United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

Research
Paper
FPL–RP–656

North America's Wood Pellet Sector

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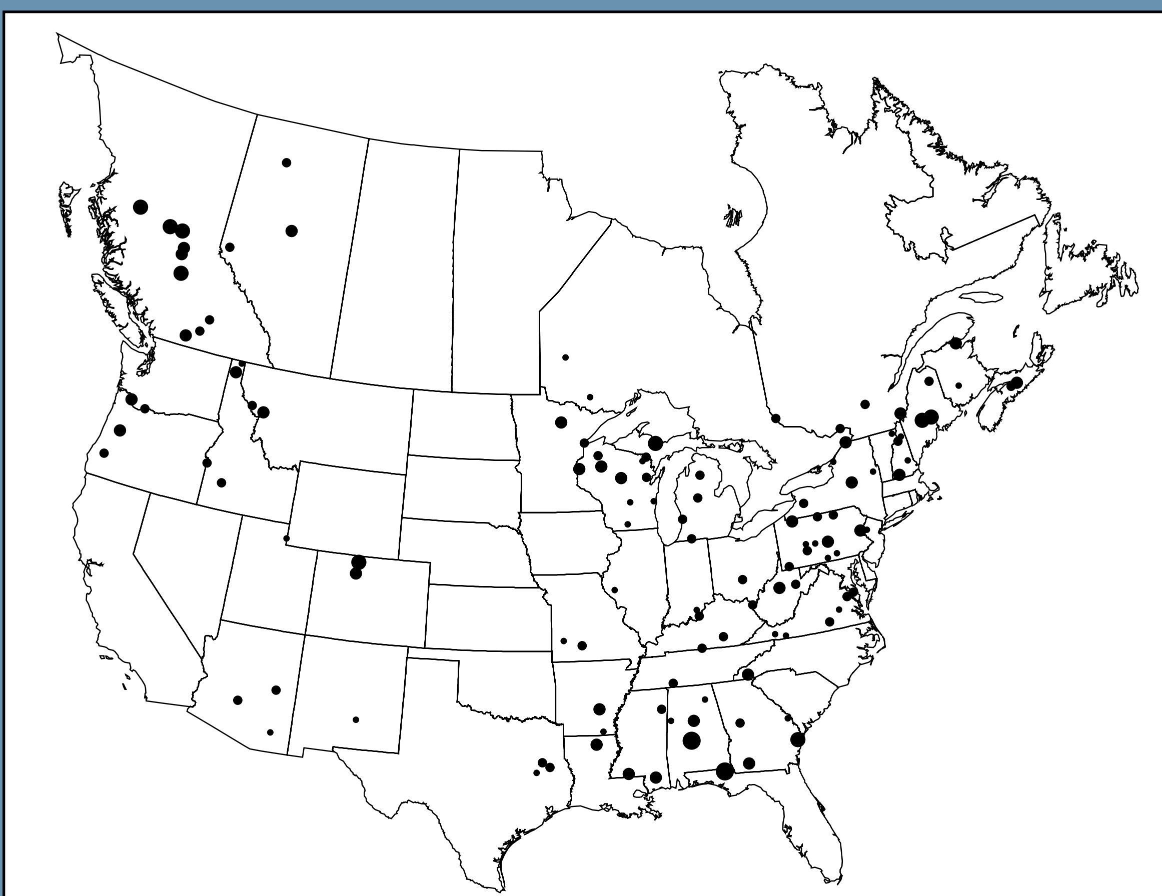

Abstract

The North American wood pellet sector is profiled in this paper. A small pellet industry has existed since the 1930s, but its main growth occurred in the wake of the energy crisis in the 1970s. Its current spurt is even greater, growing from 1.1 million metric tonnes in 2003 to 4.2 million 2008. It is set to reach 6.2 million in 2009. Most plants are small, relying on sawmill residues for fiber and thus are limited to 100,000 tonnes or less per year. A number of new mills have been built to process chipped roundwood and have capacities three to four times as large. Most pellets made in the United States are consumed domestically, but a growing offshore market is boosting exports. By contrast, most Canadian pellets are shipped overseas. The reliance on sawmill residues led to imbalances between supply and demand for fiber as the sawmilling sector retrenched in the 2008–2009 recession. This has led mills to turn to roundwood or other non-sawmill sources of fiber. The wood pellet industry and use of wood pellets as energy are in their relative infancy in North America and the recent growth of both has been fueled by increases in the cost of fossil energy. However, policies aimed at reducing carbon dioxide emissions into the atmosphere could loom as bigger factors in the future.

Keywords: Wood pellets, demand and supply, production capacity

Contents

Conversion table

Unit	Conversion factor	Metric unit
Square foot	0.0929	Square meter
Board feet (hardwood lumber)	0.00236	Cubic meter
Inches	25.4	millimeter
Short ton	0.907	Metric tonne

August 2009

Corrected September 2009

Spelter, Henry; Toth, Daniel. 2009. North America's wood pellet sector. Research Paper FPL-RP-656. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 21 p.

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The Forest Products Laboratory is maintained in cooperation with the University of Wisconsin. This paper was funded by the University of Tennessee as part of the U.S. Endowment for Forestry study of wood energy sectors.

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North America's Wood Pellet Sector

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Background

Wood has historically been the primary source of non-food energy for humans. Though its importance ebbed as more convenient alternatives were found, when market disruptions occasionally caused the costs of the alternatives to spike, interest in and use of wood as fuel was rekindled. The most recent surge in energy costs was no different. Additionally, a new impetus arose from the desire, particularly in Europe, to limit carbon dioxide emissions. In that context, the use of wood for energy is regarded as neutral because new tree growth recaptures carbon released from burning it.

To supplement fossil fuels with wood can take several pathways. In addition to being burned for heat, it can be processed into liquid fuels (ethanol through fermentation or hydrocarbons by the Fischer-Tropsch process, Niemantsverdriet 2007.) or burned in power plants to generate electricity. However, in the wood-to-liquid fuel conversion, up to half the embedded energy in the material is lost (Rakos 2008). When wood is burned to produce electricity, a similar loss occurs unless the waste heat is captured, which is seldom the case. Both of these options also involve substantial capital expense that constrains the economical use of these options under present circumstances. Burning wood directly for space heating, by contrast, is more energy efficient. Modern stoves use 85% to 95% of the energy for heat, and when the heating source being displaced is electric, the savings in fuel are magnified (Rakos 2008).

One way in which the market has responded to these changes has been to supply wood energy in pellet form. Wood in its raw state has low energy density, contains half its weight in water, and transporting and handling it is costly because of its low bulk density. Pelletization improves upon these handicaps. By densifying wood, the energy content per unit volume is increased to near that of coal. The moisture content is also lowered from around 50% to less than 10% (wet basis), enhancing its heating value by reducing the heat of vaporization and stack-gas losses. With less moisture, pellets burn hotter and more completely, thus reducing harmful particulate emissions. The dewatering and increased bulk density also makes hauling more economical. Lastly, material handling is simplified by virtue of the size reduction, enabling automated feeding of heating appliances rather than manual feeding as with firewood.

Pelletizing wood for stoker fuel in the United States may have begun in the 1930s, but its modern surge began in the 1970s in the wake of the energy crisis (Peksa-Blanchard and others 2007). A product called Woodex made from sawmill residues was marketed as a waste-derived fuel that was interchangeable with coal, yet less polluting. Although that company failed, several others, mainly in the Pacific Northwest, continued to make pellets and sell them as fuel and animal bedding.

Since 2000, the costs of fossil fuels have risen steadily, leading to growing interest in alternatives. This was intensified in the wake of disruptions caused by Hurricane Katrina in 2005. Pellet producers point to that event as the catalyst for the demand surge that elevated pellets as a serious alternative energy option (Harrison 2006). This interest was reinforced by a European Union target to supply 20% of its energy needs from renewable sources by 2020, an ambitious goal difficult to achieve from indigenous sources alone (Rakos 2008). Ensuing subsidies to promote wood fuels led to problems for existing wood users whose supply of fiber became more constrained (Anonymous 2006). To ease domestic pressures and expand supplies, European firms began to set their sights on North America as an alternate source of pellets.

These factors led to a wave of investment in pellet-producing facilities. Accordingly, the pellet industry in North America is relatively young, expanding rapidly, and occasionally experiencing growth pangs common to infant industries such as periodic shortages, hoarding, price volatility, and quality problems. In that context, a review of the industry's current status, growth, and market evolution is timely.

Wood Pelletization

In the pelletization process, raw wood is compacted into a homogeneous product with higher energy density and lower moisture content and made into uniformly sized cylindrical shapes, facilitating transportation, handling, and usage.

Pellets can be produced from roundwood but have mostly been made from cheaper waste residues of other wood-processing activities, primarily sawdust and shavings from sawmills and furniture factories. If made from roundwood, the full range of steps involving debarking, chipping, drying, and hammermilling must be done. Residues require less preparation because they are already much reduced in size, are mostly bark free, and are drier. Either way, the moisture content is a critical variable and must be confined within a range of about 12% to 17% (wet basis) (Majiejewska 2006).

Otherwise, if too dry, the heat build-up induced by friction in the pelletizer burns the surfaces, but if too wet, the trapped steam pressure weakens internal bonds and reduces the mechanical properties, increasing breakage and dust during subsequent handling.

Once dried to specifications, particles are sorted by size and overly large pieces are hammermilled to gain further size reduction. Steam conditioning may be used to soften the lignin that binds the cellulose together to facilitate pellet formation during extrusion and shape consolidation thereafter. Finally, binding agents may be added to minimize breakage during transport, though for most uses that is not necessary because lignin acts as a binder. Some additives may also be applied to improve chemical characteristics, such as kaolin or calcium oxide to limit slagging (Majiejewska 2006).

Following these preparations, particles are extruded through dies and the emerging ribbons are cut to desired lengths. The hot pellets are cooled in a counter-flow cooler to allow the lignin to reset and form a hardened, compact unit. Finally, the finished product is bagged or shipped in bulk to market.

