Appendix F Biomass Supply and Cost Profile: Worcester, Massachusetts

Introduction

This analysis looks at the biomass fuel availability for the area surrounding Worcester, Massachusetts. About forty miles west of Boston, Worcester is the second-largest city in Massachusetts, and the county seat of Worcester County. As of 2006, Worcester had about 176,000 residents. Analyses were also completed for the areas around Pittsfield and Springfield counties, and the five counties of western Massachusetts (Berkshire, Franklin, Hampshire, Hampden, and Worcester). We present these results from Worcester County as one example from Massachusetts. Results from the Pittsfield analysis are shown at the end of this report for purposes of comparison with a rural community. All reports are available at http://www.mass.gov/doer/programs/renew/bio-initiative.htm (search terms "MA Sustainable Forest Bioenergy Initiative").

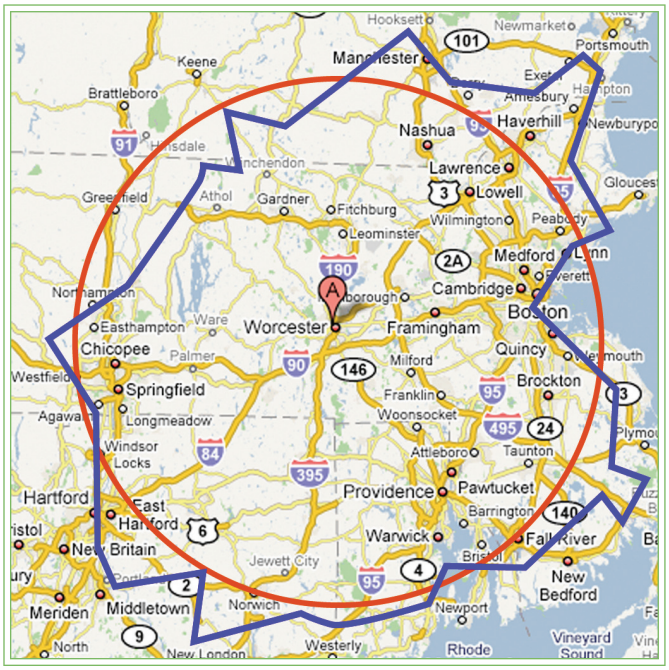
Biomass Resources Near Worcester

Forest Resources

An analysis of the area surrounding Worcester was conducted using the United States Department of Agriculture Forest Service Forest Inventory & Analysis (FIA) system[1]. As discussed in chapter 6 of this guide and toolkit, the FIA system provides a better understanding of an area's standing forest inventory, land ownership patterns, timber growth and harvest volumes, and timber mortality volume.

The FIA allows analysis on a radius from a point; in this example, the point is Worcester. Analysis was conducted for a 60-mile radius. Figure 1 shows a 60-mile radius (in red) and approximates a 90-minute drive time (in blue).

Figure 1: *90-minute drive time and 60-mile radius, Worcester, MA*.



Within a 60-mile radius of Worcester there are 3,933,636 acres of timberland, representing 61 percent of the land area in the region. Of this timberland, 83 percent is privately owned, with the remainder under municipal, county, state or federal ownership.

Table 1 and Figure 2 show the distribution of land ownership within the region.

Within a 60-mile radius of Worcester the standing timber inventory is roughly 68 percent hardwood and 32 percent softwood. Annual net growth in the region is estimated at more than 3.3 million green tons per year[2], with harvest levels fewer than 1 mil-

Table 1: *Land classifications within a 60-mile radius of Worcester, MA.*

All Land	Acres	Percent of Timberland	Percent All Land
Private	6,412,938	83%	51%
Municipal/ County	3,277,053	6%	4%
State	362,736	9%	6%
Federal	40,099	1%	1%
Timberland	3,933,636	143,105	61%

Figure 2: *Land classifications within a 60-mile radius of Worcester, MA.*

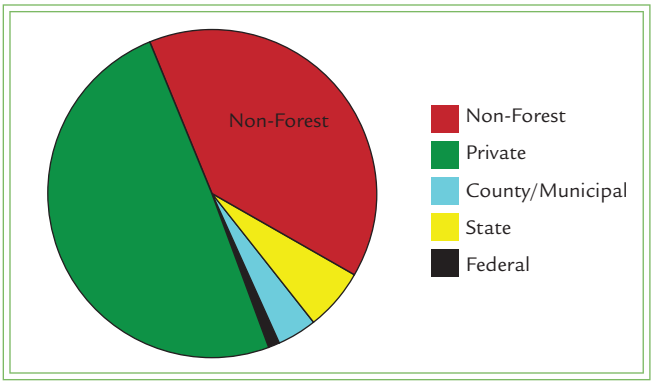


Table 2: *Annual growth and drain, 60-mile radius of Worcester, MA*[3].

