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Wood Wastes and Residues Generated Along the Colorado Front Range as a Potential Fuel Source

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Abstract

Throughout the United States there is interest in utilizing renewable fuel sources as an alternative to coal and natural gas. This project was initiated to determine the availability of wood wastes and residues for use as fuel in cement kilns and power plants located along the Colorado Front Range. Research was conducted through literature searches, phone surveys, personal communications, and public meetings to determine the types of wood wastes and residues generated. Four main sources were identified: municipal solid waste, construction and demolition debris, primary and secondary wood processing residues, and forest residues. Quantities of wood wastes and residues generated were estimated, separated into components, and further evaluated to determine availability for recovery and utilization. Overall, the results of this project made it evident that substantial quantities of wood wastes and residues exist. However, the recovery costs currently present a significant barrier to utilizing this material as an alternative fuel.

Key words: Wood waste, residue generation, recovery, utilization, municipal solid waste, construction and demolition debris, primary and secondary processors, forest residues, renewable fuel alternatives

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Contents

Introduction

During 1999 energy consumption totaled 1,226.6 trillion BTUs in Colorado, with wood energy providing less than 1% of this total (DOE 1999). An estimated 18.17 million tons (355.2 trillion BTUs) of coal and 316 billion cubic feet (318.2 trillion BTUs) of natural gas were consumed. Wood energy consumption amounted to 10.3 trillion BTUs. Along the Colorado Front Range there are significant quantities of wood wastes and residues from residential and commercial sources that are discarded in landfills. This wood could be recovered and utilized as a renewable fuel source. In addition to urban residue generation, and because of the overstocked condition of forests in many areas along the Front Range, small diameter wood material from forest restoration and fire mitigation efforts could also be another fuel source.

There are needs to identify potential wood sources for recovery and to determine if there are sufficient quantities of low cost wood to supply potential users such as cement kilns and power plants. This report characterizes wood wastes and residues for Colorado Front Range counties to determine which components can be utilized as a fuel source, and assesses the quantity of wood available.

Methodology

The study area was comprised of 18 Colorado counties highlighted in figure 1. Counties that were included for study were either intersected by or were close in proximity to the I25 corridor extending from Fort Collins to Pueblo, Colorado. This includes the region generally referred to as the Colorado Front Range.

Data sources for residue generation and use were obtained from literature and internet searches, personal contacts, a telephone survey, and public meetings. Wood residues and wastes were categorized into four specific groups/sources based on how they were generated:

- Municipal Solid Waste Stream (MSW);
- Construction and Demolition Debris (C&D);
- Primary and Secondary wood processing residues (P&S); and
- Forest residues.

These categories or residue sources were evaluated further, dissecting them into smaller components to determine which elements are recoverable for use.

For MSW, U.S. Environmental Protection Agency (EPA 2003) information provided a general assessment of the municipal waste stream composition

Figure 1—Colorado Front Range counties where primary and secondary wood processors were surveyed by Ward (2000).

and components. Estimates of MSW wood generation for Colorado Front Range counties are based on per capita consumption nationally multiplied by area population. Values and estimates that address local sources came from previous studies done within Larimer County reported by Lynch (1999).

National statistics and summaries provided information on C&D debris generation (EPA 1998; McKeever 1998). To determine the amount of C&D generated annually in the Front Range region, data from a pilot project study completed by the City of Fort Collins (2000) that worked with local development projects to separate clean construction woody materials at building sites and divert them from the MSW stream were used. From this study, an estimate of wood debris generated per square foot of new residential construction was obtained and multiplied by the average floor space in a new unit (NAHB 2001) to arrive at an average amount of woody debris generated when new housing units are constructed. This amount was then multiplied by the number of new housing units authorized in the Front Range region during 2002 (US Census Bureau 2004).