A variant of pelletization is the use of heat-treated wood called torrefied wood. Torrefaction is a somewhat slow (30 to 90 min) thermo-chemical treatment of biomass at a mild temperature range of between 200 and 300 °C (392 and 572 °F) in the absence of oxygen (Bergman and Kiel 2005). Torrefaction changes the properties of biomass: hemicellulose largely volatilizes and the remaining mass becomes hydrophobic, an important improvement from the viewpoint of transportation. Loss of hemicellulose also reduces the wood's fibrous nature, improving its ability to be ground. The process volatilizes the organics in wood, losing some energy but increasing energy density of the remaining mass. However, most of the lignin is conserved, meaning that pelletization can proceed without the need for binder additives. The first torrefaction plant, a $12 million, 150,000-tonne facility in Georgia, is being built and is expected to begin production in late 2009. In a study investigating costs of furnish to gasification plants, torrefied pellets were deemed the most economical (Zwart and others 2006).

Procedures

This paper is based on a survey mailed to 111 pellet producers thought to operate or about to start in 2009. The one-page form focused on answering the following items:

- Plant capacity and 2008 production volume
- Employment
- Fiber types used
- Fiber costs
- Market destinations
- Production by grade
- Mode of shipment

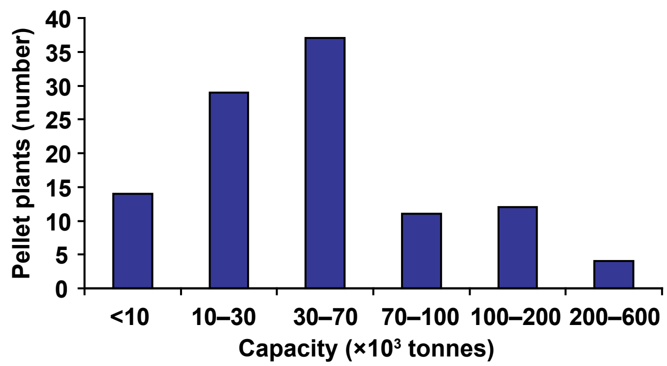

Figure 1—Distribution of pellet plants by capacity size in 2009.

Thirty-five forms were returned in various degrees of completion. Our main concern was to determine if plants were, or are likely to be, operational in 2009. In follow-up phone calls and searches of news archives for non-respondents, we focused on establishing that fact and determined that three plants had closed. From these phone contacts and searches of news reports, we established the general capacities of operations that are listed in the Appendix and discussed in the report.

Relationships of employment and production to capacity were estimated from the sample data and information gleaned from public news sources. These relationships were used to extrapolate to the non-respondent population to arrive at the estimates discussed in the following sections.

Industry Characteristics

Plant Size

The salient characteristic of most North American pellet operations is their relatively small size in comparison with pulp, board, or power plants. This stems from a business model that has largely been based on the utilization of wastes of sawmills and other wood-processing plants. Proximity to such sources of fiber is important because the relatively low bulk densities and high moisture contents of those wastes make hauling over long distances prohibitive. Normally, sawdust is landfilled or incinerated if no pellet plants, pulp mills, or other suitable outlets are nearby (Stewart 2008).

In general, most sawmills and other woodworking plants process moderate amounts of wood and thus generate proportionally moderate volumes of residues. A typically sized southern U.S. sawmill produces 100 million board feet a year that yields only about 25,000 tonnes of sawdust and shavings (Spelter and others 2007). Accordingly, the available volume of residue within a feasible hauling radius (about 80 km (50 miles)) limits the size of plants relying on that source of fiber to below 100,000 tonnes per year (Fig. 1). Where the concentration of sawmills is high, as in some locations in interior British Columbia, this constraint eases and plants are bigger. A number of new mills have

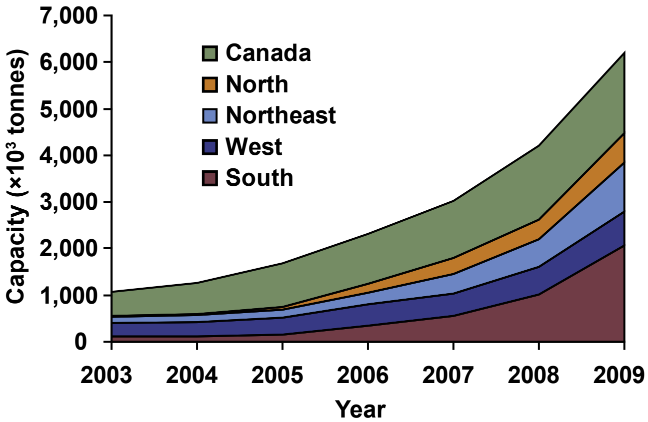

Figure 2—North American pellet capacity: 2003–2009.

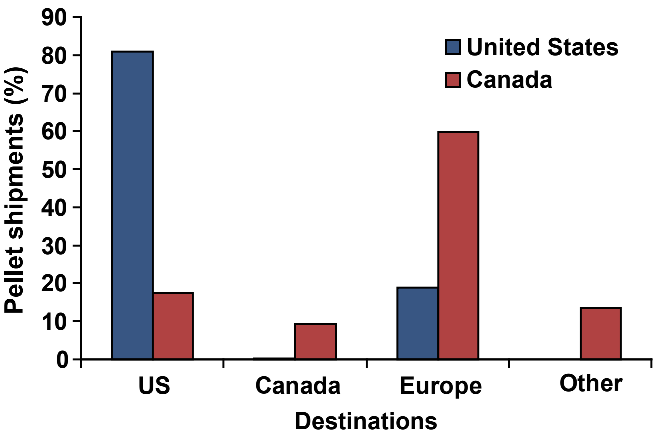

Figure 3—Destinations of pellet shipments by region in 2008.

been built to process chipped roundwood, and as they are not constrained by residue availability, have capacities three to four times as large as most of the residue-reliant facilities.

Capacity and Production

In 2008, total North American installed capacity was 4.2 million metric tonnes; up from 1.1 million in 2003. Capacity is set to reach 6.2 million tonnes in 2009 if all announced plans to start mills reach fruition (Fig. 2). The Appendix contains histories and sizes of existing or prospective pellet plants as of June 2009.

Canadian firms were first to recognize the market potential of selling pellets to European power plants and established a significant industry on the basis of using the plentiful surplus waste fiber streams available from sawmills in British Columbia. These plants accounted for about one-half of the total North American capacity in the early 2000s. With the recent surge of U.S. capacity, that share has dropped to 37%, likely falling further to 28% in 2009. Within the United States, the South accounted for the largest share (46%), followed by the Northeast (24%), the West (16%), and the Midwest (14%).

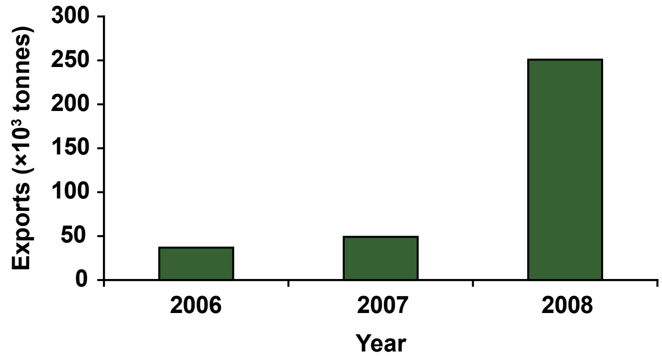

Figure 4—United States pellet and waste wood exports (U.S. International Trade Commission 2009).

Wood-pellet production in the United States in 2008 amounted to 1.8 million tonnes, which was 66% of capacity. In Canada, the estimated production was 1.4 million tonnes, about 81% of capacity. The lower capacity utilization in the United States is a result of the more recent vintage of plants. Normal start-up problems limit output in the first quarters of an operation’s life, thus depressing capacity utilization. In both countries, limits on fiber availability because of reduced sawmill activity also constrained some operations in 2008.

Markets

Over 80% of U.S. pellets in 2008 were shipped to in-country destinations (Fig. 3). Most of the rest was exported to Europe, a growing trend boosted further by the handful of large plants geared to exports (Fig. 4). By contrast, almost 90% of Canadian shipments were exported, mainly to Europe. Reflecting this difference in markets, most U.S. pellets were placed in 18-kilogram- (40–pound-) sacks, whereas over 80% of Canadian volume was shipped in bulk. Bulk shipments usually require volumes of at least 10,000 tonnes, thus favoring larger firms in exporting activity.

Bagged pellets used for home heating are generally distributed through stores and dealerships and either brought home by the users themselves or delivered by truck. In Europe and a few places in North America, specialized trucks deliver pellets to users in bulk, pneumatically unloading them into chutes that lead to storage bins. This delivery system is analogous to fuel-oil delivery methods and simplifies the logistics for consumers.

Employment

Employment has grown rapidly in the pellet industry. Plants tend to run around the clock, but the process is relatively automated, so personnel requirements are not great per mill in comparison with other wood-processing activities. In 2009, we estimate 2,300 employees are, or will soon be, directly employed in pellet production (Table 1).

Fiber Supply Sources

Over two-thirds of the fiber used in pellet manufacturing was sawmill residues (Fig. 5). Other secondary wood

Table 1—Pellet industry employment, 2008

United States					
Northeast	North	South	West	Canada	Total
380	280	710	340	590	2,300

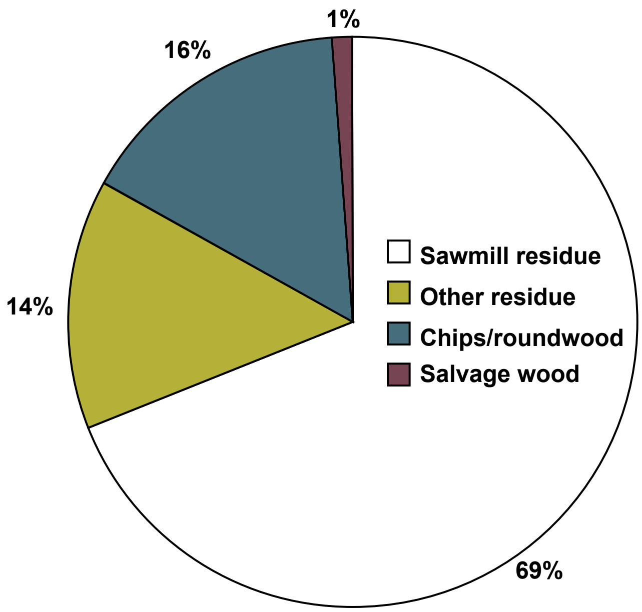

Figure 5—Fiber types used in the production of wood pellets in 2008.

