu/hr	161,777	tons/yr
Total for All Units	263,516	tons/yr

Utility-Owned Oil-Fired Boilers

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb 10% Cofire tons/yr	
1	McLean	COAL CREEK STATION	UNDERWOOD	166,125,000	0.64	931,363	6,653	
2	Mercer	GREAT RIVER ENERGY	STANTON	26,692,000	0.5	116,911	835	
3	Mercer	LELAND OLDS STATION	STANTON	42,262,000	0.6	222,129	1,587	
4	Mercer	ANTELOPE VALLEY STATION	BEULAH	115,167,000	0.64	645,672	4,612	
5	Mercer	COYOTE STATION	BEULAH	155,268,000	0.64	870,495	6,218	
6	Mercer	DAKOTA GASIFICATION CO	BEULAH	220,017,000	0.64	1,233,503	8,811	
7	Mercer	DAKOTA GASIFICATION CO	BEULAH	220,017,000	0.64	1,233,503	8,811	
8	Morton	TESORO PETROLEUM	MANDAN	156,700,000	0.64	878,523	6,275	
9	Morton	TESORO PETROLEUM	MANDAN	156,700,000	0.64	878,523	6,275	
10	Morton	TESORO PETROLEUM	MANDAN	180,000,000	0.64	1,009,152	7,208	
							57,284	**total**

Oil-Fired Boilers (20 MMBtu/hr and Greater)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Burleigh	ND STATE PENITENTIARY	BISMARCK	26,341,000	0.1	23,075	1,648	
2	Cass	AMERIPRIDE LINEN	FARGO	22,862,000	0.1	20,027	1,431	
3	Cass	PRAIRIE AT ST JOHNS	FARGO	25,176,000	0.1	22,054	1,575	
4	Cass	MERITCARE MEDICAL CENTER	FARGO	31,032,000	0.1	27,184	1,942	
5	Cass	MERITCARE MEDICAL CENTER	FARGO	31,036,000	0.1	27,188	1,942	
6	McHenry	ARCHER DANIELS MIDLAND CO	VELVA	50,885,000	0.64	285,282	20,377	
7	Morton	CAR SHOP	MANDAN	24,339,000	0.1	21,321	1,523	
8	Oliver	MILTON R YOUNG STATION	CENTER	61,658,000	0.5	270,062	19,290	
9	Ransom	NORTHERN SUN - ADM	ENDERLIN	20,630,000	0.64	115,660	8,261	
10	Richland	MINN-DAK FARMERS CO-OP	WAHPETON	21,702,000	0.3	57,033	4,074	
11	Richland	MINN-DAK FARMERS CO-OP	WAHPETON	54,963,000	0.5	240,738	17,196	
12	Stark	ST JOSEPHS HOSPITAL	DICKINSON	22,134,000	0.1	19,389	1,385	
13	Stutsman	JAMESTOWN COLLEGE	JAMESTOWN	23,996,000	0.3	63,061	4,504	
							85,148	**total**

Oil-Fired Boilers (10 to 20 MMBtu/hr)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Bottineau	MSU BOTTINEAU BRANCH	BOTTINEAU	10,876,000	0.1	9,527	681	
2	Bottineau	MSU BOTTINEAU BRANCH	BOTTINEAU	10,976,000	0.1	9,615	687	
3	Cass	AGASSIZ JUNIOR HIGH	FARGO	13,686,000	0.1	11,989	856	
4	Cass	AGASSIZ JUNIOR HIGH	FARGO	13,686,000	0.1	11,989	856	
5	Cass	WEST FARGO MIDDLE SCHOOL	WEST FARGO	16,145,000	0.1	14,143	1,010	
6	Dickey	TRINITY BIBLE COLLEGE	ELLENDALE	11,894,000	0.1	10,419	744	
7	Dickey	TRINITY BIBLE COLLEGE	ELLENDALE	11,894,000	0.1	10,419	744	
8	Grand Forks	NORTHWOOD DEACONESS HOSP	NORTHWOOD	10,581,000	0.1	9,269	662	
9	Grand Forks	MINNKOTA POWER CO-OP INC	GRAND FORKS	15,344,000	0.1	13,441	960	
10	McHenry	WINGER CHEESE INC	TOWNER	15,848,000	0.1	13,883	992	
11	McHenry	WINGER CHEESE INC	TOWNER	15,878,000	0.1	13,909	994	
12	Pierce	HEART OF AMERICA MED CTR	RUGBY	11,994,000	0.1	10,507	750	
13	Pierce	HEART OF AMERICA MED CTR	RUGBY	16,805,000	0.1	14,721	1,052	
14	Richland	IMATION ENTERPRISES CORP	WAHPETON	13,884,000	0.1	12,162	869	
15	Rolette	PRESENTATION MEDICAL CTR	ROLLA	13,192,000	0.1	11,556	825	
16	Sargent	BOBCAT CO	GWINNER	13,884,000	0.1	12,162	869	
17	Sargent	BOBCAT CO	GWINNER	13,884,000	0.1	12,162	869	
18	Stutsman	JAMESTOWN HOSPITAL	JAMESTOWN	11,208,000	0.1	9,818	701	
19	Stutsman	JAMESTOWN CIVIC CENTER	JAMESTOWN	13,884,000	0.1	12,162	869	
20	Stutsman	JAMESTOWN CIVIC CENTER	JAMESTOWN	13,884,000	0.1	12,162	869	
21	Ward	TRINITY MEDICAL CENTER	MINOT	12,914,000	0.1	11,313	808	
22	Ward	TRINITY MEDICAL CENTER	MINOT	13,632,000	0.1	11,942	853	
23	Williams	CAZA DRILLING RIG 48	WILLISTON	13,192,000	0.1	11,556	825	
							19,345	**total**

Propane Boiler Statistics

# of Propane Boilers	152	
Firing Potential for Wood (7000 Btu/lb)	8,388	tons/yr
# of Propane Boilers Over 970,000 Btu/hr	27	
Firing Potential for Wood (7000 Btu/lb)	3,881	tons/yr
# of Schools Firing Propane	5	
Total Potential	8,388	tons/yr

Major Owners of Propane-Fired Boilers (1 to 10 MMBtu/hr)