	Softwood	Hardwood	Total
	Green Tons		
Standing Volume	77,540,036	161,599,152	239,139,187
Annual Net Growth	1,432,872	2,448,896	3,881,768
Annual Removals	767,661	1,654,757	2,422,418
Net Growth Less Removals	665,211	794,139	1,459,350

Table 3: *Annual growth and drain (without branches), 60-mile radius, Worcester, MA.*

	Softwood	Hardwood	Total
	Green Tons		
Standing Volume	100,026,646	208,462,905	308,489,552
Annual Net Growth	1,848,405	3,159,076	5,007,481
Annual Removals	990,282	2,134,637	3,124,919
Net Growth Less Removals	858,123	1,024,439	1,882,562

lion green tons annually. So, growth above current harvest and mortality levels is roughly 2.4 million green tons annually. Table 2 shows the estimated annual standing volume, growth, and removal for timberland within a 60-mile radius of Worcester.

It is important to note that the USDA Forest Inventory and Analysis, used to develop the data in Table 2, accounts for only merchantable stems of the trees-the wood that traditionally goes to roundwood markets such as lumber, veneer, pulp, or engineered wood products. While this wood, particularly the lower grades, is available for biomass, the branches and tops of a tree are also potentially available. In the northeastern U.S., it is estimated that for every ton of biomass contained in the stem of a tree, another 0.29 tons of biomass are contained in the branches and tops[4] (Table 3). To account for tops and branches, values in Table 2 are multiplied by 1.29 to yield the values in Table 3.

It is important to note that a considerable amount of the nutrients contained in a tree are in the tops (particularly when leaves are attached), and removal of high volumes of this material from a logging job can raise concerns about long-term sustainability. For this reason, as well as practical availability[5], Innovative Natural Resource Solutions (INRS) recommends that availability of tops and branches be considered at no more than 50 percent of reported availability . Subtracting 1.459 million green tons total net growth minus removals (Table 2) from 1.883 million green tons total net growth minus removals (Table 3) yields 0.424 million green tons total net growth minus removals of branches. Fifty percent of 0.424 million green tons is 0.212 million green tons that are available from tops and branches. Adding 0.212 million green tons of available tops and branches to the original 1.459 million green tons total net growth minus removals (Table 2) yields nearly 1.7 million green tons of wood that could be available before harvest and mortality exceeds growth. This volume of wood is enough to support more than 125 megawatts of electric power capacity operationg at industry standard efficiency and capacity factors. Because forest biomass is widely dispersed, it is highly unlikely that all this volume of wood could be harvested in an economic or environmentally responsible manner to supply biomass fuel. Further, some of this wood is comprised of sawlogs or other high-value material, and as such would be sent to other markets.

Wood Residues

Using data from the U.S. Forest Service, the U.S. Environmental Protection Agency, the National Renewable Energy Laboratory/U.S. Deparment of Energy, and the U.S. Census Bureau, INRS developed a national database of biomass residues available by county. The following counties, within a 90-minute drive time of Worcester, are included in the analysis (Figure 3):

Massachusetts: Bristol, Plymouth, Norfolk, Middlesex, Worcester, Essex, Franklin, Hampshire, Hampden

Connecticut: Tollend, Windham, New London, Hartford, Middlesex

New Hampshire: Cheshire, Hillsborough, Rockingham

Rhode Island: Providence, Kent, Washington, Bristol, Newport

Forest Harvest Residues

Forest harvest residue is wood that is left in the forest because there is no market demand for it. In most areas, this includes tops, branches, and pieces that do not meet local specifications for sawlogs and pulpwood. Forest harvest residue is estimated to be roughly 1 million green tons a year in the counties surrounding Worcester[6]. This is largely a function of existing harvesting activity; in locations with high volumes of existing logging activity, volumes of forest harvest residue tend to be higher. Figure 4 shows annual harvest residue density by county.

