ANALYSIS OF WOOD VOLUME AVAILABLE FROM HAZARD FUEL REDUCTION PROJECTS AND DEVELOPMENT OF WOOD RESIDUE MARKETS In The FAIRBANKS AREA

State of Alaska, Department of Natural Resources,
Division of Forestry
3700 Airport Way
Fairbanks, Alaska 99709

2007

By
Douglas Hanson, Fairbanks Area Resource Management Forester

Table of Contents

List of Figures

List of Tables

I. BACKGROUND INFORMATION

A. Introduction

Nationwide and in Alaska as well, past management of wildfires near the wildland urban interface have focused on fire's immediate, and often damaging, effects. Through the application of years of generally effective fire suppression response, hazardous fuels levels have increased in volume and extent. As a result, many new fire starts are becoming more intense and more difficult to contain. In recent years, the emphasis has moved toward the understanding that fire is a vital process in these ecosystems. Managed fires (prescribed burning or strategies to use wildland fire) can often be used as a surrogate for natural fires to restore ecological balance while consuming unnatural accumulations of fuels. In some places, however, the accumulations of continuous fuel beds or flammable species compositions are so significant that prescribed fires are not practical. In addition, the presence of highly valued resources, such as those found within the wildland and urban interface, often make landscape level prescribed fire an unacceptably risky or politically unpalatable management tool. In these cases, fuels treatment options such as mechanical treatments provide a better choice. These treatments are now being implemented in many areas of the country and strategies for market development for the use of wood residue are being created. While improving fire resilience, the use of biomass from hazard fuel reduction treatments can also address needs to restore forest health and improve wildlife habitat. Funding for many of these projects is passed through from the federal government. General project goals and priorities appear in the National Fire Plan.

The impetus for hazard fuel treatments in the Fairbanks area received a jump start in 2004 and again in 2005. Wildfire activity for the 2004 season reached record levels in Alaska with over 6.7 million acres burned. Wildfire activity for the 2005 season was the third highest on record with 4.3 million acres burned. Several of the larger fires burned within the Fairbanks North Star Borough (FNSB) and in 2004 prompted evacuation of local residents. After the 2004 fire season, public meetings were held in various communities seeking public input on the fire management decision process. Through input gathered at the meetings and interagency review of the fire season, the Division of Forestry (DOF) and the FNSB's newly established Wildland Fire Commission (created in response to the 2004 fire season) each prepared reports recommending a number of risk mitigation projects. The reports recognized the dramatic increase of urban development into the highly flammable black spruce zones and recommended the initiation of an "Integrated Risk Assessment and Fuels Reduction Program". Hazard fuel reduction treatments were the top priority of both reports.

B. Development of a Community Wildfire Protection Plan

To assess wildfire risk and prioritize hazard fuel treatment areas, a Community Wildfire Protection Plan (CWPP) was developed by DOF and FNSB Emergency Management and Fire Departments in May of 2006. The CWPP, created in response to the back to back fire seasons, also had direction from the 2003 National Healthy Forest Restoration Act, which instructs communities at risk to wildfire to develop risk assessments and mitigation plans. The CWPP uses a Geographic Information System to model four components (hazard fuels, ignition risks, values of concern, suppression difficulty) to produce a map that determines the relative risk to wildfire across the landscape within portions of the borough. By examining the risk levels, areas to perform hazard fuel reduction projects can be identified and treatment units laid out on the ground.

C. Description of Hazard Fuel Reduction Timber Types

The predominant fuel models in Alaska are black spruce/feathermoss, white spruce, mixed spruce and hardwoods, deciduous hardwoods (aspen or birch), tall shrub, tussock tundra, and grass. Fire behavior can range from a creeping slow burn ground fire to a wind-driven running crown fire with long range spotting. Many of the areas prone to fires contain complexes of fine fuels that react quickly to changes in humidity. Even after substantial rainfalls these fuels are capable of rapid drying. Deep organic mats allow fires to be carried beneath the surface, increasing the probability of holdover fires with difficult mop-up conditions. In some instances fires have smoldered underground throughout the winter only to reappear in the spring during dry, windy conditions.