#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Barnes	FIRST LUTHERAN CHURCH	LITCHVILLE	1,070,000	0.1	937	67	
2	Benson	MINNEWAUKAN SCHOOL	MINNEWAUKAN	2,925,000	0.1	2,562	183	
3	Benson	GOLDEN PLAINS FROZEN FOOD	LEEDS	3,529,000	0.1	3,091	221	
4	Bottineau	GOOD SAMARITAN CENTER	BOTTINEAU	1,300,000	0.1	1,139	81	
5	Cass	PAGE CLEANERS & LAUNDRY	PAGE	1,042,000	0.1	913	65	
6	Cass	AGGREGATE INDUSTRIES	CASSELTON	2,445,000	0.1	2,142	153	
7	Divide	CROSBY HIGH SCHOOL	CROSBY	1,670,000	0.1	1,463	104	
8	Logan	NAPOLEON CARE CENTER	NAPOLEON	1,170,000	0.1	1,025	73	
9	Logan	NAPOLEON SWIMMING POOL	NAPOLEON	1,566,000	0.1	1,372	98	
10	McIntosh	ASHLEY SWIMMING POOL	ASHLEY	1,352,000	0.1	1,184	85	
11	Mercer	ZION LUTHERAN CHURCH	BEULAH	2,675,000	0.1	2,343	167	
12	Mountrail	GOOD SAMARITAN CENTER	NEW TOWN	2,925,000	0.1	2,562	183	
13	Mountrail	GOOD SAMARITAN CENTER	NEW TOWN	3,300,000	0.1	2,891	206	
14	Pierce	RUGBY CITY POOL	RUGBY	1,912,000	0.1	1,675	120	
15	Ransom	LISBON SCHOOL	LISBON	970,000	0.1	850	61	
16	Ransom	LISBON SCHOOL	LISBON	970,000	0.1	850	61	
17	Ransom	LISBON SCHOOL	LISBON	970,000	0.1	850	61	
18	Ransom	LISBON SCHOOL	LISBON	1,670,000	0.1	1,463	104	
19	Ransom	VJ'S LAUNDROMAT	LISBON	2,070,000	0.1	1,813	130	
20	Ransom	PARKSIDE LUTHERAN HOME	LISBON	5,535,000	0.1	4,849	346	
21	Renville	RENVILLE COUNTY OFFICE	MOHALL	1,900,000	0.1	1,664	119	
22	Renville	STEVENS WELDING SERVICE	GLENBURN	7,273,000	0.1	6,371	455	
23	Stark	FERRELL TRANSPORT	DICKINSON	1,170,000	0.1	1,025	73	
24	Stark	STEFFES ETS INC	DICKINSON	4,400,000	0.1	3,854	275	
25	Towner	CANDO SCHOOL	CANDO	2,070,000	0.1	1,813	130	
26	Traill	MAY PORT CLEANERS	MAYVILLE	1,654,000	0.1	1,449	103	
27	Walsh	EDINBURG SCHOOL	EDINBURG	2,500,000	0.1	2,190	156	
							3,881	**Total**

Electric Boiler Statistics

# of Electric Boilers	303	
# of Large Electric Boilers	17	
Firing Potential for Wood (7000 Btu/lb)	8,401	tons/yr
# of High-Pressure Electric Boilers	39	tons/yr
Firing Potential for Wood (7000 Btu/lb)	3,101	
Total Potential	11,502	tons/yr

Owners of Large Electric Boilers (5 to 30 MMBtu/hr)

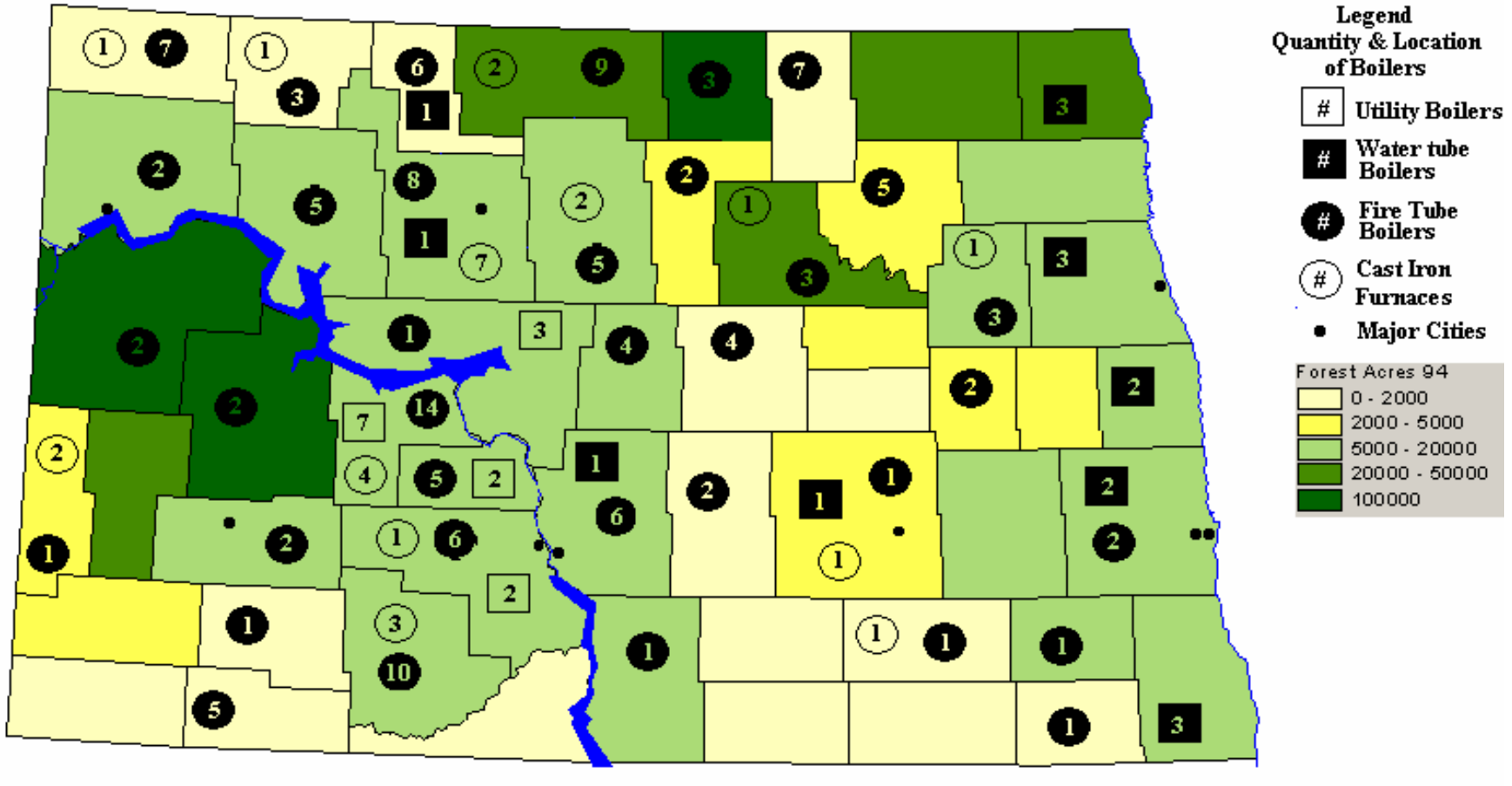
#	County	Owner	City	Relief Valve Rating (Btu/hr)	Fuel Use Factor	Est. Fuel Use MMBtu/yr	Wood @ 7000 Btu/lb tons/yr	
1	Bottineau	PRIDE DAIRIES	BOTTINEAU	5,084,000	0.1	4454	318	
2	Burleigh	BASIN ELECTRIC POWER CO-OP	BISMARCK	5,909,000	0.1	5176	370	
3	Cass	J C PENNEY CO	FARGO	5,800,000	0.1	5081	363	
4	Cass	J C PENNEY CO	FARGO	5,800,000	0.1	5081	363	
5	Cass	WEST ACRES SHOPPING CTR	FARGO	7,850,000	0.1	6877	491	
6	Cass	WEST ACRES SHOPPING CTR	FARGO	8,818,000	0.1	7725	552	
7	Grand Forks	MINNKOTA POWER CO-OP INC	GRAND FORKS	7,120,000	0.1	6237	446	
8	Grand Forks	MINNKOTA POWER CO-OP INC	GRAND FORKS	7,120,000	0.1	6237	446	
9	Pierce	HEART OF AMERICA MED CTR	RUGBY	8,470,000	0.1	7420	530	
10	Ransom	PARKSIDE LUTHERAN HOME	LISBON	5,535,000	0.1	4849	346	
11	Ransom	NORTH DAKOTA VETERANS HM	LISBON	8,994,000	0.1	7879	563	
12	Richland	SISTERS OF ST FRANCIS	HANKINSON	5,884,000	0.1	5154	368	
13	Richland	SENIOR HIGH SCHOOL	WAHPETON	5,250,000	0.1	4599	329	
14	Rolette	PRESENTATION MEDICAL CTR	ROLLA	7,184,000	0.1	6293	450	
15	Steele	FINLEY SHARON SCHOOL	FINLEY	6,300,000	0.1	5519	394	
16	Traill	AMERICAN CRYSTAL SUGAR	HILLSBORO	25,970,000	0.1	22750	1625	
17	Wells	ST ALOISIUS HOSPITAL	HARVEY	7,180,000	0.1	6290	449	
							8,401	**Total**