Primary and secondary wood processing survey information from the region was evaluated. A survey completed by the New Energy – Environmental Options & Solutions Corporation (NEOS 1993a) evaluated P&S processors in the Denver metropolitan area. A telephone survey by Ward (2000) covered a broader area, which included the counties highlighted in figure 1. The telephone survey was conducted to evaluate the amount of residues available and current methods of disposal. A total of 173 P&S processors were contacted, with 75 responses. There were many reasons that companies gave for not responding, which included being disconnected, relocated and no forwarding number, retired, closed, or no longer involved in processes that generated wood residues.

Information related to forest residue generation came from regional data in Larimer County and along the Front Range (NEOS 1993b; Lynch 1999 and 2000). Estimates of residue generation were derived from harvesting data, which was used to determine how many tons per acre of wood debris would be generated, multiplied by the total acres treated in Colorado during 2001 (USDI 2002). Analyses of transportation and other economic cost factors were also assessed.

Results and Discussion

Municipal Solid Waste (MSW)

MSW comes from materials disposed of by residential, commercial, industrial, and institutional facilities. A study done by the EPA (2003) categorized materials in MSW as being glass, metal, plastic, food scraps, wood, yard trimmings, paper, rubber, leather, and textiles, and "other" miscellaneous wastes. The amount generated and percent of MSW for each category nationally is shown in figure 2.

Wood wastes from these sources can be separated into three categories: wood, yard trimmings, and paper (including paperboard). The wood consists of discarded furniture, cabinets, pallets, containers, scrap lumber and panels from activities other than C&D projects, and wood residues from manufacturers. Data describing the percentage that each specific component comprises was unavailable. Yard trimmings consist of branches, stumps, and other woody debris. The paper category consists of corrugated cardboard, newspapers, magazines, telephone books, paper bags, packaging and cartons, office papers, third-class mail, and other commercial printings.

In 2001, the largest component of MSW was paper, which amounted to 81.8 million tons (35.7% of MSW) or almost 575 pounds per capita (EPA 2003). Yard trimmings contributed an additional 28.0 million tons (12.2% of MSW) or about 197 pounds per capita (12.2% of total MSW generation), making it the second largest component of MSW, while wood wastes totaled 13.2 million tons (5.7% of MSW) or about 93 pounds per capita (EPA 2003). Considering that the 18 Colorado Front Range counties in the study area had a combined population of 3.62 million in 2000 (US Census Bureau 2004), MSW generated in this area during 2000 included an estimated 1.04 million tons of paper, 170 thousand tons of wood wastes, and 360 thousand tons of yard trimmings.

Figure 3 shows paper, wood, and yard trimmings separated into materials recovered for recycling and those that were discarded in 2001 nationally. This figure shows that while relatively high percentages of paper and yard trimmings were recovered for recycling in 2001, only a small percentage of wood waste was recovered.

In 1996, the Larimer County landfill received a total of 187,237 tons of MSW (Lynch 1999). In the residential waste stream, wood waste amounted to 2410 tons and contributed 3.9% of the overall residential total. Wood constituted 27.7% or an estimated 29,563 tons of commercial waste. In 1997, Waste Management opened another landfill locally and this reduced the amount of MSW received by the Larimer County landfill in 1997 to 166,683 tons. Wood made up approximately 26,318 tons of this total, which amounts to about 72 tons per day (Lynch 1999). At a county meeting in March 2000, it was reported that 90 tons of wood was delivered to the Larimer County landfill daily (Henderson