Black spruce/feathermoss forests are the most problematic in terms of fire suppression. These forests are found on north-facing slopes and on valley bottoms outside of riparian areas. They often contain a flammable low shrub layer of Labrador tea, cranberry and blueberry that will carry a flame 1 to 3 feet above the surface. From that point ignition into the black spruce crown is frequent because of numerous dead and live branches that grow near to the ground. Black spruce is also capable of layering (reproduction from buried branches) that creates a nearly continuous fuel ladder from ground to tree crown. The black spruce tree itself has resinous needles and contains extremely low moisture content that contributes to its high fire susceptibility. Black spruce is the primary timber type of hazard fuel reduction areas identified in the Community Wildfire Protection Plan. Lesser amounts of white spruce, tamarack, birch and aspen are found in the better drained sites within these areas.

Although many subdivisions in the Fairbanks area are in better drained white spruce and hardwood stands, they can be in close proximity to pure black spruce timber. Unfortunately, with better white spruce/hardwood sites already occupied, there has been a dramatic increase in construction of subdivisions in black spruce forests. Breaking up the black spruce forest with clearings allows firefighters to utilize the defensible space and mount a more effective suppression response during wildfire emergencies.

II. WOOD VOLUME ESTIMATES

A. Proposed Treatment Areas in the Fairbanks North Star Borough

For 2007 roughly 1,630 acres of public land are scheduled to be treated with an additional 1,400 acres scheduled for 2008. All units are proposed to be shearbladed and windrowed in the winter. Windrow burning is scheduled to take place the following fall. The schedule of acres treated however, is not an annual occurrence and after 2008 will be dependant on additional funding. The potential use of biomass residue from these clearings may help to increase the number of acres treated by supplementing some of the costs. Even if no money is received for the biomass itself, treatment costs would be lowered by the elimination of windrow burning. Burning of windrows by Division of Forestry forest technicians cost about $100.00 per acre.

Figure 1. Windrows of shearbladed black spruce.

Proposed Treatment Unit	Unit Acreage
Little Chena River	676
Old Murphy Dome Road	600
Goldstream Creek	355
Total 2007 Treatment Area:	**1,631**

Table 1. Project acreage by treatment unit for 2007.