Owners of High Pressure Electric Boilers

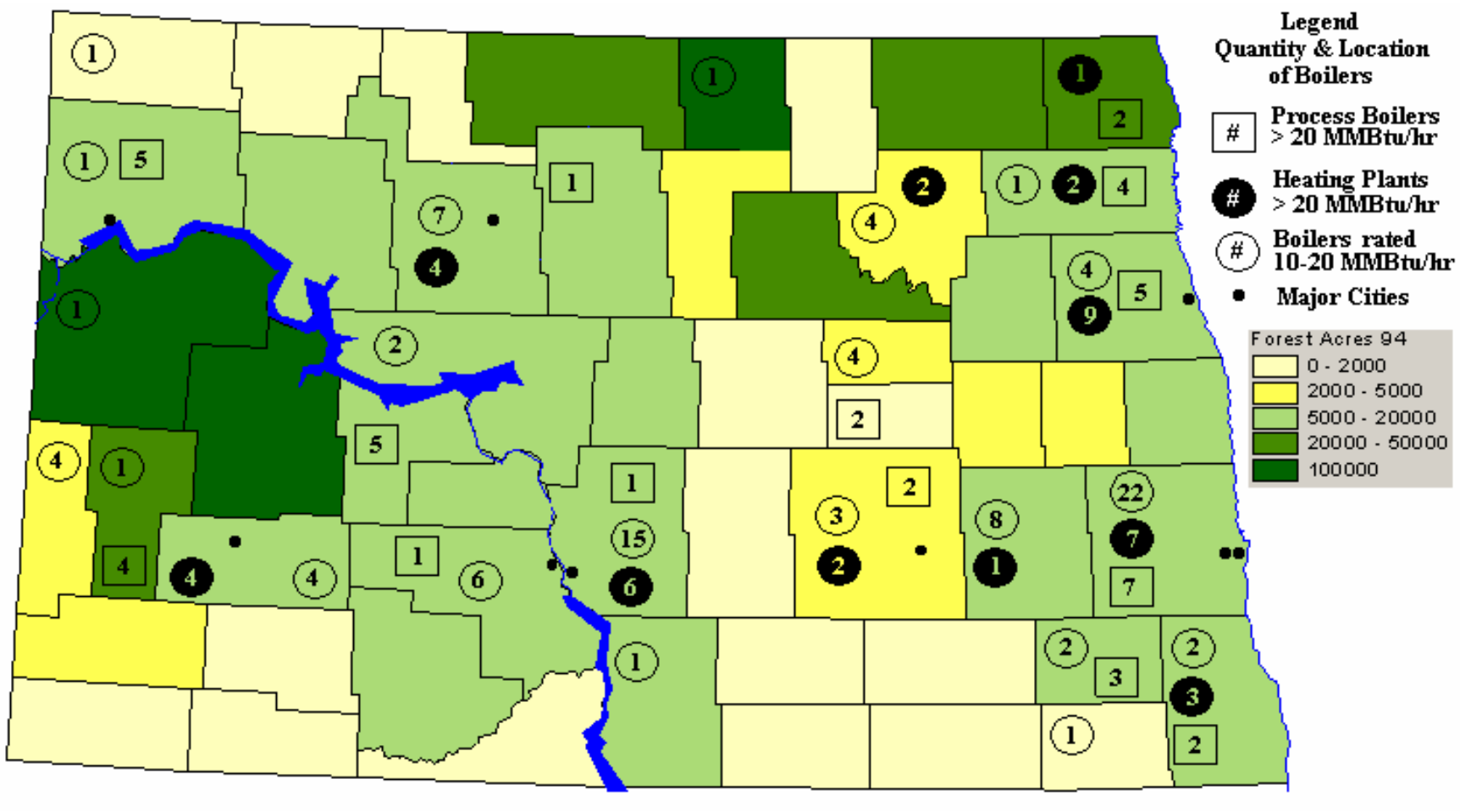
#	County	Owner	City	Relief Valve Rating	Fuel Use	Est. Fuel Use	Wood @ 7000 Btu/lb	
1	Barnes	VILLAGE CLEANERS	VALLEY CITY	586,000	0.1	513	37	
2	Barnes	NORTH CENTRAL SCHOOL	ROGERS	500,000	0.1	438	31	
3	Burleigh	JONES LINDBERG BUILDING	BISMARCK	1,402,000	0.1	1228	88	
4	Burleigh	RIDDLES JEWELRY	BISMARCK	423,000	0.1	371	26	
5	Burleigh	DAKOTA SURGERY & LASER	BISMARCK	643,000	0.1	563	40	
6	Burleigh	MICRO BIOLOGY SECTION	BISMARCK	851,000	0.1	745	53	
7	Burleigh	BISMARCK SURGICAL ASSOC	BISMARCK	1,151,000	0.1	1008	72	
8	Burleigh	JONES LINDBERG BUILDING	BISMARCK	1,695,000	0.1	1485	106	
9	Cass	ALDEVRON LLC	FARGO	423,000	0.1	371	26	
10	Cass	LAMB PLASTIC SURGERY CTR	FARGO	423,000	0.1	371	26	
11	Cass	RIDDLES JEWELRY	FARGO	423,000	0.1	371	26	
12	Cass	AIR CARE	WEST FARGO	423,000	0.1	371	26	
13	Cass	LASER & SURGERY CENTER	FARGO	643,000	0.1	563	40	
14	Cass	GREAT PLAINS FOOD BANK	FARGO	1,695,000	0.1	1485	106	
15	Cass	NDSU PILOT PLANT SVC CTR	FARGO	925,000	0.1	810	58	
16	Cass	STRAUS CO	FARGO	1,198,000	0.1	1049	75	
17	Cass	CASS COUNTY ELECT CO-OP	KINDRED	3,366,000	0.1	2949	211	
18	Cavalier	HIWAY LAUNDRY	LANGDON	643,000	0.1	563	40	
19	Divide	ST LUKES HOSPITAL	CROSBY	423,000	0.1	371	26	
20	Griggs	GRIGGS COUNTY HOSPITAL	COOPERSTOWN	448,000	0.1	392	28	
21	McHenry	GRANVILLE SCHOOL DISTRICT	GRANVILLE	640,000	0.1	561	40	
22	McLean	FALKIRK MINING COMPANY	UNDERWOOD	3,450,000	0.1	3022	216	
23	McLean	GARRISON DAM	RIVERDALE	3,220,000	0.1	2821	201	
24	McLean	COAL CREEK STATION	UNDERWOOD	3,215,000	0.1	2816	201	
25	Mercer	SAKAKAWEA MEDICAL CENTER	HAZEN	1,148,000	0.1	1006	72	
26	Mercer	BEULAH ELEMENTARY	BEULAH	1,640,000	0.1	1437	103	
27	Mercer	BEULAH HIGH SCHOOL	BEULAH	1,640,000	0.1	1437	103	
28	Mountrail	ROCKVIEW GOOD SAMARITAN	PARSHALL	2,635,000	0.1	2308	165	
29	Mountrail	ROCKVIEW GOOD SAMARITAN	PARSHALL	710,000	0.1	622	44	
30	Mountrail	MOUNTRAIL COUNTY MED CTR	STANLEY	423,000	0.1	371	26	
31	Ransom	NORTH DAKOTA VETERANS HM	LISBON	2,677,000	0.1	2345	168	
32	Richland	HANKINSON SCHOOL	HANKINSON	777,600	0.1	681	49	
33	Stutsman	CARGILL MALT	SPIRITWOOD	643,000	0.1	563	40	
34	Traill	UNION HOSPITAL	MAYVILLE	423,000	0.1	371	26	
35	Traill	UNION HOSPITAL	MAYVILLE	645,000	0.1	565	40	
36	Walsh	FIRST CARE HEALTH	PARK RIVER	2,190,000	0.1	1918	137	
37	Walsh	UNITY MEDICAL CENTER	GRAFTON	3,590,000	0.1	3145	225	
38	Ward	RIDDLES JEWELRY	MINOT	453,000	0.1	397	28	
39	Ward	CENTENNIAL MEDICAL CENTER	MINOT	1,148,000	0.1	1006	72	
							3101	**Total**