Notably, the region surrounding Worcester has relatively low concentrations of harvest residues. This is a reflection of forest harvesting activity in the region, which is active but modest. This region does not currently have the level of forest harvesting seen in neighboring New Hampshire, a state with a relatively large biomass energy industry.

Figure 3: *Counties within a 90-minute drive time of Worcester, MA.*

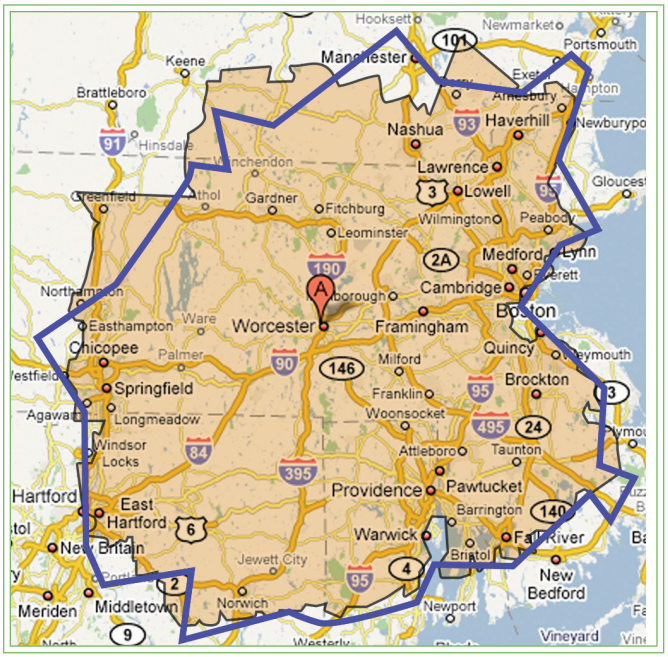


Figure 4: *Forest residues available by county (estimated).*

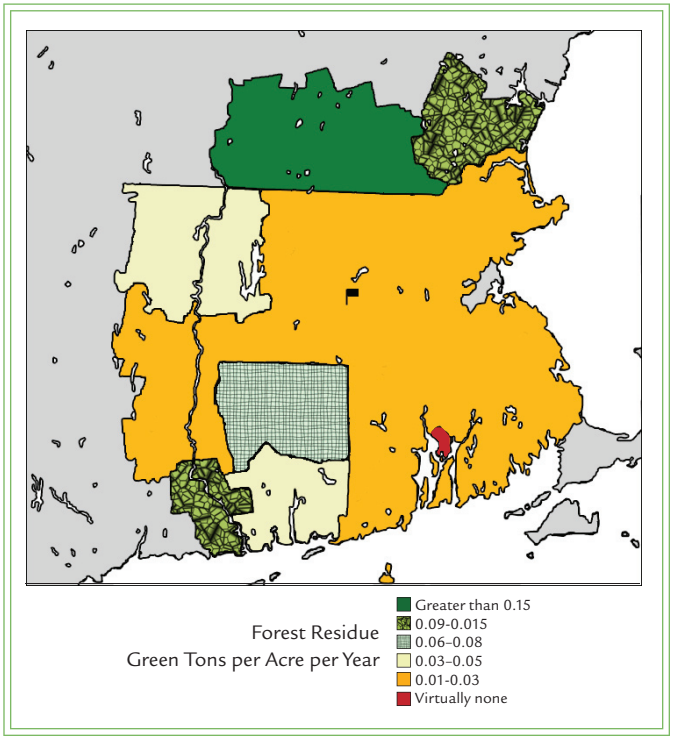


Figure 5: *Sawmill residues available by county (estimated).*

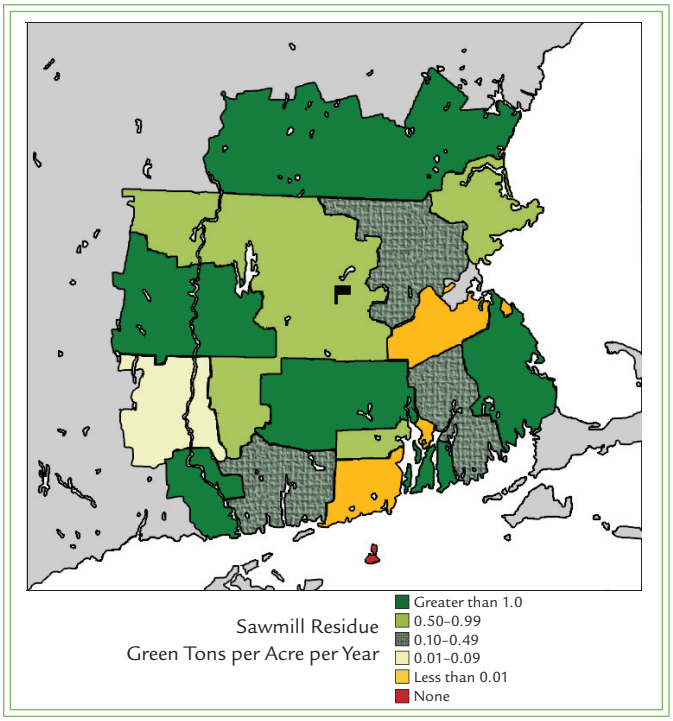
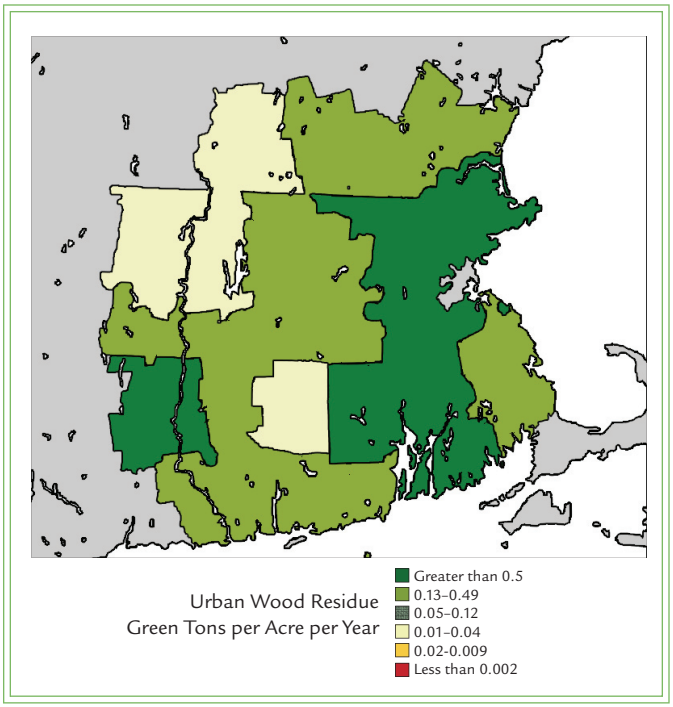


Figure 6: *Urban wood residues available by county (estimated).*



Sawmill Residue

When sawmills cut cylindrical logs into rectangular boards, residue is produced, including bark, sawdust, and mill chips. Actual residue generation varies by species and mill equipment, but a general rule of thumb is that a log in a sawmill produces 60 to 70 percent of useful timber as boards, 20 to 30 percent as wood chips, and 10 percent as sawdust[7].

Based upon the latest U.S. Forest Service Timber Product Output information, sawmill residue (chips, bark, and sawdust) in the region is roughly 850,000 green tons in the counties surrounding Worcester.

Urban Wood Residues

Urban wood residues consist of most wood generated as a result of activity in and around urban and suburban areas, and include tree trimmings, utility right-of-way clearing, ground pallets, and the clean woody fraction of construction and demolition debris.

In the counties surrounding Worcester, there is roughly 1 million green tons of urban wood available. This includes an estimated 530,000 green tons of wood from land clearing in the region.

Figure 7 shows the concentration of housing starts in the counties proximate to Worcester. Housing starts are a very good indication of the volume of land clearing expected in an area. It is important to note that land clearing activity is heavily tied to new construction activity; when construction activity slows, lower volumes of land clearing wood can be expected.