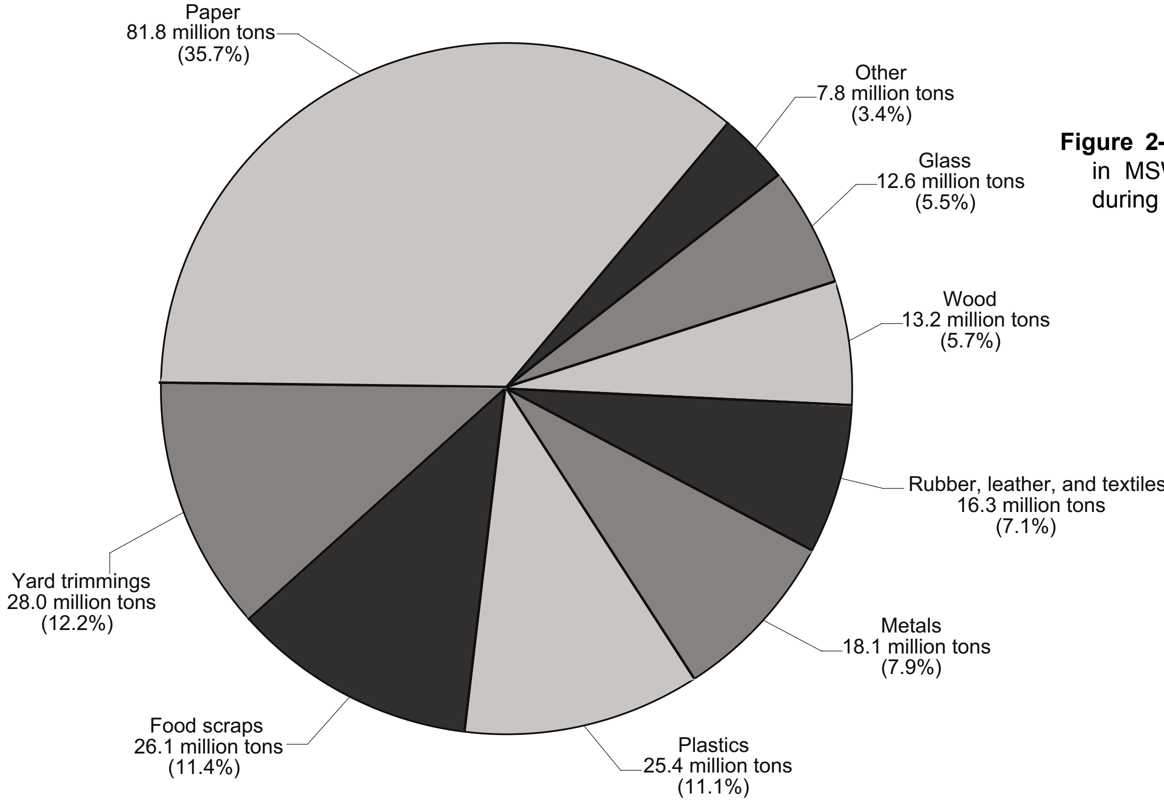

Figure 2—Categorized materials in MSW generated nationally during 2001 (EPA 2003).