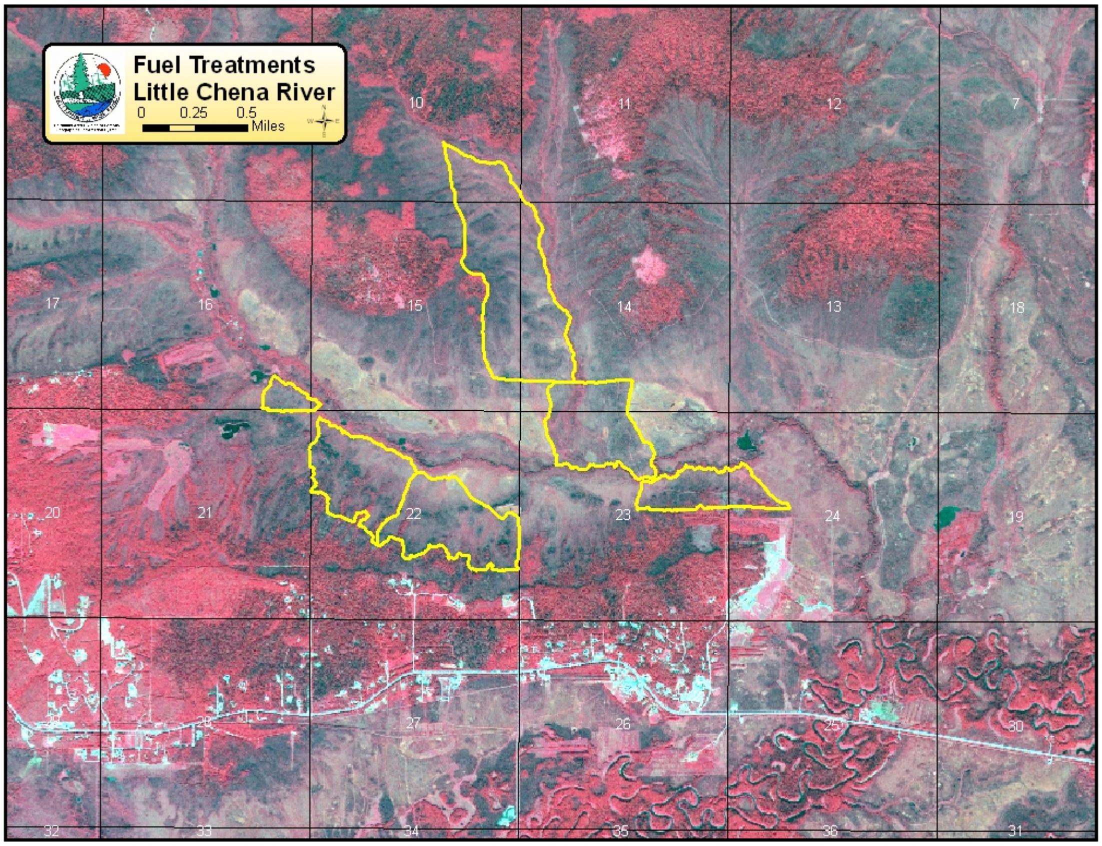

Figure 2. Fuel treatments Little Chena River.

B. Calculation of Dendrometric Parameters

Dendrometric parameters refer to individual tree measurements such as average tree height and diameter at breast height. These measurements are important to establish in the context of biomass recovery. In all tree harvesting systems the average tree size relates directly to the cost of harvesting and transporting wood volume. Generally as piece size decreases harvesting and transportation costs rise.

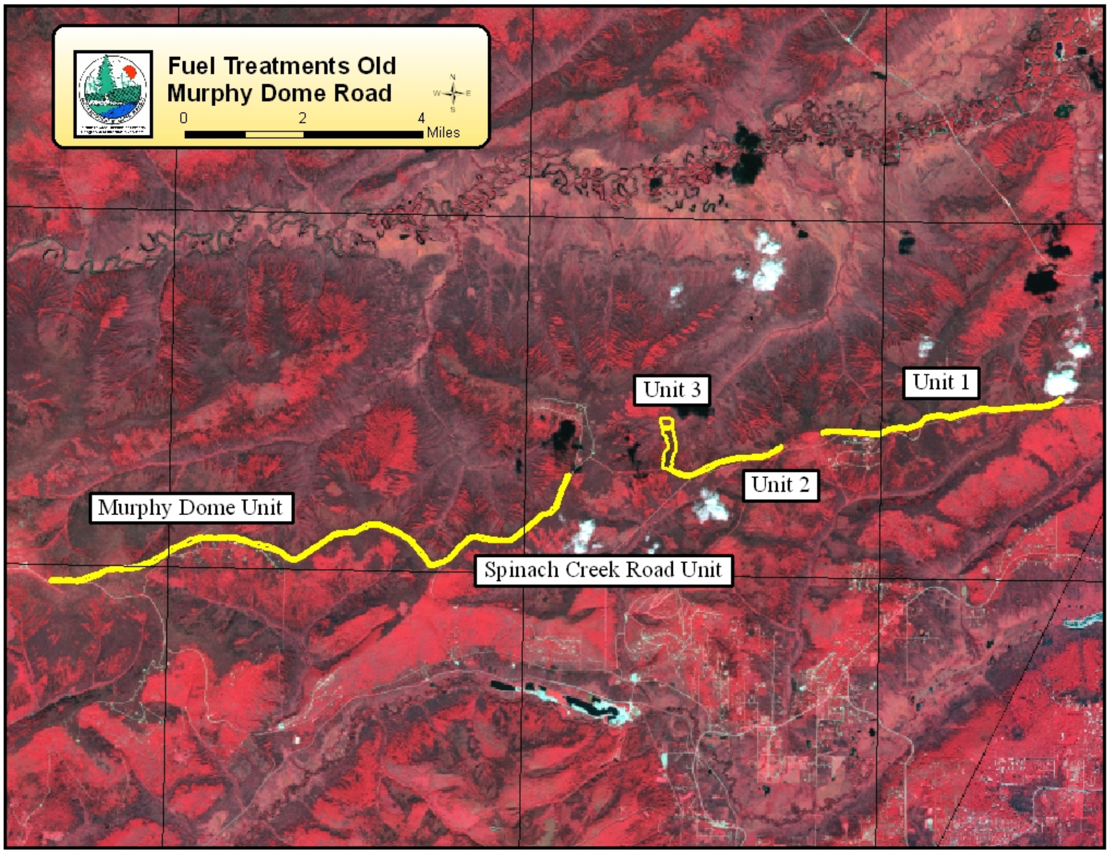

Figure 3. Fuel treatments Old Murphy Dome Road.