Biomass Supply Pricing

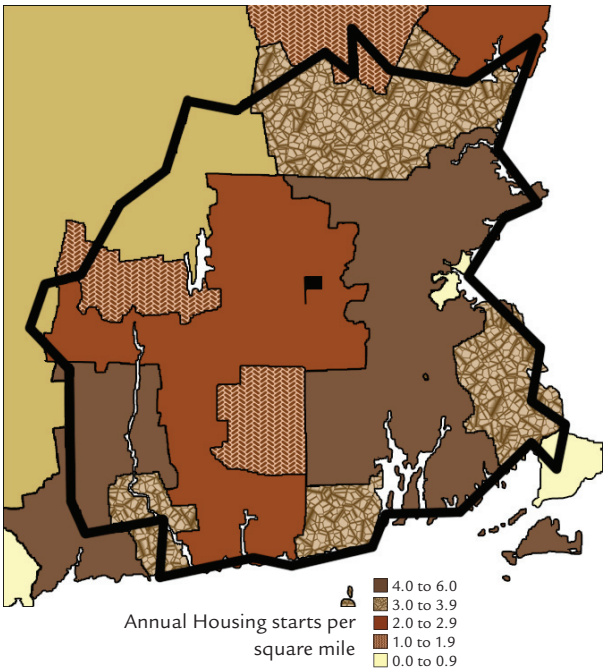
Table 4 shows anticipated biomass supply pricing, by source, for a hypothetical large biomass facility in Worcester, including the incremental volume and delivered pricing[8] by fuel source, the weighted average price, and the total tons. These results are shown as a stepwise supply curve in Figure 8.

For purposes of comparison, the results of the same methodology applied to the area around Pittsfield, Massachusetts, are shown in Figure 9. These results suggest that Pittsfield, which is more rural than Worcester, has less material from pallets, but greater access to forestry waste, resulting in a similar economic availability of woody biomass for both communities. (Complete sup-

ply reports for Pittsfield and other Massachusetts communities can be found at http://www.mass.gov/doer/programs/renew/bio-initiative.htm).

This pricing assumes that the facility has fast unloading capabilities (including truck dumps), the ability to unload and handle a variety of fuels, a screening and processing system for fuel not meeting the facility's specifications, professional management of fuel procurement; and will purchase at least 200,000 green tons annually. Prices during the first year of start-up would be higher than listed in Figure 8 as regional supply capacity is built.

Figure 7: *Land clearing in the region surrounding Worcester, MA, with 90-minute drive time.*



Each price grouping in the previous figures includes multiple suppliers, with price reflecting the average price within each grouping. For example, some land clearing chips may be available at less than $19 per green ton, but because there is a modest amount of land clearing in the immediate region, this only reflects an average price for the first 60,000 green tons. Price increases within like supplier groupings reflect increased distance to Worcester, need for companies to add processing equipment to existing operations (a significant need in the area around Worcester), and the need to compete directly with other markets as distance increases.

Pricing expectations were established based upon interviews with potential suppliers, INRS knowledge of operating costs of various types of biomass fuel suppliers, knowledge of the existing and potential supply infrastructure, and historic pricing for biomass supply in New England.

Table 4: *Anticipated Biomass Fuel Supply and Pricing.*

Source	Volume (green tons equivalent)	Price (green tons equivalent)	Extended	Weighted Average Price	Total Tons
Pallets	50,000	$18.00	$900,000	$18.00	50,000
Land clearing	60,000	$19.00	$1,140,000	$18.55	110,000
Land clearing	60,000	$20.00	$1,200,000	$19.06	170,000
Pallets	20,000	$20.00	$400,000	$19.16	190,000
Sawmill	20,000	$21.00	$420,000	$19.33	210,000
Forestry	70,000	$22.00	$1,540,000	$20.00	280,000
Forestry	60,000	$24.00	$1,440,000	$20.71	340,000
Sawmill	30,000	$25.00	$750,000	$21.05	370,000
Forestry	50,000	$26.00	$1,300,000	$21.64	420,000
Forestry	50,000	$28.00	$1,400,000	$22.32	470,000
Sawmill	40,000	$28.00	$1,1200,000	$22.76	510,000
Forestry	50,000	$30.00	$1,500,000	$23.41	560,000
Forestry	40,000	$32.00	$1,280,000	$23.98	600,000
Forestry	40,000	$34.00	$1,360,000	$24.61	640,000