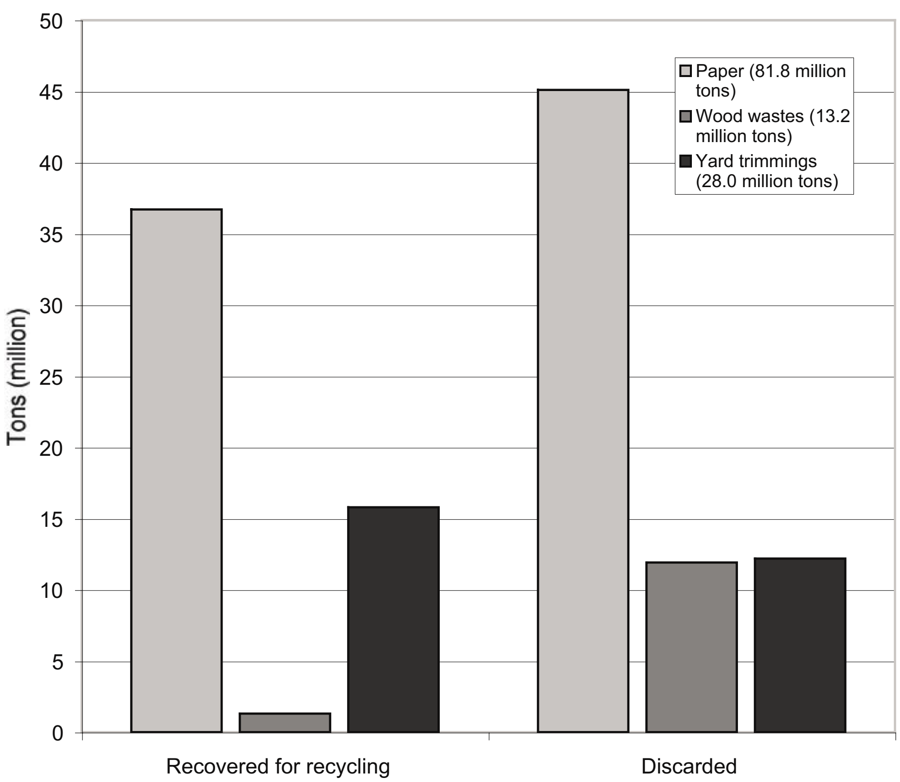

Figure 3—Wood residue in MSW generated nationally during 2001 (EPA 2003).

2000). Depending on the extent of sorting efforts, an estimated 50 to 75% of that material or 45 to 70 tons per day could be recovered.

Construction and Demolition Debris (C&D)

C&D materials are generated from new construction, renovation, and demolition of residential and commercial buildings. An EPA study (1998) identified the quantities and types of debris and how they vary from one type of project to the next. The major constituents of C&D debris are concrete, asphalt, wood, metals, gypsum wallboard, roofing, and flooring tiles. Land-clearing debris such as rocks, stumps, dirt, and sweepings can also be considered as part of C&D.

It was estimated that 136 million tons of C&D debris were generated in the United States during 1996 (EPA 1998). Building demolition accounted for 48% of the waste stream, renovations were 44%, and the remaining 8% came from construction projects. Of total debris generated, 43% were from residential projects, and the remaining 57% were from non-residential projects. At non-residential demolition sites, concrete was the largest component contributing to waste (table 1). Wood was the largest component at residential construction and renovation sites (table 2).

Table 1—Composition of demolition debris from non-residential sources (EPA 1998).

Debris	Percent
Concrete	66
Wood	16
Landfill debris	9
Scrap iron	5
Asphalt	2
Brick	1
Roofing	1

Table 2—Composition of construction debris from residential sites (EPA 1998).

Debris	Percent
Wood	42
Drywall	27
Misc.	15
Brick	6
Roofing	6
Metal	2
Plastic	2

It was also estimated that 35 to 45% of C&D wastes were discarded in C&D landfills (EPA 1998). In Colorado, there are five C&D landfills. Approximately 30 to 40% of C&D debris is managed at MSW landfills or other landfills that were not permitted, and the remaining 15 to 35% were recovered and utilized.

Wood components in C&D debris consist of framing lumber, stumps from land clearing, plywood, particleboard, oriented strandboard (OSB), dimensional lumber, pressure treated wood, and painted wood. The difference between construction debris and demolition debris is that construction wastes tend to be cleaner and more easily separated. Demolition debris may consist of commingled aggregates, concrete, metal, insulation, and other building materials. Demolition materials also tend to be older, so contaminants such as asbestos, lead-based finishes, mercury, and polychlorinated biphenyls commingle with wood preventing recovery. One way that demolition crews are trying to minimize commingling and potential contamination is to remove valuable components first, deconstructing them, and diverting them from demolition rubble to increase recovery. Deconstruction methods can potentially separate 70% by volume, 76% by weight (EPA 1998), of recoverable materials from total demolition waste.

In 1996, C&D wood debris amounted to 33.2 million tons in the United States (McKeever 1998). Figure 4 shows the quantity of wood wastes that were generated from construction and demolition projects and the amount available for recovery.

The City of Fort Collins facilitated a wood separation and recycling program in response to its end-of-year report in 1998 which revealed that approximately 55% of the city's waste generation came from construction debris, of which wood comprised a large portion. Eight construction companies were involved with this project and 13 construction sites were evaluated. This pilot program started in July and ended mid-November 2000. The two goals of this project were (1) to evaluate the quantities of wood volume that were generated from construction of new structures (residential and commercial) in Fort Collins and (2) assess factors that would encourage or hinder future recycling of wood materials (City of Fort Collins 2000).