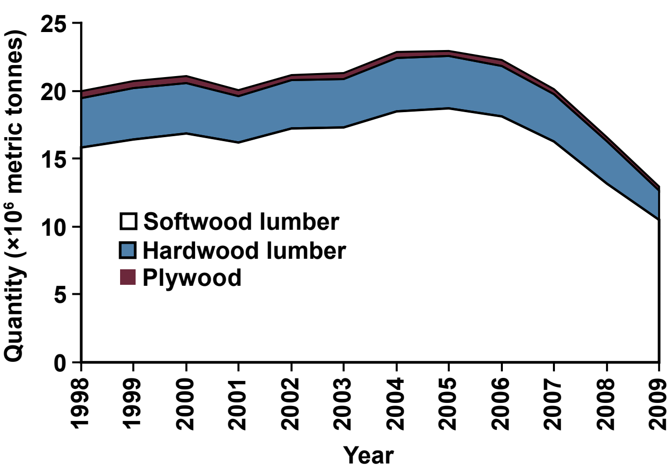

Figure 6—Fine woody residue supply from three major sources.

manufacturing facilities, such as furniture and millwork factories, supplied 14% of fiber, reflecting the large share of pellet plants located in predominantly hardwood-growing regions where furniture activity is greatest. Sixteen percent was green material sourced from pulpwood or logging residues. Only about 1% came from urban or salvage wood. Agricultural residue use was negligible.

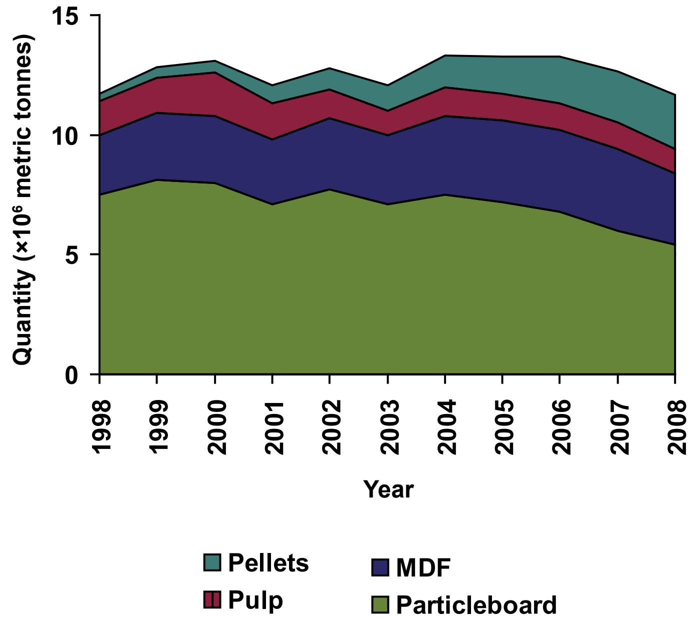

Figure 7—Fine woody residue (sawdust, shavings) demand from four major end uses.

Wood-residue fiber comes from two major sources: primary woodworking plants such as sawmills and plywood mills and secondary woodworking plants like furniture and millwork factories. The first group generates the bulk of the waste fiber and its volume over the last decade is shown in Table 2 and Figure 6. On average, sawmills and plywood plants create 0.25 and 0.025 tonnes of sawdust, shavings, and sander dust per thousand board or square feet of production, respectively (Spelter and others 2007). Considerably more volumes of other chippable residues are also generated, but those are generally used by pulpmills for paper.

Those factors convert the production volumes to residue equivalents of about 21 million tonnes of fiber in a normal year. In 2008, the volume generated fell considerably below that as these industries curtailed in the face of the recession. The volumes generated in 2009 are apt to be even smaller at about 60% of normal volume (Fig. 6).

Fiber Demand Sources

The main demand for waste wood products has historically come from the particleboard, medium density fiberboard, and pulp sectors. Their consumption in the aggregate hovered around 12 million tonnes per year, dropping to about 9 million tonnes in the recession-affected year of 2008 (Fig. 7). However, aggregate waste fiber use declined less because of the growth of pellet production.

Fiber demand is derived from pellet demand, which in turn can be estimated from the inventory of installed pellet stoves (Table 2). These consist mostly of fireplace inserts or freestanding stoves as opposed to furnaces tied into a central heating system. As such, they primarily heat the

Table 2. Supply and demand of wood residues in Canada and the United States

	Sources of supply									
	Softwood lumber[a] ($\times10^9$ board feet)	Softwood plywood[b] ($\times10^9$ ft^2)	Hardwood lumber[c] ($\times10^9$ board feet)	Sawdust, shavings, and sander dust ($\times10^6$ tonnes)	Wood pellet stoves in use[d] ($\times10^3$)	Sources of demand ($\times10^6$ tonnes)				
						Pellets	MDF[e]	Particleboard	Pulp	Total
1998	63.2	19.8	14.7	20.0	114	0.3	2.5	7.5	1.4	11.7
1999	65.6	20.0	15.2	20.7	132	0.4	2.8	8.1	1.5	12.8
2000	67.4	19.7	14.6	21.0	163	0.5	2.8	8.0	1.8	13.1
2001	64.9	17.4	13.7	20.1	217	0.8	2.7	7.1	1.5	12.1
2002	68.7	17.7	14.2	21.2	251	0.9	3.0	7.7	1.2	12.8
2003	69.0	17.2	14.4	21.3	299	1.1	2.9	7.1	1.0	12.1
2004	73.8	17.3	15.7	22.8	367	1.3	3.3	7.5	1.2	13.2
2005	74.9	17.0	15.4	23.0	486	1.6	3.4	7.2	1.1	13.2
2006	72.3	16.0	14.9	22.2	619	2.0	3.4	6.8	1.1	13.3
2007	65.1	14.6	13.8	20.1	673	2.1	3.4	6.0	1.1	12.6
2008	52.8	12.2	12.2	16.6	814	2.3	3.0	5.4	1.0	11.7
2009e[f]	42.0	10.0	8.7	12.9						

Sources:
[a] Statistics Canada (2009); Howard (in preparation).
[b] American Plywood Association (2008); Howard (in preparation).
[c] Statistics Canada (2009); Howard (in preparation).
[d] Hearth and Patio Barbeque Association (annual pellet stove shipments accumulated here to approximate the stock of stoves in service).
[e] Medium-density fiberboard.
[f] Estimated.

immediate area within a structure rather than distributing it evenly throughout the building. Consequently, pellet stoves are often used as an auxiliary heating device to permit the main fossil fuel furnace or electrical heater to be turned down or off.

To heat an average home for a winter season exclusively with pellets in a mid-northern U.S. climate zone requires about 4 tonnes of pellets (Harrison 2006), though in the coldest regions, estimates run as high as 7 tonnes (Portland Press Herald 2008). For the purposes of demand estimation, however, an average consumption per unit of 2 tonnes is more realistic. This is because of the above-noted auxiliary nature of most pellet stoves, as well as their use in milder climates, both of which decrease the average.

Pellet use for home heating is relatively new, and the Hearth, Patio & Barbecue Association only began compiling data on pellet stove shipments in 1998. In those 10 years, 735,000 pellet stoves were shipped. Estimates of underlying demand for pellets are obtained by multiplying the accumulating stock of stoves over the years by the two tonnes per stove factor (Fig. 8). Figure 8 also shows pellet production for 2007 and 2008 and installed capacity. The close correspondence between estimated demand and capacity through 2007 validates the two-tonne per stove assumption. However, a gap opens up between production and derived demand in 2008. This reflects the start-up of a handful of larger plants focused primarily on the bulk European export market. It may also indicate an expanding market into institutional heating and power generating where usage is not dependent on pellet stoves. These markets are likely to loom larger in coming years.

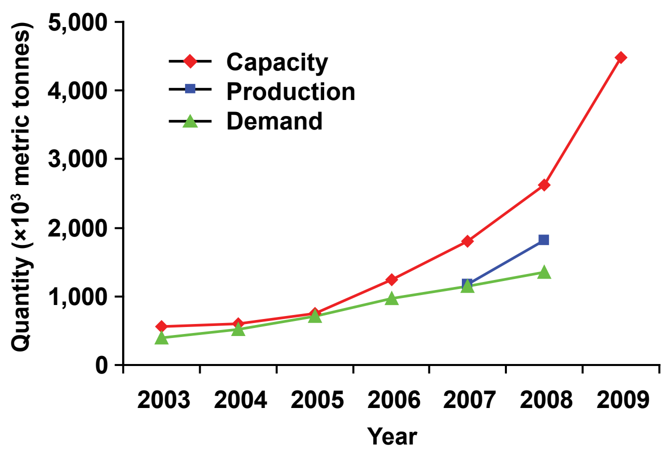

Figure 8—Capacity, production, and domestic demand for wood pellets in the United States. Sources: Howard (in preparation) and the survey distributed for the present study.