PART II – NORTH DAKOTA ENERGY INFRASTRUCTURE OF REGISTERED BOILERS

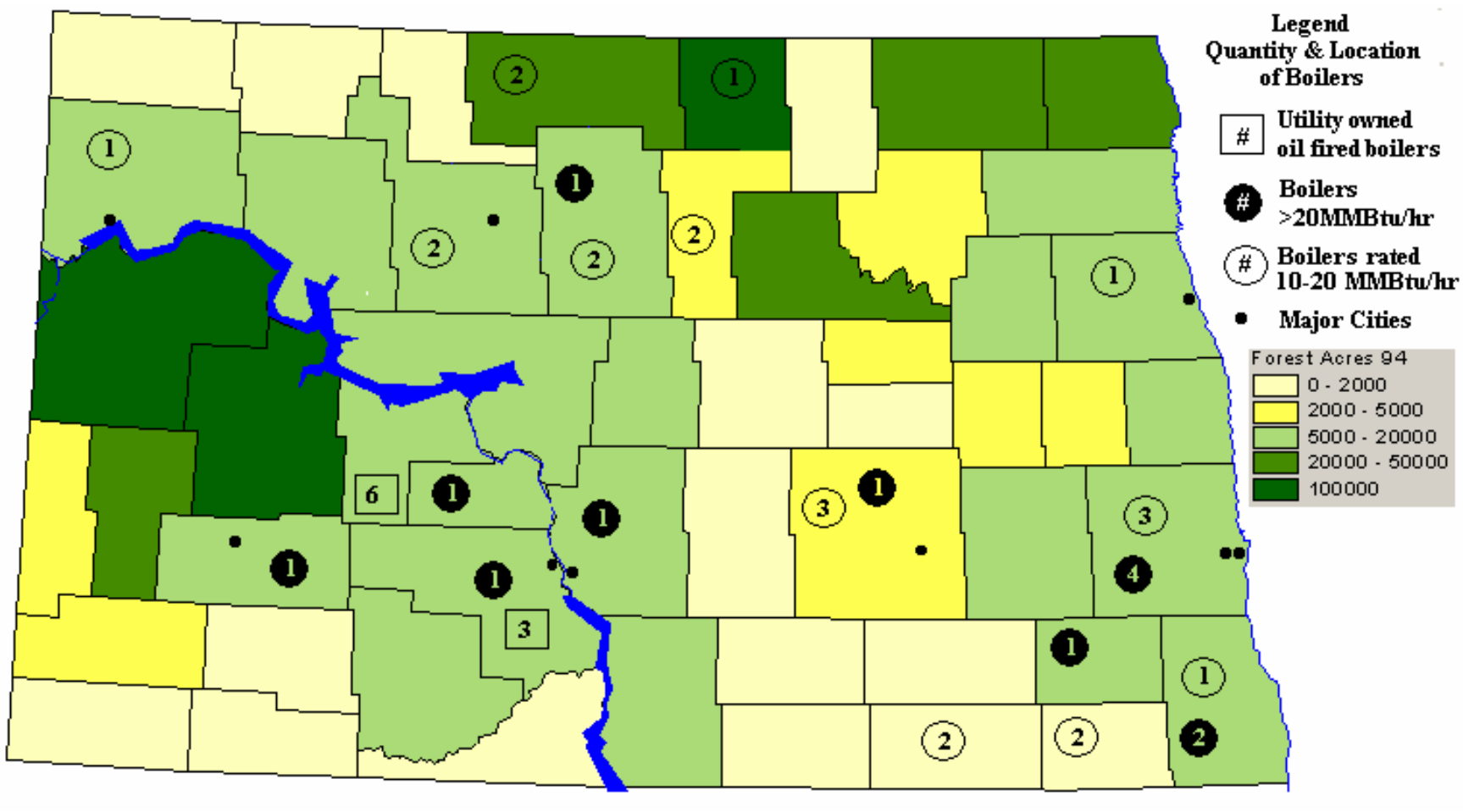
Appendix B – Coal-Fired Boilers – Location and Magnitude Relative to Forest Resources



Appendix B – Natural Gas-Fired Boilers – Location and Magnitude Relative to Forest Resources



Appendix B – Oil-Fired Boilers – Location and Magnitude Relative to Forest Resources



PART III – MARKET ANALYSIS POTENTIAL FOR VALUE-ADDED PRODUCTS FROM WOOD RESOURCES IN NORTH DAKOTA

SCOPE

This study examines the potential for value-added products from wood resources in fire-prone areas in North Dakota. Potential value-added products include both existing and emerging markets. Potential markets for wood resources include animal bedding and litter, mulch, playground cover, potting soil, compost amendment, soil amendment, erosion control, road stabilization, chunkrete, boiler fuel, ethanol, methanol, pulp and paper, firewood, particleboard, hardboard/fiberboard, landfill cover, methanol, composite materials and oriented strandboard, packaging filler, and wood–plastic composites. The focus of primary research was placed on the potential in the mulch market. Secondary research regarding several potential markets is addressed in this report.

The mulch market was chosen for several reasons. First, it is an existing market. Second, given the resource assessment of wood waste and species available, mulch is an appropriate product for the state. Third, it is the market expected to have the greatest business potential for existing businesses, start-up businesses, landfills, and municipalities. Other potential markets, such as art, are very small niche markets. Fourth, extensive prior research in smallwood utilization already exists from various Forest Service publications. Prior to initiating the research, it was hypothesized that the mulch market has growth potential in the region, based on nationwide trends.

STUDY METHODOLOGY

The information contained in this study was compiled from both primary and secondary sources. Primary research was conducted by consulting industry experts, surveys, and visits to nurseries and garden outlets. Secondary research entailed analysis and synthesis of a vast range of information collected from the Smallwood 2002 conference, industry publications, industry trade associations, government documents, marketing publications and press releases, and other relevant sources. Market estimates are based on a comprehensive evaluation of primary research and extrapolated market estimates.

Obtaining information on demand for mulch in North Dakota was the focus of this study. The cities and park districts are effectively utilizing municipal tree trimmings, power company tree trimmings, and wood waste from landfills in their own operations. Many landscapers also grind and utilize their own wood waste in their businesses. City foresters in Bismarck, Minot, Williston, and Grand Forks were contacted to learn more about the programs in the areas considered to be fire risk areas from the resource assessment.