Of the 13 sites that contributed construction debris, 11 were residential developments and the remaining two were commercial. The building sizes ranged between 1,500 and 8,500 square feet. For all sites evaluated, the average building size was 3,485 square feet. By the end of the study, 330 cubic yards or approximately 75,000 pounds of wood material were diverted from the landfill waste

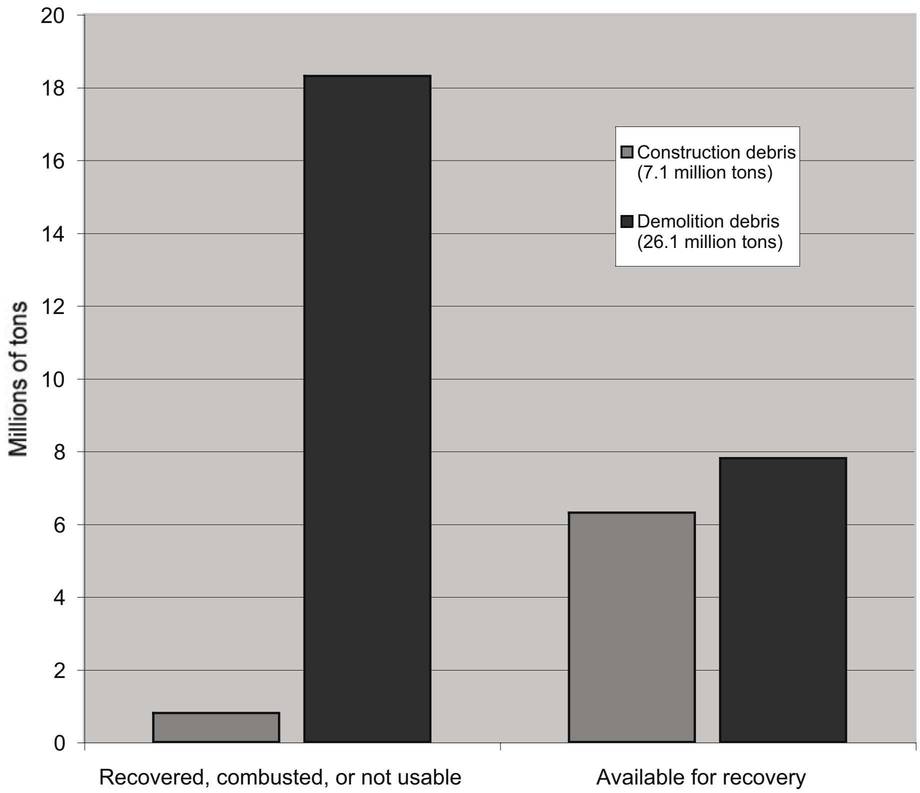

Figure 4—Quantity of wood waste generated from construction and demolition sites in the United States during 1996 (McKeever 1998).

stream. Considering all buildings, wood debris amounted to 1.72 pounds per square foot with a volume of 7.27 cubic yards per 1000 square feet.

Based on this research, companies involved with separating materials were able to divert on average 39.3% of their residues from the landfill. The amount of residues diverted ranged from 28.57% to 62.50%. As a result, participating companies experienced considerably lower bills for trash removal.

Woody debris collected during the study was characterized into two building material categories: (1) dimensional lumber and (2) composite panels, including plywood, oriented strandboard, and particleboard. Based on estimates, 38% of the material collected was dimensional lumber and 59% was composite panels. The remaining 3% was comprised of trash and contaminated materials. The wood residues that were collected at the Larimer County landfill were set aside for processing into landscape mulch.

To determine estimates of total annual C&D debris generated by Colorado Front Range counties, data from the research done by the City of Fort Collins (2000) were used. Based on the study, it was estimated that an average of 1.72 pounds of wood debris per square foot was generated in new residential housing construction. Considering that the average size of a new residential housing unit is 2,200 square feet (NAHB 2000), each new unit that is built generates an average of 3,780 pounds of wood wastes and residues. In 2002, 40,340 new housing units were constructed in Colorado Front Range counties (US Census Bureau 2004). Based on the number of new housing units constructed and estimates of average wood residue generation per new housing unit, over 76,200 tons of wood wastes and residues were generated from the construction of new housing units in the region during 2002.