Fiber Demand and Supply Balances

Figure 9 summarizes the demand and supply balances for fine wood residues (sawdust, shavings, sander dust) over the past decade. The surplus of supply over consumption exaggerates the availability of residues because many mills use the residues themselves for process heat or co-generation activities. The more important feature of the chart is the narrowing of the gap in 2007–2009, which illustrates the drawback of the pellet industry's reliance on residue fibers. The residue-generating industries are cyclical, whereas wood pellet demand for heat energy is more static. Mismatches can develop between residue availability on the one hand

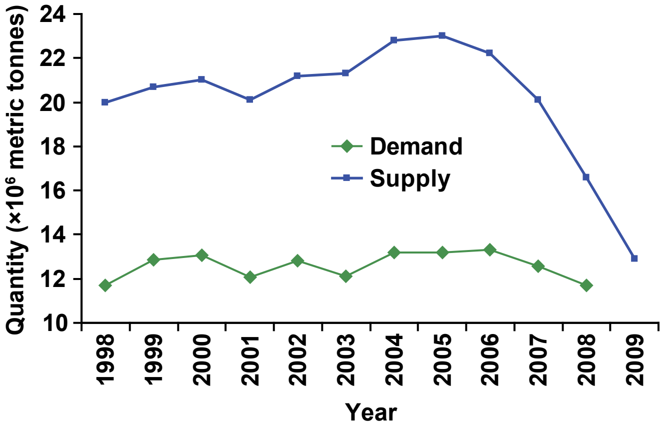

Figure 9—North American wood residue supply (from three main sources: softwood lumber, hardwood lumber, and plywood) and demand (from four main end uses: pellets, medium-density fiberboard, pulp, and particleboard).

and fiber needs for pellet making on the other. In 2008, this resulted in shortfalls that forced some plants to operate below their capability and at least one to cease operations because of the closure of a supplier. Others extended their procurement radii or installed equipment to process roundwood. Despite these measures, pellet shortages were reported, leading some users to hoard pellets (Ellen 2008; Langston 2008).

Future growth of pellet manufacturing will inevitably have to spread to alternative fibers, chiefly roundwood, as that resource is available in concentrated volume in compact areas. Because of widespread beetle epidemics in the western United States and British Columbia that render timber unsuitable for higher value uses such as lumber and plywood, this resource is increasingly becoming available at advantageous rates. Two plants in Colorado have recently been built to take advantage of this resource opportunity (Confluence Energy 2008; Shore 2009).

Other Sources of Pellet Demand

Another large source of pellet demand is as fuel in power generation. This poses both an opportunity and risk for wood pellet manufacturing.

Eighty electricity-generating facilities in 16 states use biomass as fuel (Biomass Power Association 2009). However, unless cheap biomass in the form of waste by-products from another activity is available nearby, power plants fueled entirely by wood have difficulty competing with coal- or gas-fired plants without tax subsidies or mandates. The drive to reduce carbon emissions, however, has created opportunities for biomass in general and wood in particular. Demonstrations and trials have shown that an effective, minimally disruptive way to use biomass in power plants is as an amendment to coal. Up to about 15% of the total energy input can be substituted without incurring major equipment or modification costs (Bain and Amos 2003). Woody biomass is most appropriate because of availability, costs, and operating parameters. Compared with agricultural biomass, the alkali and chlorine contents of bark-free wood are low, which minimizes slagging, fouling, and corrosion in boilers (Maciejeweska 2006).

Table 3—Biomass sizing requirements

	Maximum size	
Boiler type	(mm)	(in.)
Pulverized coal	<6	<0.25
Cyclone	<13	<0.5
Stoker	<76	<3.0
Fluidized bed	<76	<3.0

In power plants, however, size of the biomass is critical. The criteria for four boiler types are shown in Table 3. Biomass that does not meet these specifications is likely to cause flow problems in the fuel-handling equipment or result in incomplete burn of the material.

Pulverized coal boilers, typical of larger power plants, require the smallest sized particles and offer the greatest potential for wood pellets. Dry pelletized wood works most seamlessly because it pulverizes easily in contrast with wood in its raw fibrous, non-friable state (Bergman and Kiel 2005). Such use of pellets has become widespread in Europe but is only beginning to emerge in North America. It is likely to accelerate in the future as governments establish Renewable Fuel Portfolio Standards for the use of renewable fuels in power generation.

The threat to pellet producers comes from the ability to use biomass in smaller, stoker-type boilers that tolerate larger sized pieces. In this application, chipped or chunked wood can be used, which costs less than pellets. The threat to pellet-making stems from the possibility that these types of users could bid away and divert fiber, including residues, from pellet manufacturers, making fiber more scarce and expensive.

The proposed conversion of a 312-megawatt power plant in Ohio to biofuels illustrates the potential impact of this shift. The particular facility would require 725,000 tonnes of biomass per year and, in this instance, wood briquettes made from dedicated fast-growing plantation trees are being considered to supply the plant (Downing 2009).

Fiber Costs

Fiber forms a substantial part of the total costs of pellet manufacturing. In comparative studies of Austrian and Swedish conditions, for example, fiber represented 36% and 50% of the production costs, respectively (Fig. 10). The next highest cost element was drying, a factor influenced by the moisture content of the material being used.

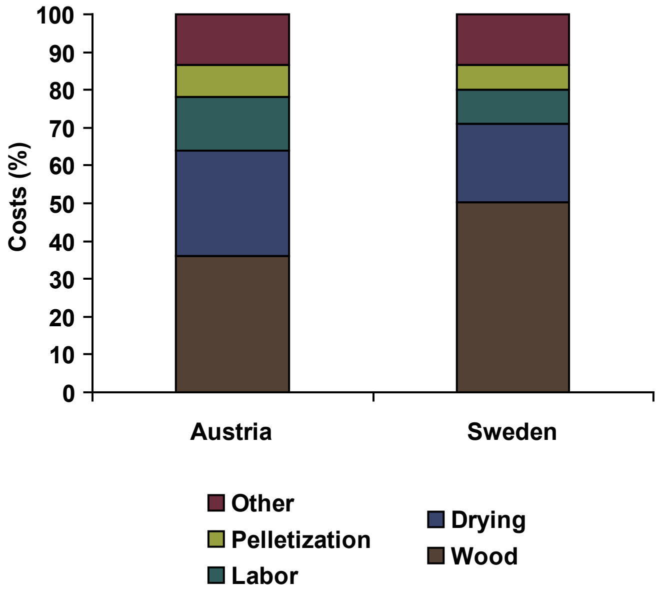

Figure 10—Wood pellet production cost shares in Austria and Sweden (Thek and Obernberger 2004).

Table 4—Delivered costs of woody residues in United States

Region	Residue cost ($/tonne)	Sample
West	56	5
North	49	6
South	42	3
Northeast	38	6

Shavings and sawdust from sawmills have been preferred because they have been the least expensive to procure and required the least amount of processing (drying and milling) to pass through the pelletizing dies (Balint 2008). In the first quarter of 2009, bark-free, in-wood pine chips, excluding transport costs, were quoted in the range of $31–$39 per green tonne ($28–$35 per green short ton (1 ton = 0.907 tonne)) (Timber Mart-South 2009).

Delivered residue fiber costs in 2008 among our respondents ranged from $56/tonne (green weight) in the U.S. West to $38/tonne in the U.S. Northeast (Table 4). We received too few Canadian responses to estimate fiber costs in Canada.

Responses on roundwood prices were also too few to generalize. Delivered pulpwood prices in the U.S. south in 2008 averaged $30/green tonne (Timber Mart-South 2009) but, from the viewpoint of a pellet operation, costs for debarking, chipping, and drying would increase that amount.

Product Quality Standards

An issue facing nascent industries producing a fungible, interchangeable commodity is the establishment of grades and ensuring that products consistently conform to those grades. Its absence can lead to quality inconsistencies, with the lowest quality producers potentially damaging the image of the whole industry. This is a particular point of vulnerability for a product made from wood, which exhibits great variability in properties. That variability is magnified when wood is sourced as residue from different producers who have subjected it to different degrees of processing.

In the mid-1990s, the Pellet Fuels Institute (PFI) developed a set of pelletized fuel standards to help bring consistency to the industry. The original standards defined criteria for premium and standard grade pellets and were quickly adopted by industry, PFI members, and non-members alike. However, over time, it became apparent that these standards lacked key components. The grades were too broad, test methods were not defined, there were no specified quality assurance or quality control (QA/QC) practices, and there was no enforcement.

In 2008, PFI's new standards defined criteria for four grades of pelletized fuel and identified standardized methodology for testing each parameter (Table 5). The PFI's QA/QC program provides an industry-wide quality management system for demonstrating compliance with the standards. This program also includes product grading based on a year's worth of testing data, quarterly data evaluation to verify continued compliance, and a proficiency testing program for third-party testing laboratories (PFI 2008).

In our survey, 79% of the volume was reported to be "premium" under the old standards. Only 5% was classed as "standard." Two percent was reported to be below standard or "utility." Interestingly, 14% of the volume was claimed to exceed "premium" grade standards ("super premium"). Generally, "premium" grade is required for most residential stoves whereas power plants can tolerate lower grades.

Summary and Observations

The wood pellet industry and the use of wood pellets as energy are in their relative infancy in North America. The recent growth of both has been fueled by increases in the cost of fossil energy and policies aimed at reducing carbon dioxide emissions into the atmosphere. Whereas fossil energy costs have moderated and their future course is uncertain, policies on carbon mitigation are likely to become more stringent. Coal-fired plants produce over half the electricity in the United States, and coal burning is the primary target for carbon dioxide mitigation. This is likely to increase demand for biomass to be used alongside, or in lieu of, coal in power plants.

These changes in the market over the past five years have rewarded long-time producers of wood pellets and created opportunities for new entrepreneurial enterprises. As of June 2009, we identified 110 American and Canadian wood pellet plants in operation or about to become operational. Most

Table 5—Pellet Fuel Institute[a] 2008 fuel grade standards

Property	Super premium	Premium	Standard	Utility
Bulk density (kg/m^3)	533–613	533–613	506–613	506–613
Diameter (mm)	6.35–7.25	6.35–7.25	6.35–7.25	6.35–7.25
Durability	> 97.5	> 97.5	> 95.0	> 95.0
Fines (%)	< 0.5	< 0.5	< 0.5	< 0.5
Inorganic ash	< 0.5	< 1.0	< 2.0	< 6.0
Moisture (%)	< 6.0	< 8.0	< 8.0	< 10.0
Chloride (ppm)	< 300	< 300	< 300	< 300

[a] PFI 2008.

relied on relatively inexpensive waste fiber from primary wood processing plants and had relatively small capacities.