Tree measurements are derived from samples in 13 individual proposed treatment units. Units include some of the 2007 proposed treatments as well as some of the 2008 units. In each unit, five fixed 100th acre plots were installed. Tree counts by species were tallied and the diameter at breast height (dbh) and total tree height measured. Only trees that equaled or exceeded ½ inch in diameter at breast height were measured. Plot summaries included number of trees per acre, average diameter and average height.

1. Dendrometric Features

Results of the 1,526 measured trees in the proposed treatment stands indicate that most of the trees are black spruce (94%). White spruce is the second most numerous in terms of number of trees (4%). Small amounts of birch and tamarack comprise the remaining stocking. White spruce comprises 14% of the trees in terms of basal area indicating the larger average size of the white spruce trees. Almost 90% of trees have a dbh between 1 and 3 inches and more than 80% are between 7 and 26 feet tall.

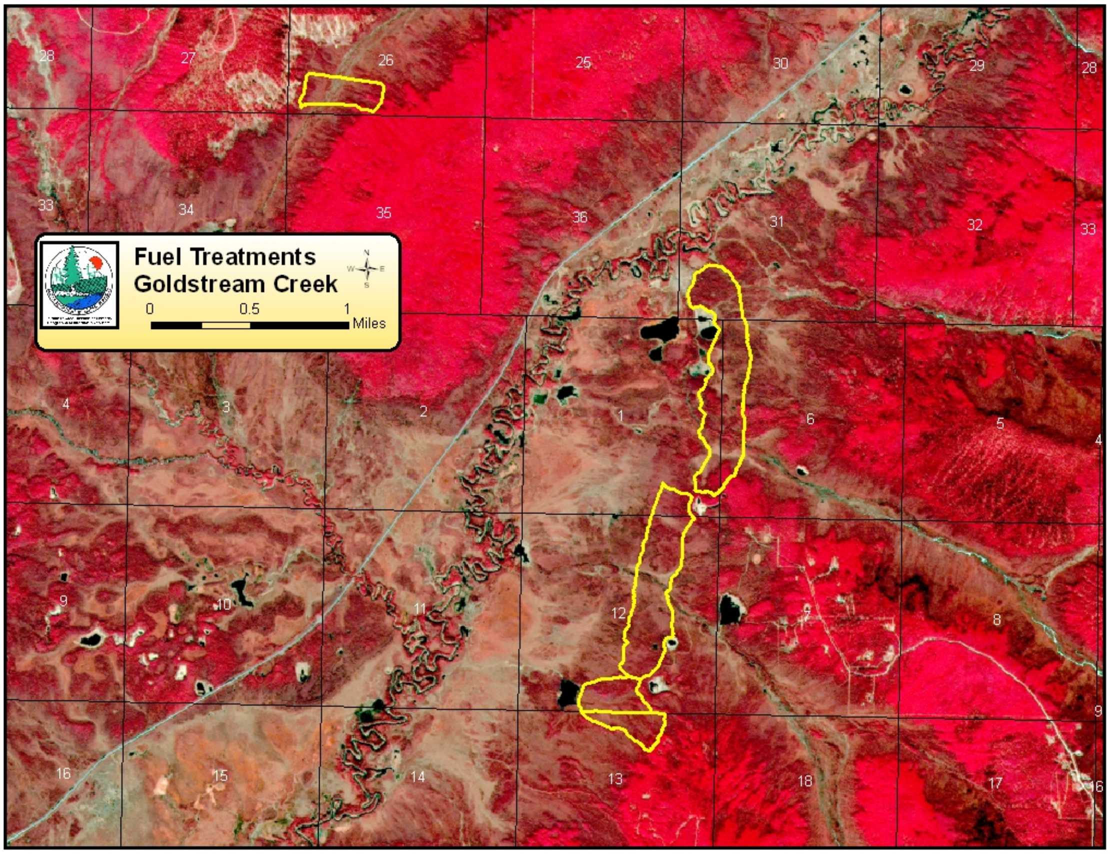

Figure 4. Fuel treatments Goldstream Creek.