Primary and Secondary Processing Residues

Primary processing includes the production of roundwood, lumber, and composite panel products. Residues from primary processing include bark, sawmill slabs and edging, sawdust, and peeler log cores. It has been estimated that 30.3 million tons of bark and 86.7 million tons of wood residues were generated in the United States during 1997 (McKeever 1998). Most of these residues were used in producing other materials such as paper, leaving only about 5% of bark and 6% of wood residues remaining that could potentially be recovered for alternative uses.

In Colorado, residues from primary processing were estimated to be about 115,000 bone-dry tons in 1993 (NEOS 1993a). There were approximately 100 mills in Colorado at the time of the survey, and on average, for every 1 million board feet

Table 3—Secondary wood processing residues produced by Colorado processors surveyed by NEOS (1993a).

Residue	Bone dry tons
Sawdust	211
Chips	12
Shavings	174
Sander dust	1393
Solid wood	215

Table 4—Percent distribution of wood residues generated by Colorado processors surveyed by Ward (2000).

Residue	Percent
Sawdust	39
Scrap	35
Shavings/chips	16
Pole peelings	6
Pallets	1
Dunnage	1
Fines	1
Firewood	1

processed there were 576 bone-dry tons of residue generated.

Secondary processing utilizes primary forest products and further manufactures them into other products. Residues from secondary processing include sawdust, shavings, wood chips, sander dust, and solid wood residues. In 1993, there were approximately 300 secondary processing facilities in Colorado, of which more than 200 were located along the Front Range. There were 60 to 70 facilities within Boulder, Weld, and Larimer Counties (NEOS 1993a).

The amount of wood residues produced annually by 41 of 176 secondary processing facilities in the Denver and Colorado Springs metropolitan areas is shown in table 3. Based on the survey conducted by NEOS (1993a), 77% of wood residues were deposited in landfills. Seventy percent of the respondents were interested in alternatives to landfill disposal.

A more recent study (Ward 2000) surveyed P&S processors along the Front Range of Colorado. From the data that was collected, the major forms of residues generated fell into eight categories:

- Sawdust
- Scrap
- Pole peelings
- Pallets
- Dunnage
- Fines
- Shavings and chips
- Firewood

Of these, table 4 reveals that the three most common forms of residue were sawdust (39%), scrap material (35%), and shavings/chips (16%).

The means by which these residues were further utilized or disposed of fell into seven categories:

- Landfilled (MSW)
- Horse bedding
- Used on site
- Fuelwood
- Given away
- Stockpiled on site
- Sold for other products/uses

The two most significant means of end use/disposal were landfill disposal (37%) and given away (36%). Both serve to get rid of material either at an expense or, at best, no additional cost. In the case of landfill disposal, further consideration for using the wood as a byproduct is eliminated.

From the results of the survey, the total quantity of wood residue generation was conservatively 380 tons per week (19,760 tons annually) along the Front Range. Of those that responded, 49% were definite in their willingness to utilize their residues for alternative uses. Another 20% would strongly be in favor of alternative uses and 31% would likely not consider alternatives because they were currently utilizing their residues, selling them for use as a byproduct, or did not generate enough residues to consider the effort.

Forest Residues

Forest residues could come from a variety of activities on private and public lands. This would include activities such as traditional logging operations, forest restoration work, and road construction. In addition, wood removal on private land can also result from landowners implementing best management practices or providing for defensible space around structures.

Forest restoration and fuel hazard reduction projects could provide a significant source of wood supply. These projects are designed to improve forest health and mitigate conditions favorable for catastrophic wildfire. The Colorado State Forest Service has identified Red Zone Regions across the state where the conditions are favorable for catastrophic fire. Over 6.3 million acres of forests statewide are considered as "buffered high" risk for catastrophic wildfire. About 2.4 million acres of red zone are located along the Front Range. In addition, approximately 17.3 million acres of forests are considered moderate to high risk in Colorado.