The outlook is positive for further expansion of demand. Only a small share of North American homes uses wood as their primary heating source. Electrical heating, one of the least energy-efficient means of space heating, is the primary source of heat in over 30 million homes in the United States (EIA 2005). Conventional firewood stoves, which also exceed pellet stoves in number, are another potential market area because firewood stoves are less convenient. They are also more polluting, and their use can be prohibited on days when atmospheric conditions are unfavorable. Because they burn hotter, pellets emit fewer particulates and can thus be used when firewood burning is banned.

As a result, the potential to heat homes with pellets has not been fully exploited. Pellet stoves are mostly used for local area heating. In more mature European markets, pellet-fueled furnaces are commonly used as central heating units. Such an evolution in North America would be aided by improvements in pellet delivery logistics. Bulk home delivery in specialized trucks, similar to the delivery of heating oil, would simplify handling and improve convenience.

Pellets represent an upgrading of wood as fuel but still have drawbacks typical of wood including moisture absorption, which requires care and expense in transportation and storage. A potential enhancement of pelletization technology is substituting torrefied in place of raw wood, particularly when the application is in a power plant.

Whether conventional or torrefied, the pellet industry faces a constraint on its growth from the limited availability of waste fiber. However, a switch to roundwood is likely to incur higher costs. Producers may need to consider expanding facility size to achieve economies of scale to offset the costs of potentially more expensive furnish. Such flexibility is also desirable from the viewpoint of fiber supply in light of the cyclical nature of waste-supplying industries.

The prospect of power plants requiring a substantial part of their fuel to come from biomass is a potential market-altering event. The volumes involved are on a different scale of magnitude than current uses and would likely overwhelm existing supply capabilities and prevailing patterns of fiber use, as experienced in Europe. This represents an opportunity for pellet fuel producers but a threat to long-time waste users such as panel plants.

Non-binding, voluntary standards for product grading and classification are a weak link in an industry's marketing. In difficult procurement environments, producers desperate to meet contractual obligations can be tempted to use whatever source of fiber is available, such as waste wood with bark content. This can lead to inconsistency in performance and hamper consumer acceptance. Mature industries producing a minimally undifferentiated commodity typically submit to third party inspection and verification to assure buyers of their product's quality and consistency.

The possibility of a big increase in use by power plants also looms as a major challenge for pellet manufacturing. Power plants are capital-intensive enterprises that require long-term, assured flows of fuel. Reliance on a cyclical wood industry for residues is a potential drawback for meeting power plant needs for an assured and consistent flow of supply. Long-term growth of wood as fuel ultimately means the need to use roundwood, potentially pitting the wood energy sector against long-time traditional wood-using industries, elevating pellet fiber costs to those paid by those established users, and shifting the debate to sustainability of biomass supplies for the expanding uses.

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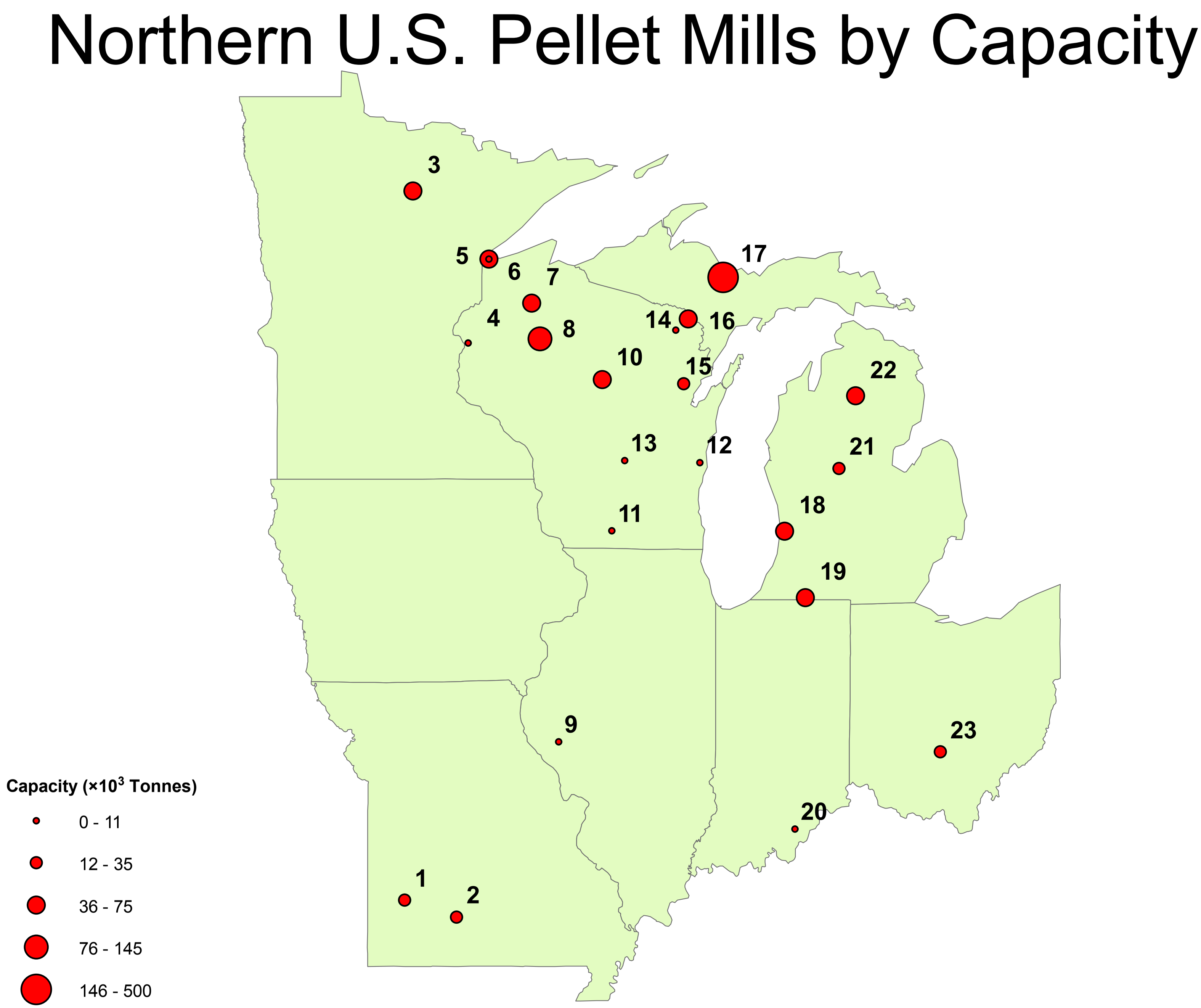
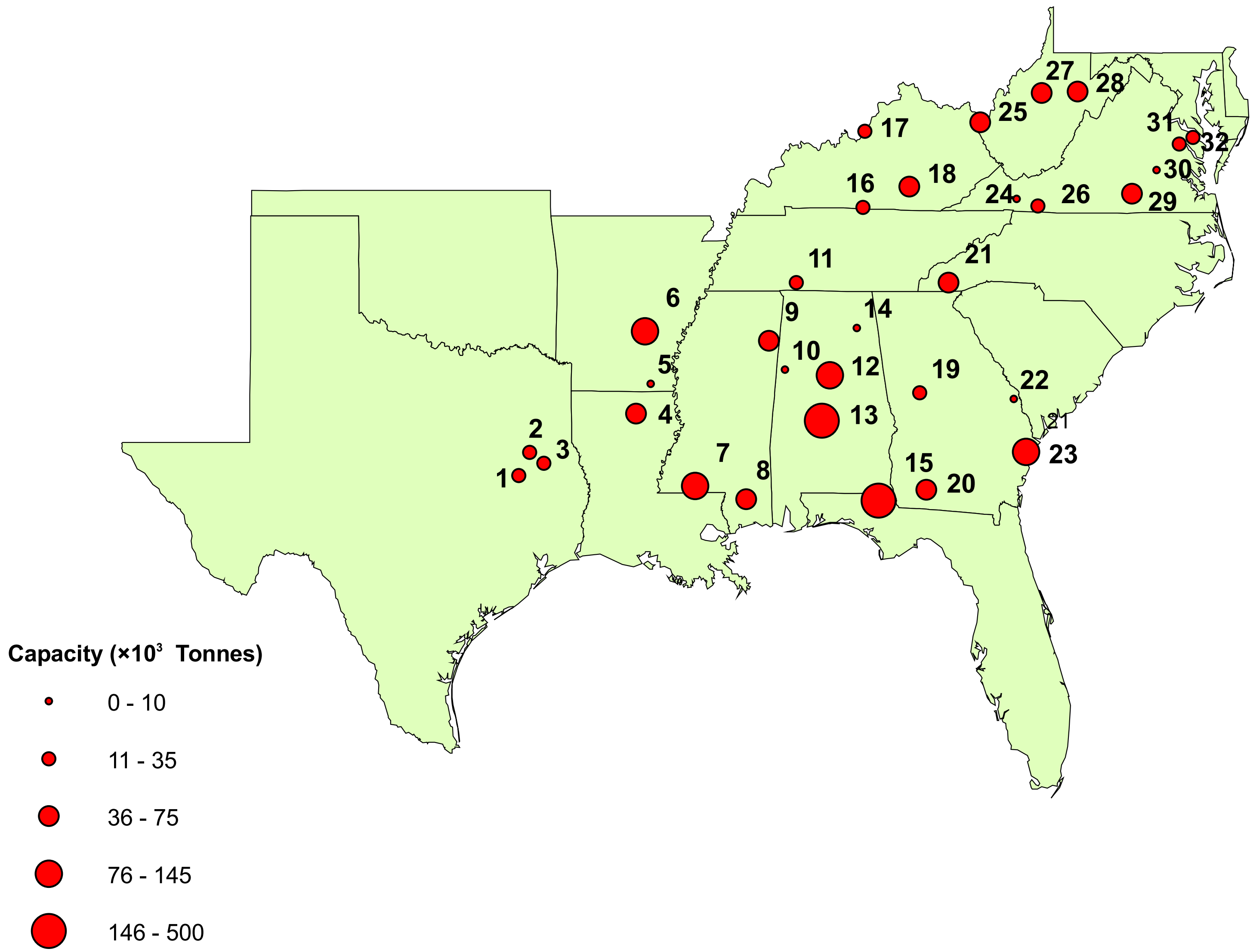
Appendix—Pellet Mill Locations