Approximately 100 calls were made to nurseries and garden center outlets to determine the retail market for mulch. Local nurseries, garden centers, and franchise outlets sell mulch products. With some exceptions, the majority of bagged mulch and much of the bulk mulch

comes from outside of North Dakota. An opportunity may exist for area businesses to buy less out-of-state products if more North Dakota products were available to them.

MULCH – MARKET ANALYSIS

Mulch – Market Overview

Demand for bagged mulch is forecast to grow 5.8% a year to $485 million in 2006, driven by product innovations, growing consumer interest in landscaping, and the increasing availability of plants, flowers, and shrubs in the retail market. Strongest growth is expected for value-added mulches such as colored mulch and treated mulch. Competition from bulk suppliers will continue based on the lower prices for bulk materials and the increasing availability of bulk products.

Mulch can be created from a variety of materials, including bark, shredded wood, wood chips, straw, cocoa beans, gravel, lava rocks, stone, shredded tires, plastic film, and crushed brick. Hardwood mulches dominate the market. Growth in the mulch market is the result of product improvements including colored mulch and mulch treated for insect and fungus control. Colored mulch is growing above the lawn and garden industry average. Demand is expected to reach $100 million by 2006. Colored mulch benefits include consistency, long life, and design flexibility. Nationwide, the most popular colors have been red, brown, and black, although custom colors are increasingly offered.

Landscaping is the largest application for mulch and demand is expected to rise over the next decade, although smaller markets such as playground surfaces are also exhibiting fast growth. Mulch controls moisture and weed growth, insulates and enriches the soil, and provides aesthetic benefits.

According to the National Bark and Soil Producers Association, the market for bagged mulch is an estimated $300 million to $400 million per year. Given the fragmented nature of the mulch industry, that figure is probably conservative. For instance, Rob English of Jolly Farmer in Maine estimates the bulk market for mulches in New England to be more than $30 million annually, with about two million cubic yards per year of bulk mulches sold. English also estimates that another 12 million bags of mulch are produced in New England annually. The demand for mulch is greater than the demand for wood chips.

Regional mulch producers, waste recyclers, and lumber processors dominate the supply of mulch. However, a few national lawn and garden firms, such as Scotts, are also increasing their presence in this sector. The national companies offer value-added products such as colored mulches.

Organic mulch is used in landscaping and gardening applications for both decorative and practical purposes. As mulches decompose, they affect soil structure and microbial activity. Wood decomposes more rapidly than bark, softwoods such as conifers more rapidly than hardwoods, finely ground mulch more rapidly than coarse, and fresh tissues more rapidly than dry. Some varieties provide insect resistance as well. The type of wood comprising a sample of

mulch dictates the price. Homogeneous mulches are more highly valued. Hardwood mulches receive the highest prices because they hold their appearance for a relatively long time. Mulches comprised of assorted hardwoods are available and are frequently dyed to improve appearance.

Market Characteristics

Wood mulch may be sold in bags or in bulk. The appeal of bagged mulch is its convenience for the small user. Bagged mulch is generally sold through retail stores that specialize in lawn and garden and landscaping materials.

Many mulch manufacturers produce different types and grades, promoting considerable competition in the industry. Manufacturers differentiate themselves from competitors based on product-related attributes, including the tree species comprising the mulch, particle size, particle consistency, and age of the mulch. Particle sizes appropriate for mulch and other wood waste products are found in Appendix A. Likewise, service attributes, such as credit terms, product availability, promptness of delivery, and supplier–purchaser relationships are also successfully used to differentiate between mulch suppliers. The industry also faces competition from substitute products including pine bark nuggets, pine straw, cypress bark mulch, stone and rock chips, and wood chips. In interviews in North Dakota, rock mulch was often mentioned as preferable to wood mulch, because it does not blow away.

Mulch may be sold in bags or in bulk. Bagged mulch is targeted primarily toward homeowners and "do-it-yourself" landscapers. A table entitled "Consumer Mulch Selection Factors for Common Products" is found in Appendix A. The appeal of bagged mulch is its convenience. Unlike bulk mulch, bagged mulch can be transported in the trunk of a car without a mess. It is easy to work with and can be purchased in small quantities. Bagged mulch, however, is expensive since the consumer must pay for the additional cost incurred by the bagging operation and the longer channels of distribution needed to get bagged bark to market. Mulch is generally sold through retail stores that deal in lawn and garden and landscaping materials. Such stores may range from large chain superstores to small privately owned "mom-and-pop" nurseries. Generally, bagged mulch is of high quality and is well processed, a result of the relatively low cost of the bark as compared to the bagging costs.

Bulk mulch is generally targeted to larger users such as professional landscapers. However, a limited retail market exists for bulk mulch targeting homeowners. The range of quality among mulch suppliers is much greater in the bulk mulch market than in bagged mulch. Bulk mulch may be highly processed or sold directly off the debarker without screening or grinding. Likewise, pricing is more varied in bulk mulch, where a trade-off exists between price and quality.

Regardless of whether the mulch is sold bagged or in bulk, mulch is usually sold based on volume instead of weight. However, bulk mulch is generally sold in units of cubic yards, with 27 ft^3 in a cubic yard. Bagged mulch is sold in cubic feet. The most popular sizes carried by those surveyed were 2 ft^3 and 3 ft^3.

Colored Mulch

Colored mulch entered the market about 12 years ago in Ohio, and national sales of the product have increased annually (Amy Satkofsky, 2002). Colorants can add value to mulch. Kurtz Bros., Inc. of Groveport, Ohio, has been coloring wood chip mulch for at least seven years. According to Rob McCartney, site manager, colored mulch is useful in specific applications, such as high traffic areas. For example, the Ohio State Fair uses colored mulch on its walkways. Kurtz uses a Continental Biomass Industries, Inc. (CBI) 6000 as a primary grinder and a CBI 4000 as a secondary grinder. They prefer dry wood to absorb the color. Chips ground to about 1 in. are then put through an AmeriMulch colonizer. They process red, brown, and black mulch.

Colored mulch is used in virtually every state across the country, comes in all colors, and sometimes is used for specific landscaping applications, such as putting a company's logo in a walkway garden. Homeowners influence the market and create the demand for specific colors.

Mulch – Market in North Dakota

The market for mulch is growing in both bagged and bulk mulch. In 2001, the total U.S. mulch market was estimated at 16,783 million lb by the Freedonia Group. Of that, 7200 million lb are bagged mulch as found in Table 1. Based on population size, 0.25% of that market is within North Dakota. The breakouts for the 2001 mulch market in North Dakota are found in Table 2.

Popular mulches in North Dakota are pine bark and cedar mulch. Some dyed mulch products are available, with the most prevalent in North Dakota being red- and gold-colored mulch. Manufacturers in Idaho, Arizona, and Minnesota supply that bagged mulch product. It is likely distributed through outlets in Minnesota or South Dakota. The mulch is colored using pigments and equipment that could be potentially purchased by a start-up business. Their popularity is due to color fastness and fade resistance in the elements.