The Colorado State Forest Service conducted fuel break thinning projects at three sites located in the vicinity of Cheesman Reservoir in the spring of 2000. The purpose of these projects was to reduce fire hazard and restore forest health and diversity. Lynch (2000) completed an economic analysis that evaluated the costs associated with removal and transportation of logs to the Louisiana Pacific oriented strandboard mill located in Olathe, Colorado. In addition to cost data, information related to the quantity of trees cut, diameter, number of logs skidded and loaded, and truckload weights was recorded. Almost 160 acres were treated on the three sites with an average density of 58.9 trees per acre. Overall, 9,545 trees were cut and 2,113 green-tons of logs were removed. An average of 13.3 tons of trees was removed per acre. Treatment of each site resulted in a financial loss to the logger, which totaled about $77,870. The average loss per ton of green logs removed was around $37.

Based on this study, it was estimated that forest restoration projects along the Front Range of Colorado could conservatively yield 9 to 15 green tons per acre. The majority of the trees removed from each site, 88% to 90%, were classified as small diameter (less than 12 inches diameter at breast height), which limits how merchantable they would be in wood processing markets. Considering the acreage involved along the Front Range, there is an enormous amount of wood that could potentially be removed. The NEOS Corporation (1993b) estimated that Larimer County forests have over 1.4 million tons of wood that could be removed during fuel hazard reduction and restoration projects. More recently, the National Fire Plan (USDI 2002) stated that 30,442 acres were treated in Colorado during 2001 as part of hazardous fuels reduction and forest restoration efforts. The precise amount of forest biomass generated from these projects is difficult to estimate because a high percentage of it was left in the forest loped and scattered, chipped and blown on the forest floor, or piled and burned. However, based on conservative yields (9 to 15 green-tons per acre) from restoration projects, the amount of forest biomass that could have been removed and utilized was in the range of 270,000 to 460,000 green tons. Because this was for the entire state, the potential amount of biomass generated along the Front Range in 2001 was considerably less.

In addition, there is a pine beetle epidemic underway in ponderosa pine forests of Colorado, including the Front Range. Beetle-killed trees removed to promote forest health could be utilized for fuel. In 1999, Larimer County had 4,000 to 5,000 beetle-killed pine trees (CSFS 2000).

Potential for Utilizing Wood Wastes and Residues

Even though a substantial wood supply exists, there are many factors that could interfere with utilizing it. Costs associated with procurement can be a limiting factor. This would include recovery (sorting), transportation, drying, and processing (chipping and/or grinding) costs. For significant amounts of wood to be utilized, procurement costs will have to be much less than the current price of coal, which is $20 to $25 per ton.

MSW debris is commingled, making it difficult and expensive to sort. To maximize wood recovery from the MSW, it might be most efficient to have wood sorted by households for curbside collection, similar to the way existing recycling programs are implemented. This would minimize the effort and cost to the county associated with sorting. A curbside wood-sorting program would increase the recoverability of wood that otherwise is typically deposited in landfills. If sorting is done at the landfill, the only realistic means of covering costs associated with sorting would be to charge appropriate tipping fees that would pay for separation.

Separated construction woody material is clean and would be suitable for fuel and other alternative uses. However, there are possible limitations and barriers that could impede proper sorting. Construction debris often consists of commingled wood and non-wood products (shingles, caulk, plastic tubing, and other miscellaneous contaminants). Other limitations that were cited in the City of Fort Collins (2000) study stated that size of site and method of cleanup also significantly contributed to how effective wood sorting efforts would be. Generally, the larger the site is (longer distance to sorting bins), the greater the contamination.

To encourage future efforts and progress in maintaining successful recycling programs, it would be optimal for the costs of recycling woody materials to be less than standard trash disposal. As previously stated, most of the companies involved in the Fort Collins pilot project did experience lower trash disposal fees. However, time and labor costs increased because materials needed to be sorted. To create more incentive and keep costs lower for construction companies, consideration is being given to reduced tipping fees or directly subsidizing efforts.