U.S. North

Mill ID	Company Name	Former Name or DBA	Town	State	2003	2004	2005	2006	2007	2008	2009	Comments
					Capacity (×10^3 tonnes)							
							Operating mills					
9	Pike Pellets		Griggsville	IL								mostly ag
20	Koetter and Smith		Borden	IN				1	1	1	1	
19	Fiber By- Prod		White Pigeon	MI				41	41	41	41	
	Kirtland Products		Boyne city	MI							14	opened in 2009
21	Maeder Brothers		Weidman	MI					23	23	23	
22	Mich Wood Pellet		Grayling	MI					45	45	45	opened in 2007
18	Mich Wood Pellet Fuel	Woodstone USA	Holland	MI					23	45	45	opened in 2007
17	Renewafuels		Marquette	MI							136	opens in 2009
16	Vulcan Wood Prod		Kingsford	MI				23	45	45	45	since 2007
3	Valley Forest Prod		Marcell	MN			9		9	54	54	Opened in 2005 & 2007
2	Ozark Hardwood Prod		Seymour	MO	5	18	18	18	18	23	68	started in 2003
1	Pennington Seed		Greenfield	MO				9	14	14	14	at least since 2007
23	American Wood Fibers		Circleville	OH			23	23	23	23	23	started 2005
12	Badgerland Pellets		Sheboygan Falls	WI					2	5	5	
15	Bay Lakes Cos		Oconto Falls	WI							18	high ash pellets
5	Elkhorn Industries		Superior	WI						33	33	high ash content
7	Great Lakes Renewable Energy		Hayward	WI						5	33	$6 million investment
4	High Quality Shavings		Centuria	WI								opens 2010? No financing yet
8	Indeck Ladysmith BioFuel Center		Ladysmith	WI							36	90K tons/yr, July 2009
10	Marth Wood Shaving Supply		Marathon	WI	7	7	9	68	68	68	68	
11	Risley Pellet Solutions		Monticello	WI					45			burned down 2/6/07
6	Superior Wood Prod		Superior	WI								started permitting
14	Wisconsin Wood Energy		Goodman	WI								permits applied for
13	Wood Residue Solutions		Montelo	WI								plant under construction
					2003	2004	2005	2006	2007	2008	2009	
	Estimated Capacity				12	25	59	183	357	424	702	
	Estimated 2008 Production									329		

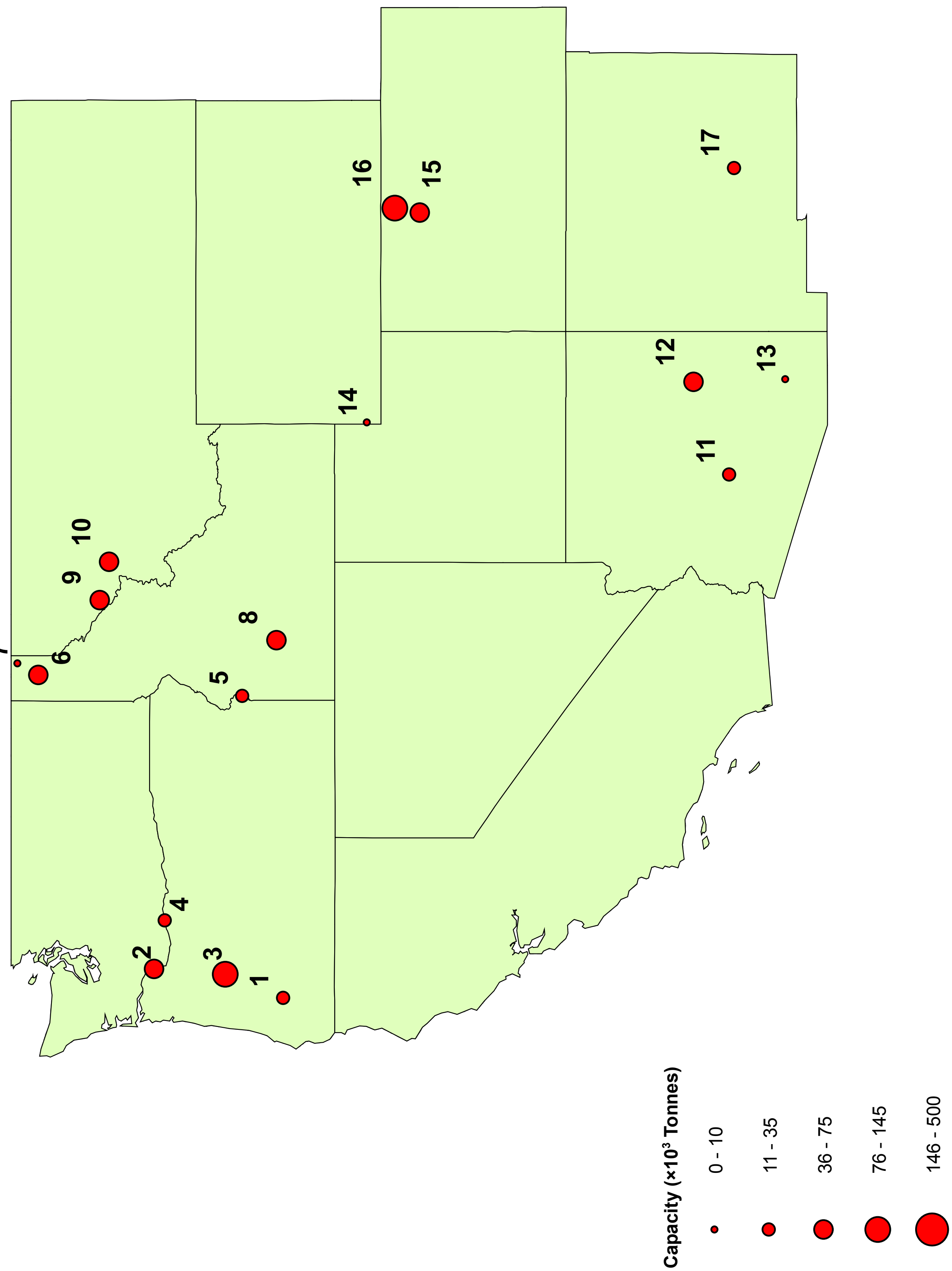
Southern U.S. Pellet Mills by Capacity



U.S. South

Mill ID	Company Name	Former Name or DBA	Town	State	2003	2004	2005	2006	2007	2008	2009	Comments
					Capacity ($\times 10^3$ tonnes)							
	Closed Mills											
	FutureFuel Chemical Co		Batesville	AR			27	36	36			Open in 2005, now down
	Operating mills											
14	Lee Energy Solutions		Crossville	AL								2009 or 10, 75K tons
10	Nature's Earth Pellet Energy		Reform	AL				5	5	6	6	100 tons/week in 2006
12	New Gas Concepts		Jackson	AL								2010? Eventually 600 stons
13	New Gas Concepts		Selma	AL						45	454	eventually 500 stons
5	Barnes Bros Hardwood Flooring		Hamburg	AR					9	9	9	
6	Fiber Resources		Pine Bluff	AR	67	67	67	90	90	112	112	
15	Green Circle BioEnergy		Cottondale	FL						227	454	Open May 2008
22	Big Heat Wood Pellets	Equustock	Sylvania	GA	9	9	9	9	9	9	9	since 2001
23	Fram Renewable Fuels		Baxley	GA						42	132	started plant 3/2008
19	Rock Wood Prod		The Rock	GA					14	18	18	
20	Woodlands Alternative Fuels		Meigs	GA							68	June 2009, 300 in 2010
17	Anderson Hardwood Pellets		Louisville	KY					18	18	18	started in 2006
16	S Kentucky Hardwood Flooring		Gamaliel	KY				18	18	18	18	available in 2006
18	Somerset Pellet Fuel		Somerset	KY				46	46	46	46	
4	Bayou Wood Pellets		West Monroe	LA						54	54	started Jan 08
9	CKS Energy		Amory	MS				23	44	45	45	since 2007
7	Indeck Magnolia BioFuel Center		Magnolia	MS								2010?
8	Piney Woods Pellets		Wiggins	MS							19	up in july 2009, 50K tons
21	Carolina Wood Pellets		Franklin	NC							62	expected start Q1 2009
11	Hassell & Hughes Lumber		Collinwood	TN					18	18	18	started Jan 2007
2	Good Times Wood Prod		Rusk	TX			9	23	23	23	23	
1	Northcutt Woodworks	Christopher Lum Co	Crockett	TX				14	14	14	14	since 2006
3	Patterson Wood Prod		Nacogdoches	TX					18	18	18	At least since 2007
24	American Wood Fibers		Marion	VA								plant will start in 2009
30	Big Heat Wood Pellets/Equustock		Chester	VA	9	9	9	9	9	9	9	
29	Lignetics Lunenburg			VA						45	45	
31	O'Malley Lum Co		Tappahannock	VA						32	32	since Sep 2008
32	Potomac Supply		Kinsale	VA							18	started 2/09
26	Turman Hardwood Flooring		Galax	VA					14	14	14	started in 2005
25	Hamer Pellet Fuel		Kenova	WV				36	41	41	41	
28	Hamer Pellet Fuel		Garden Grounds	WV					41	41	41	
27	Lignetics		Glenville	WV	36	36	36	36	36	59	59	
					2003	2004	2005	2006	2007	2008	2009	
	Estimated Capacity				122	122	158	344	502	964	1855	
	Estimated 2008 Production									592		