Supply of Mulch in North Dakota

In North Dakota, virtually all mulch is supplied from out of state. Some of the lawn and garden centers use mulch obtained from the park districts or city landfills, but that is not sold retail. Interviews with lawn and garden centers in North Dakota showed that retail mulch is supplied from companies, such as the following:

- Western Organics, Tempe, AZ
- JMB Logistics, Plover, WI
- Wood Ecologys, Elk Mound, WI
- Florida Garden Products, Oviedo, FL
- Waupaca Northwoods, Waupaca, WI
- Mountain West, Rexburg, ID
- Corbitt Manufacturing, Lake City, FL
- Blommer Chocolate, Chicago, IL
- Aaction Mulch, Southwest FL

Table 1. Past and Projected U.S. Mulch Sales in Lawn and Garden Applications, 1992–2011*

Item	1992	1996	2001	2006	2011
Total Lawn and Garden Mulch Sales	550	630	850	1080	1350
% Bagged	40.9	41.3	42.9	44.9	48.1
Lawn and Garden Mulch Sales	225	260	365	485	650
By Type:					
Wood Mulch and Chips	215	245	340	440	570
Conventional	213	240	290	340	390
Colored	2	5	50	100	180
Other	10	15	25	45	80
By End User:					
Consumer	165	195	280	390	545
Professional	60	65	85	95	105
By Market:					
Residential	165	195	280	390	545
Commercial	21	23	30	33	37
Golf Courses	18	20	26	29	32
Government and Other	21	22	29	33	36
$/lb	0.04	0.04	0.05	0.06	0.07
Lawn and Garden Mulch Sales (mil lb)	5600	6100	7200	8300	9500

* Sales totals are listed in millions of dollars.
Source: The Freedonia Group

Table 2. North Dakota Mulch Potential Capacity

Mulch	Million lb	Tons	Million ft^3	Cubic Yards
Bagged	18	9000	1.2	44,444
Bulk	24	12,000	1.6	59,259
Total	42	21,000	2.8	103,703

In addition, many of the smaller lawn and garden centers buy their mulch from Menards or WalMart and then resell it. Those who buy from outside of North Dakota often rely on just one supplier. Dependability is important because the season is short, and running out of mulch is a problem for some retailers.

Demand for Mulch in North Dakota

Smaller lawn and garden retailers face strong competition from the larger chain stores, so they have noticed decreased demand in the past. However, the demand for mulch overall is growing, so demand is strong again even for the smaller retailers. They are selling more premium mulch to compete with the chain stores.

All of the survey respondents indicated that a good market exists for mulch. Others stated the market to be strong. One respondent indicated that, “I am simply astonished by the demand for mulch this year. It’s just word of mouth. I didn’t advertise or anything.”

Marketing Strategies – Mulch Example

When attempting to penetrate an existing market, a new venture should expect to meet resistance from current suppliers. The new entrant acquires market share usually at the expense of existing suppliers. When a new entrant competes against existing suppliers, they are usually at a disadvantage. The new entrant does not have the experience, knowledge, or customer relationships held by existing suppliers. In the face of such challenges, a firm should have a well-planned marketing strategy. At the simplest level, the marketing plan should address the classic marketing mix. The marketing mix is often referred to as the four "P's" of marketing: product, price, place, and promotion. Each of these areas will be discussed below.

Product

The first concern a venture must address is which product and service attributes it wishes to offer. This includes determining the quality of mulch to manufacture, how it will be sold, and what other important differentiating product attributes it will have. A venture should strategically position itself against potential competitors.

Higher-quality mulches generally consist of a large percentage of reddish-brown-colored barks and are more extensively manufactured to produce a consistent texture. Mulches, which consist of high percentages of light-colored barks, are considered less desirable. Likewise, mulches of highly inconsistent particle size are characteristic of low-end products. In addition, from interviews in North Dakota, the lawn and garden centers indicated that they like their bulk mulch to be relatively clean.

A venture interested in entering the mulch market in North Dakota might conduct a simple investigation to determine if their idea can be successfully marketed. To test-market and assess the marketability of product, visiting potential customers with a sample of mulch is recommended. Not only should the potential customer be asked about their product preferences, but also what product and service characteristics they desire from a supplier. Based on reactions expressed by landscapers and other potential buyers, the venture may then consider altering its product and services to target the chosen market.

Product attributes are not the only considerations. Service attributes can have as great an impact on the customer's decision to purchase as product attributes. The important thing is for the firm to determine which product and service attributes are most important to the targeted market and incorporate them into the marketing strategy. The following are a list of product and service attributes, which may be considered by a firm in defining their product or service.

Product Attributes

- Age of bark
- Color of bark
- Consistency of particle size
- Packaging of bark
- Texture of bark

Service Attributes

- Availability
- Credit terms
- Delivery time
- Dependability
- Flexibility to supply large or small loads
- Personal relationship with supplier

Price

Once a venture has defined the product and services it wishes to provide, a price structure must be developed. A good starting point is to look at competitors' products and prices. Differences in pricing among competitors should reflect differences in product quality and service offerings. A firm should determine price structures from its most similar competitors and price its product accordingly. Delivered prices should be used for these comparisons.

Place

Place refers to distribution. Distribution means defining the targeted market and determining how to get the product to market. A mulch producer may sell at any point in the chain of distribution. However, trade-offs exist in deciding at which point in the channel to sell. Generally, the higher up the channel, the lower the price received for the product, but the larger the order. As the venture moves down the channel of distribution, more orders of smaller volume must be sold. This involves increased paperwork and liabilities, as well as additional costs. The firm must decide based on its own situation where on the channel of distribution to position itself.

Potential geographical markets are generally limited to regions near the manufacturing facility. The effective distance in which a firm can be competitive depends on competing mulch prices in the geographical region in question. Potential regions to target can be graphically demonstrated by plotting price data on a map. By comparing the firm's delivered prices (mulch price plus freight) to average market prices in each region, a map of potentially successful geographical areas can be generated. Ideally, in the mulch market the distance would be 75 to 100 miles or less.

Promotion

Promotion is often what people think of when they think of "marketing." Promotion includes personal selling in the form of personal visits to prospective customers, advertising, and promoting at trade shows. Mass mailings to potential customers, cold-calling prospects identified from the yellow pages or association lists, or a combination of methods may be used. In North Dakota, a key organization is the North Dakota Nursery and Garden Association. Promotion is very important, especially when a firm enters a new market. It is very important to create awareness with potential customers that a new supplier of mulch exists offering better products and services.

Personal contact with potential customers is critical during the early stages of the marketing program. Not only does it provide exposure for the firm, but it also provides an opportunity to collect important marketing data. When talking to potential customers, the sales staff should 1) identify what product and service attributes are most important to the customer, 2) determine immediate competitors and their prices, 3) identify the competitions' strengths and weaknesses, and 4) find leads for other prospective customers. Likewise, personal relationships with potential customers are developed when a face is associated with the supplying company.

Secondary research has also been conducted on what is important to potential customers. Table 3 shows the results of a survey identifying what consumers look for when they are choosing landscape and lawn/tree care professionals.

Table 3. What Consumers Look For When Choosing Landscape and Lawn/Tree Care Professionals

Reason	Percentage
Good References and Reputation	67.4
Satisfaction Guaranteed	39.5
Free Estimates	33.8
In Business for a Number of Years	32.9
Locally Owned and Operated	32.4
Insured and Bonded	27.9
Member of a Professional Trade Association	13.3
Certification of Professional Training	12.4
Licensed by Government	7.4
Local Representative of a National Company	5.7
Award Winning Company	3.0
Other	4.6

Sources: The Gallup Organization and American Nursery & Landscape Association.

Examples – Mulch Ventures

Rainbow Farms Enterprises
25715 South Ridgeland
Monee, IL 60449
Phone: (708) 534-1070
Fax: (708) 534-1138

Rainbow Farms is a mulch-manufacturing business in the Chicago area that includes 24 transfer sites and six processing areas. As the business grew, many of the owner's principal feedstock suppliers were subcontractors that trimmed trees along the power lines of ComEd, the area's electricity supplier. ComEd began discussions with Rainbow Farms about the possibility of accepting additional material from its other subcontractors.