With regard to P&S wood processors, they generally support the concept of recovering and utilizing their wood residues. The main factors that interfere with diversion and recovery of wood residues are the costs. It is often easier for processors to dispose of materials rather than take the time to sort. There are also some processing facilities that sell their residues. The majority breakeven or incur losses, but a few make a profit (generally small). If costs of diversion are less than or comparable to current disposal methods, there will be more willingness to utilize residue productively. The cost of disposal and/or the revenues generated from selling wood residues varies depending on the type and quantity generated.

To utilize wood residues, the primary requirement is that they be clean and free of foreign materials such as steel and other contaminants. Therefore, some consideration might be given to developing collection methods that minimize the commingling of wood with other materials that might be unacceptable for combustion or other uses.

While some research of forest residue generation in the region is available (NEOS 1993b; Lynch 1999), specific data on residue availability and costs associated with collecting forest residues are harder to come by. Significant quantities of forest residues could be available, but the costs associated with collecting these residues create the greatest barrier to utilizing this resource.

For the three fuel mitigation (forest restoration thinning) projects near Cheesman Reservoir in Colorado assessed by Lynch (2000), work was completed at an average loss to the logger of about $491 per acre. This was primarily due to high costs associated with removing small diameter trees, the poor quality of trees removed, and the average hauling distance of 256 miles to the nearest processing facility that would take them. It has become evident that even though tree densities are high and thinning will be necessary to improve forest health conditions and reduce fire hazards, it is more than likely that without subsidies, thinning will not occur on public forestlands unless higher value products can be produced from small diameter material.

Forest residues are expensive to collect. In a test conducted at the Holcim (formerly Holnam) Cement Plant north of Fort Collins, 98 tons of forest residues were delivered to the plant at a cost of $35 per green-ton for the wood and an additional $10 per ton to chip logs into a useable form (Mackes and Lightburn 2002). Costs could be reduced if an operation were set up specifically to supply wood chips for energy. However, the concept of utilizing conventional logging to supply wood to these facilities is not promising. Mobile collection sites where private landowners can deposit wood residues have been established in Larimer County and other Front Range counties. These sites could provide a solution for collecting wood at a low cost. Efforts need to be directed at educating private landowners so they will properly manage their forested acres and provide for defensible space around structures, utilizing these sites to dispose of the wood removed from their property.

Conclusion

Wood residues and wastes could be used as a fuel source. Sources of this material include MSW, C&D, P&S, and forest residues. Significant quantities of wood are being deposited into landfills, even though opportunities and markets exist for utilizing woody residues. The majority of this wood wastes (excluding paper) comes from construction and urban forest residue. Although these residues tend to be cleaner and better sorted, a program is needed to separate C&D materials and urban forest residues from the MSW stream going into landfills. This can be accomplished by sorting at curbside, construction sites, or landfills, or by establishing specific areas designated to receive wood wastes and residues.

Primary and secondary wood processors could potentially supply significant quantities of wood as well. Processors appeared willing to consider alternative wood disposal methods such as using them for fuel given that any costs associated with utilizing the material were equal to or ideally less than current methods of disposal/end use. In some cases, it may be necessary to purchase higher quality residues with specified form and cleanliness. This ultimately depends on the desired end use for the residue.

Although significant quantities of forest residues could be generated and available from thinning projects, in the absence of government subsidies, forest residues may be too expensive. The economic feasibility and functionality of sites established to receive forest residues have to be assessed further to determine if they are a viable collection alternative.

Many types of wood wastes and residues can be recovered for use. Uses for this material aren't limited to fuel alternatives. Further analyses should also evaluate the potential for utilizing wood residues that are currently sent to landfills in other commercial uses, such as landscape mulch, animal bedding, and compost. However, given the current market conditions, it will take willingness on the part of the public and wood processors in the region to recover wood destined for landfills and utilize it for fuel and/or other products that benefit society.

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