Species	Trees/acre	Basal area/acre (feet²/acre)	Average dbh (inches)	Average Height (feet)
White Spruce	91	11	4.1	28
Black Spruce	2222	63	2.0	15
Birch	20	2	4.3	38
Tamarack	15	1	2.7	26

Table 2. Trees and basal area per acre by species.

2. Analysis by Treatment Unit

Variations between treatment units mostly appear as differences in the number of trees per acre. Tree stocking is influenced by site conditions such as drainage, slope position and aspect. Past fire history also influences stocking depending on the severity of the burn. The units range from a low of 780 trees per acre to a high of 4280 trees per acre.

Treatment Unit	Avg. dbh	Average Height	Trees Per Acre	Topography
Old Murphy Dome Road 1	2.0	13	2460	Upland
Old Murphy Dome Road 2	1.7	12	3960	Upland
Old Murphy Dome Road 3	2.1	16	4280	Upland
Goldstream Creek 1	1.9	14	2260	Valley Bottom
Goldstream Creek 2	4.1	29	1000	Valley Bottom
Goldstream Creek 3	2.7	19	1400	Valley Bottom
Goldstream Creek 4	2.6	20	2340	Valley Bottom
Goldstream Creek 5	1.9	16	3020	Valley Bottom
Goldstream Creek 6	1.9	14	2060	Valley Bottom
Spinach Creek Road	1.6	11	3080	Upland
Murphy Dome	2.6	16	840	Upland
Haystack	2.3	14	780	Upland
Nordale Road	1.9	16	3040	Valley Bottom
Total Average	**2.1**	**15**	**2348**	

Table 3, All species averages by sampled treatment unit.

C. *Estimation of Green Weight per Acre*

Analysis of biomass availability in proposed treatment stands uses local biomass regression equations that relate the weight of individual tree components by species to physical measurements that are easy to obtain in the field (Yarie, J., Kane, E. and Mack, M. 2005. *Biomass Equations for the Tree Species Present in interior Alaska.* Unpublished manuscript.). The regression equations were applied to the field data measurements from samples in 13 individual proposed treatment units. The equations predict weight of stemwood, bark, stemwood and bark, current wood growth, total growth and total above ground biomass. Only stemwood and total above ground biomass equations were applied to the data. When the data were analyzed a wide variation in tons per acre was found between individual component equations and individual species equations. Some of the equations particularly for tamarack and birch were found to be unsuitable to the data and predicted a negative weight for small trees in diameter and height. Other equations, particularly for the white spruce, predicted weight significantly higher than for the same diameter and height black spruce. Consequently, these equations were not utilized in biomass predictions. In order to produce a conservative estimate of potential biomass volume available, the equations for stemwood and bark rather than the total above ground biomass were used. Besides producing a more conservative estimate, the potential exists for trees that are felled but not removed immediately to dry and lose an important part of their foliage and branches thus reducing their weight. Based on these factors and through analysis of the results, the black spruce equation seemed to be the most suitable for all species encountered. It predicts an average of **12.3 tons per acre**.

The equation appears below:

$$\textbf{Green Weight} = -463.56703 \cdot DBH + 186.39597 \cdot DBH^2$$

Where Green Weight= stemwood and bark in grams
DBH= diameter at breast height (1.37 meters aboveground) in centimeters

Using an estimated average of 1,500 acres per year of hazard fuel projects, and a value of 12.3 tons per acre, there would be a potential supply of 18,450 tons available on an annual basis. Assuming a 75% recovery factor, roughly **13,840 tons** of biomass could potentially be utilized from hazard fuel reduction clearings.