Initially, incoming material is stored in a windrow for approximately 3 months. During that time it is usually turned only once. At the end of the 3 months, the wood chips are put through a tub grinder for sizing. Except for the Monee site, where a stationary Haybuster tub grinder is used, a mobile Morbark unit is brought in and set up as needed. Following the grinding, the mulch is put back into windrows and aged for several more months. In North Dakota, a Jamestown company called DuraTech has a Haybuster line of grinders.

Processing 70,000 cubic yards of tree trimmings created approximately 50,000 cubic yards of commercial-grade mulch. Rainbow Farms markets most of that material as "Nature's Blend" wood mulch. About 80% of its end product is sold for use in commercial applications, such as shopping centers. They also market playground mulch, which is a blonde color. The company keeps the finished mulch at its six processing sites and distributes it from there, which helps to keep the products close to the market and cuts down on hauling.

Source: Glenn, J. Tree trimmings boost a mulch business. *BioCycle*, Oct **1998**.

Mountain Valley Farms & Lumber Products, Inc.
1280 Nawakwa Road
Biglerville, PA 17307-9728
Phone: (717) 677-6166
Fax: (717) 677-9283
E-Mail: pallets@cvn.net
Web Site: www.palletsusa.com
Bradley W. Starner, Business Manager

Mountain Valley Farms has been selling mulch for more than 20 years. It produces hardwood bark mulch; about 75% is sold to the wholesale market. It is a $500,000 business. Landscapers comprise about three-quarters of that market and garden centers about one-quarter. They belong to nurserymen's associations in Pennsylvania, Maryland, and New Jersey, attending annual shows and advertising in the newsletters.

To produce its bark mulch, Mountain Valley grinds the bark that comes off its debarker and edging strips from the sawmill. The ground material is placed in 20-foot by 20-foot windrows, where it is watered and turned every 30 days. It is aged in this manner for 6 to 9 months prior to being sold. Initially, the company just marketed its own mulch, but gradually, as demand grew, sawmills that were selling it lumber for pallets began to supply raw materials. Today, Mountain Valley buys anywhere from 100 to 150 trailerloads of bark from a network of sawmills.

Source: Glenn, J. Tree trimmings boost a mulch business. *BioCycle*, Oct **1998**.

Jolly Farmer
Route 95
Houlton, ME 04444
Phone: (207) 532-6347

Jolly Farmer functions as a stand-alone operation that purchases bark from mills throughout Maine, New Hampshire, Quebec, and New Brunswick and processes it into a wide variety of mulch products. They use a portable grinding mill to process bark into mulch at sawmills in the northeast. Today, the company operates one of the most sophisticated mulch production facilities in the country on an 85-acre site.

Until 1992, Jolly Farmer produced only bulk softwood mulches consisting primarily of hemlock, pine, and spruce. That year, they introduced a line of bagged products that is steadily expanding. Unlike many bagged mulch producers, Jolly Farmer caters to smaller retailers.

Greendell Mulch & Mix
749 West Street Road 42
Mooresville, IN 46158
Phone: (317) 996-2826
Fax: (317) 996-2032
Web Site: www.greendellmulch.com

Greendell Mulch and Mix is the largest mulch producer in Indiana. Greendell receives predominately hardwood bark from sawmills within a 200-mile radius of its plant in Mooreville, utilizing a fleet of trailers, which are spotted at the mill sites. The 160,000 to 170,000 cubic yards of bark the company processes each year goes into three products. Anything fewer than 5/8 inches is used as a soil amendment or as part of a growing mix. Two grades of mulch, medium and coarse, are produced. Products are distributed in five midwestern states, and 90% of the business is in bulk. One of Greendell's most popular products is its line of playground cover made of woodchips.

Source: Glenn, J. Tree trimmings boost a mulch business. *BioCycle*, Oct **1998**.

South Dakota Entrepreneur – Mulch Business

Leroy Smith of Burke, South Dakota, began researching ways of converting cedar into a value-added product, ultimately to protect his grazing lands in 1998.

Smith worked with Randall RC&D Coordinator Les Labahn to obtain a U.S. Department of Agriculture Sustainable Agriculture Research and Education (SARE) grant. The SARE grant has enabled Smith to produce cedar mulch. The county highway department for roadside erosion prevention and seeding uses the mulch. A performance and cost evaluation of the mulch is expected to determine the product's success.

Source: Utilizing Municipal Trees: Ideas from Across the Country, Stephen M. Bratkovich

POTENTIAL MARKETS FOR WOOD RESOURCES

Wood resource utilization projects vary widely by size, scope, and geographic location. In the United States, more than 200 million cubic yards of urban tree and landscape residuals are

generated annually, according to an article in the Journal of Arboriculture. Of that number, 15%, or 30 million cubic yards, are logs. To put this number into perspective, if these logs were sawn into boards, they theoretically would amount to 3.8 billion feet of lumber, or nearly 30% of the hardwood lumber produced annually in the United States.

Several examples are provided in the areas of composite materials, contract grinding, and art. A related presentation will describe opportunities in small-diameter wood.

Composite Materials

Corex Products, Inc.
Hayden Lever
377 Cottage Street
Springfield, MA 01104
Phone: (413) 781-0927
E-Mail: corexinc@aol.com
Web Site: www.corex.cc

As part of a goal to find new uses for industrial waste products and reduce costs for local businesses, officials in Springfield, Massachusetts, launched an Eco-Industrial Baseline study. New Ecology Inc. researched the feasibility of Corex Products, a recycling business, to expand into on-site production of wood flour from local waste wood feedstocks.

Corex manufactures plastic components for the school furniture market, such as desktops, contoured seats and backs, and stool tops. Their products are made from recycled plastic and wood waste, using wood flour mixed with melamine resin and heating the mixture in molds under high pressure.

Corex purchased wood flour in 50-pound bags from a company 50 miles away, paying about ten cents/pound, including transportation. Corex used approximately 88,000 pounds/week to make its furniture components. Since demand is less than supply of available feedstock, it was determined that local waste hardwood might fulfill current and future needs. The research calculated that Corex could save up to $250,000/year by purchasing a grinder and using local waste hardwood. A conservative $35/ton purchase price was assumed for the hardwood. Some would be free, thereby increasing the estimated savings for Corex to over $300,000 annually.

Source: Goldstein, J. Finding new markets for local waste wood. *BioCycle*, Dec **2002**.

Altree

P&M Plastics, Inc.
202 East Broadway
PO Box 567
Mountainair, NM 87036
Phone: (505) 847-2850

Fax: (505) 847-0007
Web Site: www.altree.com

The utilization of juniper or pine fiber as a raw material for making a composite panel product has attracted the interest of the private sector, state and federal agencies, and universities. Phil Archuletta worked with the Forest Products Laboratory to create wood–plastic composite materials from juniper wood fiber and plastic from recycled milk jugs. Compared to traditional sign materials made of aluminum and plywood, the new composite signs were less expensive, more durable, and resistant to animal damage. They are working with the Kaibab and Cibola National Forests to obtain resources. The facility is located in the small community of Mountainair, New Mexico. Through the removal and utilization of undesirable trees, they are able to add value to wood fiber. The company is working to improve rural community sustainability through job formation and the development of a viable rural manufacturing facility.

Source: Smallwood 2002 Conference, Albuquerque, New Mexico.