Western U.S. Pellet Mills by Capacity

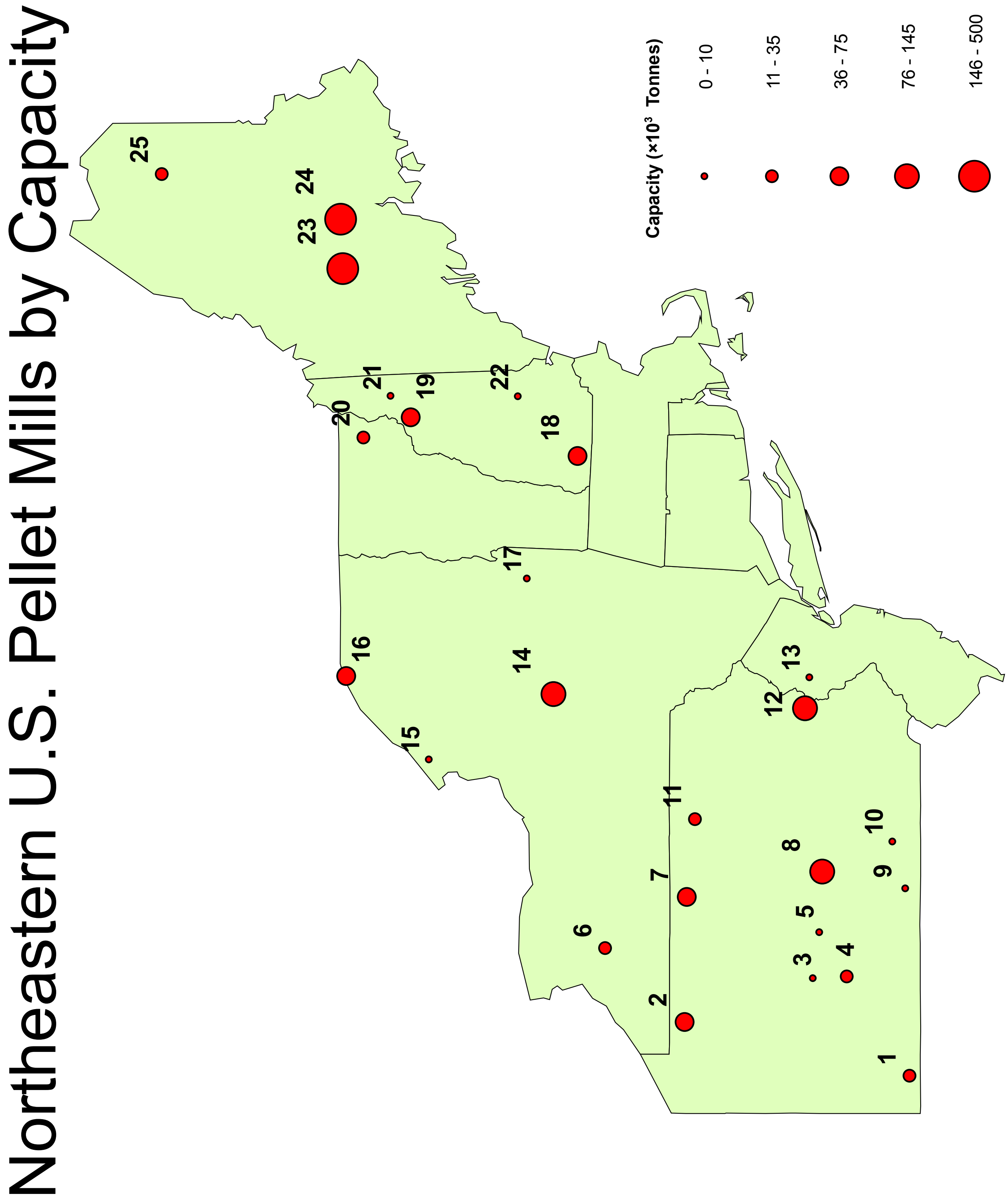


U.S. West

Mill ID	Company Name	Former Name or DBA	Town	Town	2003	2004	2005	2006	2007	2008	2009	Comments
							Closed mills					
	Rocky Mountain Forest Prod		Laramie	WY			18	18	9			millwork producer, bankrupt 9/07, closed
	CNZ Corporation		Sheridan	WY	9	9	9	5	5	2		sawmill closed 12/15/08
							Operating mills					
12	Forest Energy Corp		Show Low	AZ				45	45	45	45	Using USFS roundwood
11	Southwest Forest Prod		Phoenix	AZ							23	started making wood fuel in 2007
13	Sunizona Greenhouses		Wilcox	AZ					2	2	2	primarily for own use
15	Confluence Energy		Kremmling	CO						63	63	beetle killed wood ground up.
16	Rocky Mountain Pellet Co		Walden	CO						27	73	Summer 2008, 150,000 tons possible
6	Lignetics		Sandpoint	ID	45	45	45	63	63	68	68	started in 1983, also fire logs
7	Treasure Valley For Prod		Mt Home	ID				9	18	18	33	
8	North Idaho Energy Logs		Moyie Springs	ID						7	7	
10	Eureka Pellet Mills		Missoula	MT	36	45	45	54	54	54	54	started 1987
9	Eureka Pellet Mills		Superior	MT	18	27	27	30	30	50	50	opened in 2003
17	Enchantment Biomass Prod		Ruidoso Downs	NM					14	14	14	
3	Bear Mountain Forest Prod		Brownsville	OR	91	100	104	104	104	104	104	founded in 1977
1	Roseburg For Prod		Dillard	OR						2	20	startup in 2008-09 heating season
	Dailey Wood Products		Reedsport	OR								2010 ?
2	West Oregon Wood Prod		Columbia City	OR	45	45	68	68	68	68	68	
5	Woodgrain Millwork		Prineville	OR						27	27	"Nature's pellets", 100% wood
4	Bear Mountain Forest Prod		Cascade Locks	OR	27	27	27	27	27	27	27	founded in 1982
	Heartland Pellet		Spearfish	SD				24	24	0	24	Insolvent sawmill bought by Neiman
14	South & Jones Timber Co		Evanston	WY	9	9	9	9	9	9	9	

Capacity ($\times 10^3$ tonnes)

	2003	2004	2005	2006	2007	2008	2009
Estimated Capacity	281	308	354	458	473	589	711
Estimated 2008 Production						473	


Northeastern U.S. Pellet Mills by Capacity
Capacity (×10³ Tonnes)
0 - 10
11 - 35
36 - 75
76 - 145
146 - 500
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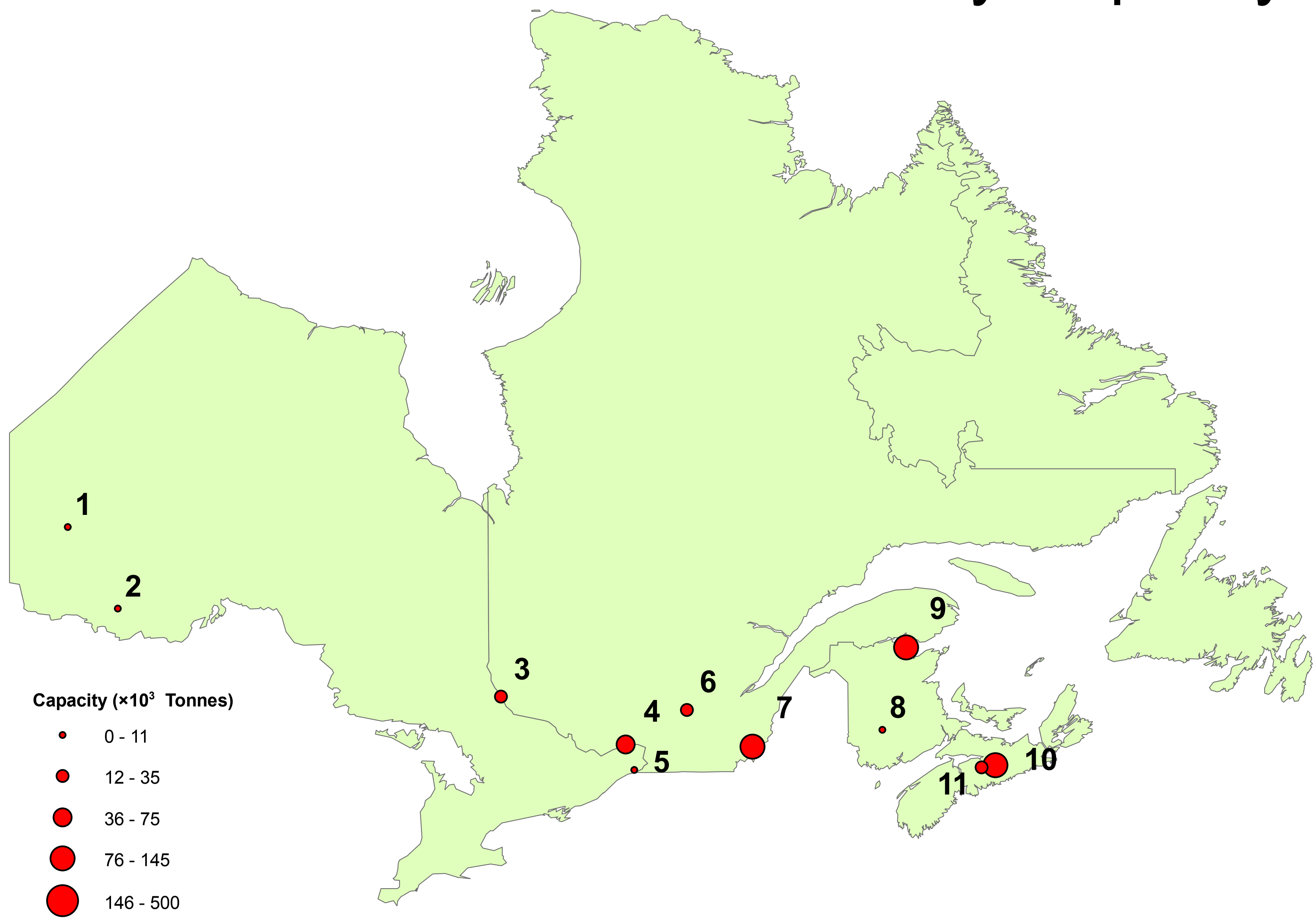
23
24
25