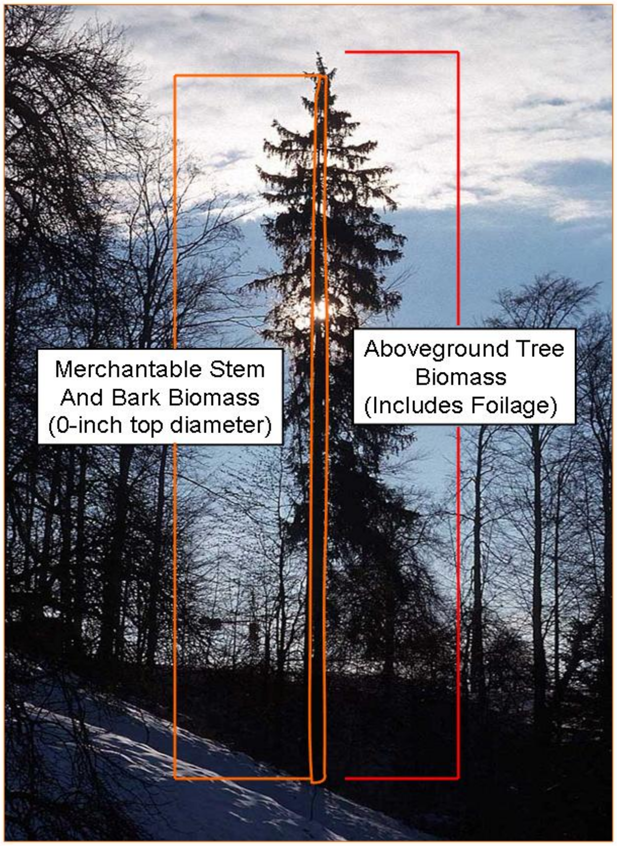

Figure 5. Tree component biomass definitions.

Treatment Unit	Acres	Tons Per Acre	Total Tons
Old Murphy Dome Road 1	127	10.6	1,346
Old Murphy Dome Road 2	60	12.0	720
Old Murphy Dome Road 3	86	21.9	1,883
Goldstream Creek 1	141	9.8	1,382
Goldstream Creek 2	63	23.5	1,481
Goldstream Creek 3	44	14.1	620
Goldstream Creek 4	98	18.3	1,793
Goldstream Creek 5	45	10.0	450
Goldstream Creek 6	52	9.8	510
Spinach Creek Road	233	6.6	1,538
Murphy Dome	103	7.1	731
Haystack	100	4.8	480
Nordale Road	60	10.7	642

Table 4. Tons per acre of all species by sampled treatment unit.

III. UTILIZATION OF THE BIOMASS RESOURCE

Forest biomass is waste material generated from logging or clearing of forests. This is in contrast to wood products residue generated from sawmills or urban wood waste such as discarded yard waste that ends up in the landfill. Forest biomass generally is considered as small diameter waste material too small to be used for traditional timber products. Even though quantities of forest biomass may be greater than wood products residue or urban wood waste, it is the most costly to transport. Feasibility analyses of utilizing the biomass resource require the integration of three factors.

1. Resource Assessment: Quantify the amount, size and type of biomass available. For any one particular location, assume a 75% recovery factor (13,840 tons/year from Fairbanks area clearings).
2. Market Study: Determine cost of production, potential product mix, and product demand. Consider how changing prices for competing energy sources (i.e. coal, oil, natural gas etc.) will affect demand for finished product.
3. Commercially Sustainable Biomass Production: Estimate how long biomass production can continue over time. To ensure a sustainable and appropriate size of development, the needs for hazard fuel reduction should determine the scale of a biomass industry. For financing and development of bioenergy projects, assume 2 to 3 times the volume of fuel needed to sustain the project feedstock requirements.

In terms of biomass availability from proposed hazard fuel reduction projects, approximately 13,840 tons/year of recoverable volume may be expected in the Fairbanks area. Estimates of costs assume that shearblading and windrowing of the trees are paid for by various hazard fuel reduction funding sources or grants. Remaining costs are closely tied to collecting, processing and transporting of the material. Costs of competing energy sources need to be considered. Coal can be delivered to Fairbanks for about $40.00 per ton. While there are broad ranges of timber and hazard fuels removal costs, many studies have shown that successful Lower 48 biomass projects comprise a round trip haul that is less than 100 miles and delivered biomass costs of between $30.00 and $50.00 per green ton. Material can be collected and chipped on site or collected and delivered in bulk to a central processing facility.