Figure 8: *Anticipated biomass fuel supply and pricing for Worcester, MA.*

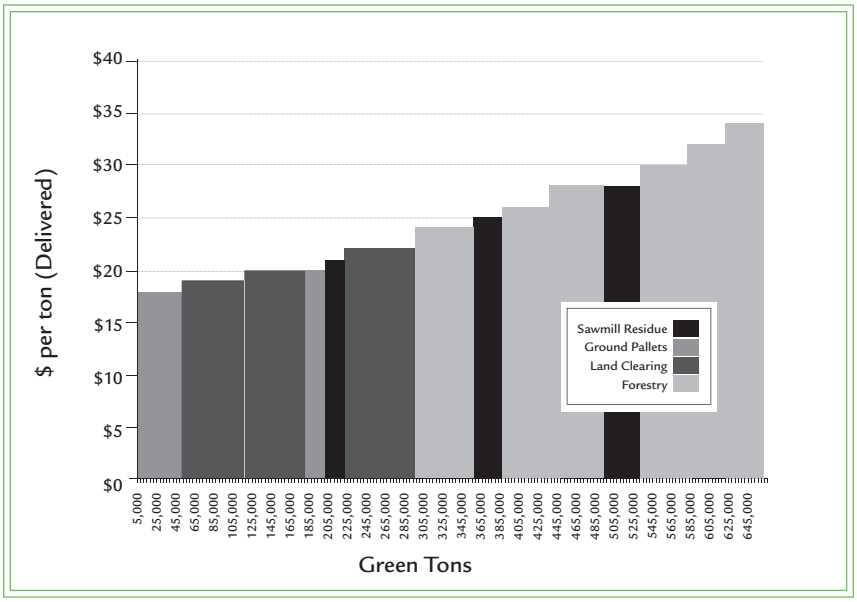
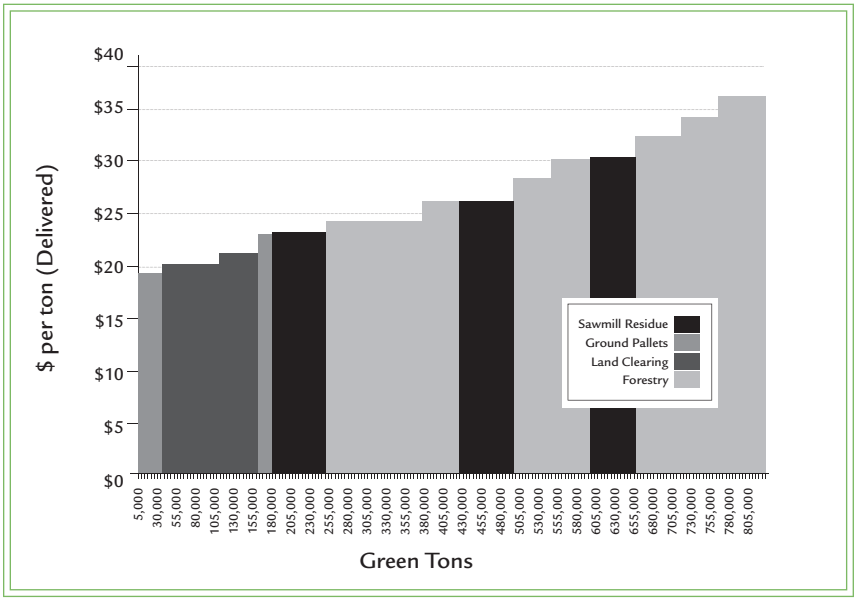


Figure 9: *Anticipated biomass fuel supply and pricing.*



Regional Markets For Low-Grade Wood

A number of markets exist or are proposed for low-grade wood, including but not limited to biomass fuel, in the region surrounding Worcester. Figure 9 shows the areas within a 30-, 60-, 90- and 120-minute drive time of Worcester.

In a 120-mile drive time of Worcester, there are ten active, idle or proposed facilities that use biomass, or low-grade wood that comptes with biomass energy production.

- Three operating facilities, with combined annual wood use of up to 840,000 green tons

- Two idle facilities
- Five publicly proposed facilities, in various stages of development

Wood use from all of the listed facilities has the potential to reach over 3.1 million green tons.

In addition to these facilities, there are many projects in the early stages of development that have not made public announcements or taken obvious steps to begin development activities. Figure 10 and Tables 6-8, show only markets large enough to exert their own market influence. Small facilities, such as those typically used at schools and hospitals, present excellent opportunities for biomass development, but do not individually influence the overall market for and pricing of biomass fuel.