U.S. Northeast

Mill ID	Company Name	Former Name or DBA	Town	State	2003	2004	2005	2006	2007	2008	2009	Comments
					Capacity (×10³ tonnes)							
	Closed mills											
	Narragansett Pellet		Rumford	RI					73			ph disconnected
	Finger Lakes Pellet		Geneva	NY								ph disconnected
	Operating mills											
24	Corinth Wood Pellets		Corinth	ME					54	165	272	Opened April 07
	Geneva Wood Fuels		Strong	ME							23	Opened 2nd quarter 2009
23	Maine Woods Pellet	Fulghum Fibre	Athens	ME						45	165	Opened May 08
25	Northeast Pellets		Ashland	ME			23	23	23	23	23	Opened in 2005
21	Greenovia	Woodstone USA	Berlin	NH								2010?
22	Lakes Regions Pellets		Barnstead	NH							9	June 2009,bedding first
18	New England Wood Pellet		Jaffrey	NH	63	63	63	63	63	63	63	
19	Presby Environmental		Whitefield	NH							50	May 2009?
15	Associated Harvest		LaFargeville	NY			9	9	9	9	9	
16	Curran Renewable Energy		Massena	NY							9	Target cap 100K tons
6	Dry Creek Prod		Arcade	NY				23	23	23	23	
14	New England Wood Pellet		Schuyler	NY						82	82	Opened 1/2008
17	Woodstone USA		Moreau	NY								2010?
9	AJ Stoves & Pellets		Marion	PA								no permit yet
2	Allegheny Pellet		Youngsville	PA	2	2	7	7	15	15	68	
5	Bald Eagle Pellet		Tyrone	PA						5	6	opened in 2008
11	Barefoot Pellet		Troy	PA				23	24	27	30	~ 35 K cap
8	Energex Pellet Fuel		Mifflintown	PA	45	45	45	45	45	45	54	Opened 2000, cap doubled in QIII 09
3	First Nation Wood Pellet		Cambria Co	PA								possibly 2010
1	Greene Team Pellet Fuel		Garards Fort	PA					22	22	22	opened in 2007
7	PA Pellets		Ulysses	PA				27	33	33	33	started 2006
10	Penn Wood Prod		East Berlin	PA		4	4	4	4	4	4	small, local
12	Treecycle		Nazareth	PA							73	Opening Spring 2009
4	Wood Pellets		Summerhill	PA	29	29	29	29	29	29	29	Started in 1992
20	Vermont Pellet Fuel		Island Pond	VT							11	Apr-09
13	Treecycle		Glen Gardner	NJ								2009

	2003	2004	2005	2006	2007	2008	2009
Estimated Capacity	140	143	180	253	416	589	1056
Estimated 2008 Production						435	

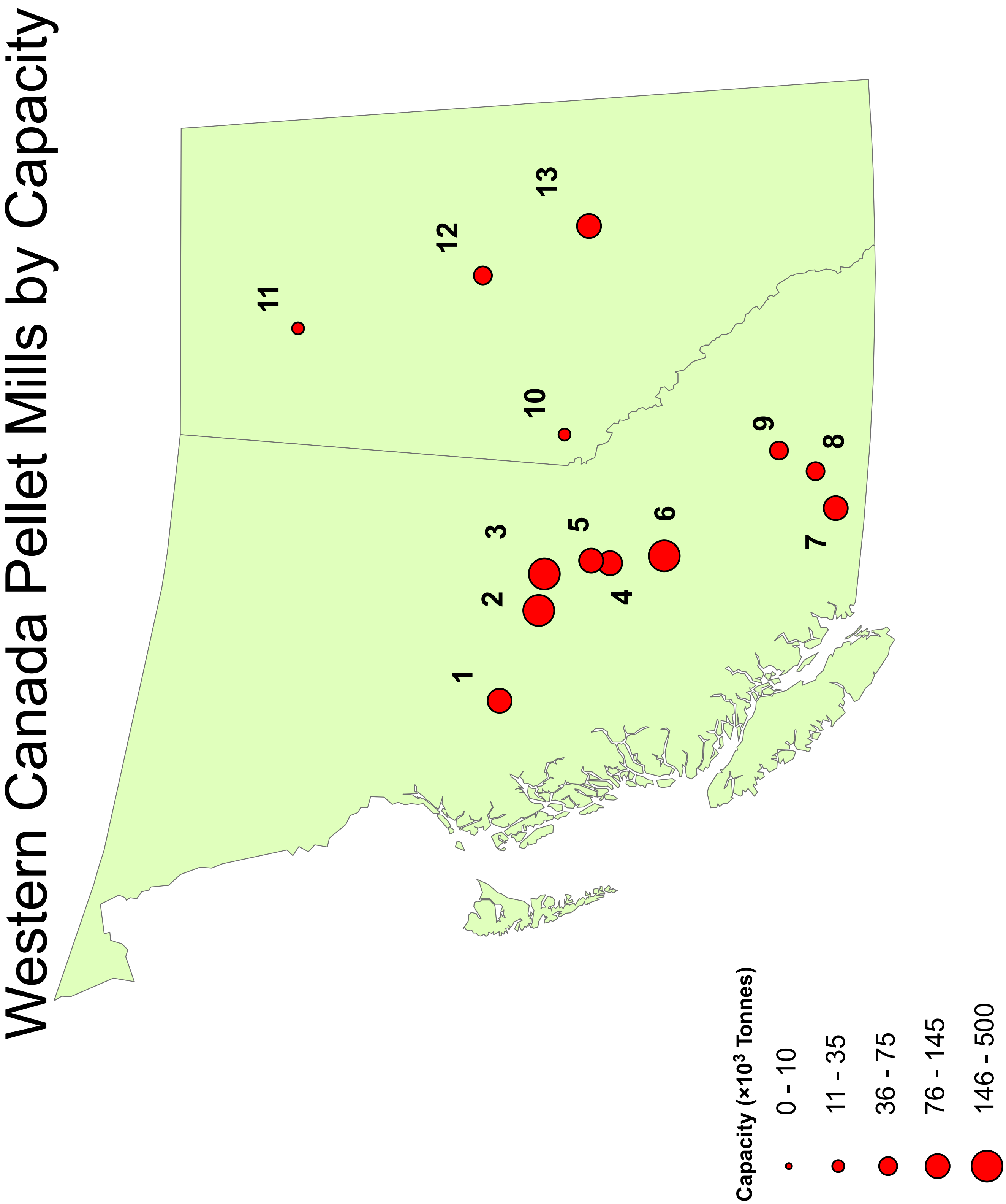
Eastern Canada Pellet Mills by Capacity



Canada East of the Rockies

Mill ID	Company Name	Former Name or DBA	Town	Town	2003	2004	2005	2006	2007	2008	2009	Comments
					Capacity (×10^3 tonnes)							
							Closed mills					
	Fulghum Fibrefuels	McTara	Upper Musquodoboit	NS			50	80	80			bought by Enligna
							Operating mills					
8	Marwood Ltd		Fredericton	NB				6	6	10	10	
9	Shaw Resources		Belledeune	NB						70	75	
10	Enligna		Upper Musquodoboit	NS						80	80	plan to expand to 100K
11	Shaw Resources		Shubenacadie	NS	20	20	20	20	20	20	20	
2	Atikokan Renewable		Atikokan	ON								possibly in 2009
5	Canadian Biopellet		Ingleside	ON								possibly in 2009, 500K
1	Lakewood Industries		Ear Falls	ON	6	6	6	6	6	6	6	
7	Energex Pellet Fuel		Lac-Meganic	QC	60	60	60	60	60	120	120	began in 1993
3	Fabrication EcoFlamme		Temiscaming	QC							30	
4	Lauzon		Papineauville	QC	40	40	40	40	40	40	40	
6	Lauzon		St Paulin	QC	20	20	20	20	20	20	30	rebuild 4/2008

	2003	2004	2005	2006	2007	2008	2009
Estimated Capacity	146	146	196	232	232	366	411
Estimated 2008 Production						276	


Western Canada Pellet Mills by Capacity
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Capacity (×10³ Tonnes)
0 - 10
11 - 35
36 - 75
76 - 145
146 - 500

British Columbia & Alberta

Mill ID	Company Name	Former Name or DBA	Town	Prov	Capacity (×10³ tonnes) 2003	2004	2005	2006	2007	2008	2009	Comments
13	Dansons Group		Edmonton	AB			80	80	80	80	80	
10	Foothills For Prod		Grand Cache	AB				10	20	20	20	planning to upgrade to 120K
11	LaCrete Sawmills		LaCrete	AB	20	30	35	35	35	35	35	
12	Vanderwell Contr		Slave Lake	AB		60	60	60	60	60	60	
1	Houston Pellet	Pinnacle Pellet	Houston	BC					100	113	150	60% canfor, 40% pinnacle
3	Pacific BioEnergy		Prince George	BC	130	130	130	140	140	188	188	
9	Pinnacle Pellet	Armstrong Pellet	Armstrong	BC		30	50	50	50	50	50	
4	Pinnacle Pellet		Quesnel	BC	60	60	60	100	100	100	100	
5	Pinnacle Pellet		Strathnaver	BC						100	150	
6	Pinnacle Pellet		Williams Lake	BC			65	65	110	170	170	
7	Princeton Co-Generation		Princeton	BC	60	60	60	104	104	104	104	
2	Premium Pellet		Vanderhoof	BC	120	120	180	180	190	200	200	
8	Westwood Fiber Prod		Westbank	BC		50	50	50	50	50	50	

	2003	2004	2005	2006	2007	2008	2009
Estimated Capacity	390	540	770	874	1039	1270	1357
Estimated 2008 Production						1142	