Contract Grinding

Dakota Wood Grinding
15325 Babcock Avenue
Rosemount, MN 55068
Phone: (651) 322-2622
Contact: John Guillemette

Purchasing the wood grinding operation from NRG Energy, Dakota Wood Grinding's owner was hired to clean up and grind 30,000 tons of trees and brush from a 2002 storm in Grand Forks, North Dakota. The Federal Emergency Management Agency provided funding for only 13,000 tons of the material. Contract grinders usually charge by the hour for use of equipment and labor. They submit bids to local government, who may have lists of prequalified vendors. Dakota Wood Grinding receives $350/hour for using a grinder and $90/hour for a loader.

Source: Emerson, D. Contract grinders meet storm cleanup demands. *BioCycle*, Apr **2003**, *44* (4), 40–44.

Woodworking

Cincinnati Parks
950 Eden Park Drive
Cincinnati, OH 45202
Phone: (513) 352-4080
Contact: Sam Sherill

A fallen-down cherry tree in Cincinnati, Ohio, served as the inspiration for Harvesting Urban Timber, an effort started by woodworker Sam Sherrill. A pilot project initiated by Sherrill

and a colleague was publicized by Popular Wood Working magazine and local newspapers and was directly supported by Wood-Mizer Products, Inc., which donated a portable sawmill, and the Cincinnati Park Board, which cut select logs into proper lengths and loaded them onto trucks.

The project links tree owners who want to convert trees into furniture with local woodworkers. For example, an old oak tree that had stood on a family farm since the late 1800s, estimated to be over 500 years old, was made into a dining room table with sentimental value after it was blown over in a storm.

Source: Utilizing Municipal Trees: Ideas from Across the Country, Stephen M. Bratkovich

Municipalities have developed ways to utilize and market urban wood residuals. In Bismarck, North Dakota, wood chips and firewood are stockpiled at the city landfill and sold on a first-come, first-served basis. Firewood is also sold at $10/ton, and individuals can cut logs to length and drive across a scale to determine payment. Cincinnati attributes its 100% wood utilization rate to the effective use of city-operated wood yards for selling firewood and wood chips. The city uses tree service firms for all tree work, and the firms stock the city wood yard with firewood and chips. The annual sales are well publicized. Profits go toward the planting of trees in neighborhoods where old trees have fallen or been harvested.

Source: Utilizing Municipal Trees: Ideas from Across the Country, Stephen M. Bratkovich

Art

Many tree service firms are beginning to recognize the value of lumber that can be transformed into value-added products. Jim Cook, owner of Able Tree Service in Missoula, Montana, realized that many local artists were constantly seeking wood for their projects. He created a database of these artists, complete with information on preferred species. Today, he supplies artists with free wood of the preferred species from his tree removal projects. Artists have used his removed trees to make carousel horses, furniture, and wooden bowls. The majority of wood from Cook's tree removal service is used either for firewood or chipped for mulch.

Source: Utilizing Municipal Trees: Ideas from Across the Country, Stephen M. Bratkovich.

REFERENCES

Colored Mulch Still "The In Thing". *BioCycle*, June **2002**.

Appendix A – Wood Resources Specifications

Table 1. Consumer Mulch Selection Factors for Common Products

Characteristics	Pine Nuggets	Pine Mini-Nuggets	Pine Mulch	Cypress Grade A	Cypress Grade B	Hardwood Mulch	Western Mulch	Western Pathway	Western Medium	Western Large
Color[1]	Reddish brown	Dark brown	Light brown	Golden brown	Golden brown	Dark brown to black	Reddish brown	Reddish brown	Reddish brown	Reddish brown
Longevity[2]	Multiple	Multiple	Single	Single	Single	Single	Single	Single	Multiple	Multiple
Moisture Retention	Low	Medium	High	High	High	High	High	Medium	Medium	Low
pH	Neutral	Neutral	Slightly acidic	Neutral	Neutral	Slightly acidic	Slightly acidic	Slightly acidic	Neutral	Neutral
Particle Size	1.25–3.5 in.	0.5–1.5 in.	< 1.5 in.	< 3 in.	< 3 in.	< 3 in.	< 1 in.	0.25–0.5 in.	0.5–2 in.	1.75–3 in.
Wood Content[3]	< 15%	< 15%	> 15%	< 15%	> 15%	< 15%	> 15%	< 15%	< 15%	< 15%
Benefits	Pine nuggets	Pine mini-nuggets	Pine mulch	Cypress Grade A	Cypress Grade B	Hardwood mulch	Western mulch	Western pathway	Western medium	Western large
Decoration	Excellent	Excellent	Good	Excellent	Good	Good	Good	Good	Excellent	Excellent
Erosion Control	Fair	Fair	Excellent	Excellent	Good	Excellent	Excellent	Good	Fair	Fair
Moisture Control	Fair	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Fair
Soil Conditioning	Fair	Good	Excellent	Fair	Fair	Excellent	Excellent	Excellent	Fair	Fair
Weed Control	Good	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Good
Applications	Pine nuggets	Pine mini-nuggets	Pine mulch	Cypress Grade A	Cypress Grade B	Hardwood mulch	Western mulch	Western pathway	Western medium	Western large
Edging	Good	Good	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Good	Fair
Drainage Areas	Fair	Fair	Good	Good	Fair	Good	Good	Good	Fair	Fair
Planting Beds	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Planters	Good	Good	Good	Excellent	Good	Excellent	Excellent	Excellent	Good	Good
Play Areas	Fair	Good	Excellent	Fair	Excellent	Excellent	Excellent	Excellent	Good	Fair
Slopes and Grades	Fair	Fair	Good	Excellent	Good	Excellent	Excellent	Good	Fair	Fair

[1] Color may vary depending on regional tree species.
[2] Longevity is a rating of how long the product substantially maintains its original appearance and function. The rating for a single season or multiple seasons is an average based on a temperate climate and moderate intensity sun exposure.
[3] Wood content percentage is measured as a percentage of wood to total product weight.

Source: Mulch and Soil Council, 10210 Leatherleaf Ct., Manassas, VA 20111-4245
Phone: (703) 257-0111; Fax: 703-257-0213

Appendix A – Wood Resources Specifications

Table 2-A. Particle Sizes for Wood Waste

Type	Pieces	Chips	Coarse Shavings		Fine Shavings			Sawdust					
Sieve Sizes	>36"	>1"	3/4"	1/2"	3/8"	1/4"	4	8	16	30	50	100	200
Particle Size	36"	1"-6"	0.75"	0.5"	0.375"	0.25"	0.187"	0.094"	0.047"	0.023"	0.012"	0.006"	0.003"
Animal Bedding and Litter		x	x	x	x	x	x	x					
Boiler Fuel		x	x	x	x	x	x	x	x	x			
Chunkrete		x	x	x	x	x	x						
Compost Amendment			x	x	x	x	x	x					
Erosion Control	x	x	x	x	x								
Ethanol								x	x	x	x	x	x
Firestarter Fire Logs					x	x	x	x	x	x	x	x	
Hardboard/Fiberboard	x	x	x	x	x	x	x	x					
Landfill Cover		x	x	x	x	x	x	x					
Methanol/Syngas								x	x	x	x	x	x
Mulch Manufacturers		x	x	x	x	x	x						
OSB/Waferboard	x												
Packaging Filler		x	x	x	x	x							
Particleboard			x	x	x	x							
Playground		x	x	x	x	x							
Potting Soil					x	x	x	x	x	x	x	x	x
Pulp and Paper		x	x	x									
Road Stabilization		x	x	x	x	x							
Soil Amendment/Top Soil					x	x	x	x	x	x	x	x	x
Wood Pellets								x	x	x	x	x	x
Wood–Plastic Composites								x	x	x	x	x	x