Figure 10: *Urban wood residues available by county (estimated).*

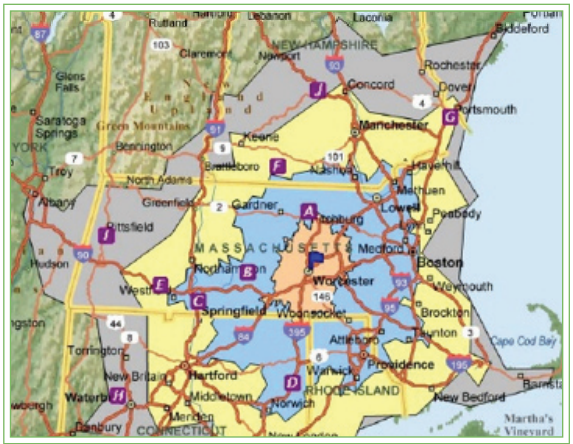


Table 5: *Facilities Using Low-Grade Wood near Worcester, MA.*

Drive Time (minutes)	Facility	Current	Potential
		Green tons	
60	Pinetree-Fitchburg	180,000	180,000
	Ware Co-Gen	-	50,000
	Palmer Renewable Energy	-	235,000
	Plainfield Renewable Energy	-	400,000
	Subtotal	180,000	865,000
90	Russell Biomass	-	630,000
	New England Wood Pellet	160,000	160,000
	PSNH Schiller Station	500,000	500,000
	Subtotal	660,000	1,290,000
	Running Total	840,000	2,155,000
120	Watertown Renewable Power	-	400,000
	Berkshire Renewable Power	-	600,000
	Bio-Energy	-	140,000
	Subtotal	-	1,000,000
	Total	840,000	3,155,000

Table 6: *Facilities within 60-minute drive time of Worcester, MA.*

Facility A	Pinetree-Fitchburg
Location	Westminster, MA
Status	Operating
Product	Electricity
Owner	Suez Energy North America
Size	17 MW (14 MW wood boiler, 3 MW landfill gas)
Fuel	Whole-tree chips, sawmill residue, ground pallets, paper cubes, and landfill gas
Annual wood use (est.)	180,000 tons
Worcester - road miles	24 miles
Worcester - minutes	31 minutes

Table 6 cont.: *Facilities within 60-minute drive time of Worcester, MA.*

Facility B	Ware Co-Gen
Location	Ware, MA
Status	Idle, approved for MA REC's
Product	Electricity
Owner	Ware Energy Company
Size	8.6 MW (2 units)
Fuel	Construction and demolition
Annual wood use (est.)	50,000 tons (estimate)
Worcester - road miles	28 miles
Worcester - minutes	41 minutes

Facility C	Palmer Renewable Energy
Location	Springfield, MA
Status	Proposed
Product	Electricity
Owner	Palmer Renewable Energy
Size	30 MW
Fuel	Wood, derived from a variety of sources
Annual wood use (est.)	235,000 tons
Worcester - road miles	52 miles
Worcester - minutes	53 minutes

Facility D	Plainfield Renewable Energy
Location	Plainfield, CT
Status	Proposed, in permitting
Product	Electricity
Owner	Decker Energy International and NuPower
Size	30 MW
Fuel	Whole tree chips; pallets, sawmill residue, and the wood fraction of construction; and demolition debris
Annual wood use (est.)	400,000 tons
Worcester - road miles	44 miles
Worcester - minutes	46 minutes

Table 7: *Facilities within 90-minute drive time of Worcester, MA.*

Facility E	Russell Biomass
Location	Russell, MA
Status	Proposed, in permitting
Product	Electricity
Owner	Russell Biomass LLC
Size	50 MW
Fuel	Whole-tree chips, sawmill residue, and pallets
Annual wood use (est.)	630,000 tons
Worcester - road miles	67 miles
Worcester - minutes	1 hour, 10 minutes

Facility F	New England Wood Pellet
Location	Jeffrey, NH
Status	Operating
Product	Wood pellets
Owner	New England Wood Pellet, http://www.pelletheat.com
Fuel	Sawmill residue, sawdust, and pulp quality chips
Annual wood use (est.)	120,000 tons (equivalent of roughly 160,000 green tons)
Worcester - road miles	49 miles
Worcester - minutes	1 hour, 1 minute

Facility G	Northern Wood Power Station (Schiller Station)
Location	Portsmouth, NH
Status	Operating
Product	Electricity
Owner	Public Service of New Hampshire
Size	50 MW
Fuel	Whole-tree chips with some sawmill residue and pallets
Annual wood use (est.)	500,000 tons
Worcester - road miles	88 miles
Worcester - minutes	1 hour, 32 minutes

Table 8: *Facilities within 120-minute drive time of Worcester, MA.*

Facility H	Watertown Renewable Power
Location	Watertown, CT
Status	Proposed, in permitting
Product	Electricity
Owner	Tamarack Energy
Size	30 MW
Fuel	Whole-tree chips, sawmill residue, and pallets
Annual wood use (est.)	400,000 tons
Worcester - road miles	94 miles
Worcester - minutes	1 hour, 42 minutes

Facility I	Berkshire Renewable Power
Location	Pittsfield, MA
Status	Proposed
Product	Electricity
Owner	Tamarack Energy
Size	30-50MW
Fuel	Whole-tree chips, sawmill residue, and pallets
Annual wood use (est.)	Up to 600,000 tons
Worcester - road miles	100 miles
Worcester - minutes	1 hour, 42 minutes

Facility J	BioEnergy
Location	Hopkinton, NH
Status	Idle
Product	Electricity and thermal energy
Owner	Bio Energy Corporation (privately held)
Size	50MW
Fuel	Traditionally whole-tree chips and pallets
Annual wood use (est.)	135,000-145,000 tons per year
Worcester - road miles	98 miles
Worcester - minutes	1 hour, 35 minutes

Summary and Conclusion

Economic concerns are important to discussions of using wood for energy. For many communities, the conversation begins with the recognition that there might be enough wood at an affordable cost. This supply analysis suggests that about 400,000 green tons of wood per year are available in areas surrounding both Worcester and Pittsfield at prices up to $25.00 per green ton delivered. This is equivalent to about $3.00 per million Btu, a price competitive with other fuel options. The total of about 800,000 green tons per year is equivalent to about 60 MW of electricity generation capacity.

This profile was adapted from the following source and used with permission. Biomass Availability Analysis, Worcester, Massachusetts. Prepared by Innovative Natural Resource Solutions, LLC, for the Massachusetts Division of Energy Resources & Massachusetts Department of Conservation and Recreation, January 2007.

Endnotes

[1] Data developed using latest publicly available complete USDA Forest Service Forest Inventory & Analysis information – Massachusetts 1998, Connecticut 1998, New Hampshire 1997, New York 1993, Rhode Island 1998, and Vermont 1997.

[2] All USDA Forest Service Forest Inventory & Analysis is presented in cubic feet; converted to green tons assuming 85 cubic feet of solid wood in a cord, a cord of hardwood weighing 2.6 tons, and a cord of softwood weighing 2.3 tons.

[3] Data developed using latest publicly available complete USDA Forest Service Forest Inventory & Analysis information – Massachusetts 1998, Connecticut 1998, New Hampshire 1997, New York 1993, Rhode Island 1998, and Vermont 1997.

[4] North East State Foresters Association. *Carbon Sequestration and Its Impacts on Forest Management in the Northeast*. December 19, 2002. http://www.nefainfo.org

[5] The issue of forest sustainability standards for biomass fuel is beyond the scope of this report, and is a complex and controversial subject matter. However, at least one state, Minnesota, has developed draft biomass harvesting standards. *Draft Biomass Harvesting on Forest Management Sites in Minnesota*. Prepared by the Minnesota Forest Resources Council Biomass Harvesting Guideline Development Committee. May 1, 2007. http://www.forestrycenter.org

[6] This figure includes a remarkably high volume of logging residue in Cheshire County, New Hampshire. This information could be incorrect or could be the result of unique local conditions. INRS has confirmed the data with the USDA Forest Service and the US Department of Energy / National Renewable Laboratory, and both parties indicate that the baseline data as reported is correctly listed.

[7] Wakefield, Emily. "PyNe Workshop Report." *ThermalNet*. Issue 04. June 2007.

[8] These prices assume 2007 dollars and oil at $75 per barrel.