A. Transportation and Wood Chipping Costs

Currently no wood chip industries are operating in the Fairbanks area. Local costs are based on past research projects and current log hauling rates only. In-woods processing of material require chipping or grinding of the biomass prior to transportation. Processing can be accomplished by various types of chippers or shredders that reduce the material in size. After the material is reduced it can be transported in chip vans, side dumps, flat beds or dump trucks to a biomass facility.

1. Cache Creek Road Treatment Trials

State Division of Forestry-Fairbanks Area (DOF) and Tom St. Clair, a University of Alaska Fairbanks graduate student, established research plots in various 5.3 acre hazard fuel treatment units at 10-mile Cache Creek Road. Treatments were evaluated for cost as well as effectiveness (St. Clair 2006). Effectiveness considered vegetation composition, duff depth and downed woody debris amounts. Hazard fuel treatments of shearblading, windrowing and burning of windrow piles were determined to be the most effective and totaled $550.00 per acre. These treatments produced the desired effects of site conversion to less flammable hardwoods and the removal of most of the hazardous fuels. Treatment areas were all located in a mixed spruce and hardwood fuel type. Sample plots estimated 5,384 stems per acre. The fuel type was linked to a corresponding type within the Alaska Photo Series Volume IIa publication (Ottmar and Vihnanek 2002). This fuel type, AKHD 05, predicts a total aboveground mass of 24 tons/acre.

One of the treatment areas included grinding of the windrowed material. The equipment, a CMI Maxigrind 460 multi purpose tub grinder, moved along the windrows with the aid of a D-7 dozer and fed its hopper with a grapple attachment. Some of the material however, was in long pieces, which had to be pre-bucked with a chainsaw into shorter lengths prior to being fed into the hopper. The processed material was in the form of chunks, not chips that ranged in size from a couple of inches to 6 inches in length. Chunks were hauled 2.5 miles to a hilly area on Cache Creek Road and spread for erosion stabilization. Hauling was completed by a 10 yard dump truck and a 4 yard front end loader. Grinding and hauling in this trial were quite expensive due in part to the relatively small amount of total biomass available. Final haul costs were **$8.95 per ton per mile**.

TREATMENT TYPE	COST PER ACRE	COST PER TON
Hand fell trees, pile, and burn piles	$2,700.00	$112.50
Mastication (similar to hydroaxing)	$4,830.00	$201.25
Shearing	$ 350.00	$ 14.58
Windrowing	$ 100.00	$ 4.17
Burning of windrow piles	$ 100.00	$ 4.17
Grinding	$2,990.00	$124.58
Chunk Hauling	$1,074.07	$ 44.76

Table 5. Fuel treatment costs, Cache Creek trials.

Figure 6. Grinder processing windrowed material.

2. Tanana Valley Commercial Timber Sale Transportation Costs

Another way to analyze transportation costs is to compare current log haul rates. In the Tanana Valley State Forest contract log trucks charge about $85/hour for hauling logs into local mills. The hourly rate is similar to rates charged for Susitna Valley timber sales. For a round trip haul distance of 80 miles plus loading and unloading of logs, a time of 5 hours is required. Total cost is $425.00 per load for 4,500 board feet of volume. This same truck weighs about 30 tons which translates into a **$14.16 per ton** delivery rate or **$0.177 per ton per mile**.

3. Tanana Valley Wood Chip Study

Chip delivery rates and volumes have been estimated for the Fairbanks area previously (Richmond et al. 1987). Timber volume was determined for a 50 mile radius of Fairbanks. Volume was further broken down into several sources that included (1) logging residues at the landing such as tops or poletimber, (2) un-harvested hardwoods in spruce timber sales, (3) fire-killed timber, and (4) sawmill residues. Production rates and costs assumed conventional ground-based logging techniques to move logs to the landing. Rates were established for different volume sources, volume amounts, products and equipment scenarios but assumed that volume removed from the woods coincided with the removal of a spruce sawlog component. For an annual delivery of 20,295 tons of hardwood chips, transportation costs for 23 ton chip vans traveling an 80 mile round trip were $5.83 per ton in 1987. Using a 20 year time period and a discount rate of 6% this rate is equivalent to **$18.69 per ton** in today's dollars or **$0.234 per ton per mile**. Chipping rates were calculated using the chipper manufacturer's claims for capacities. A Morbark Super Beaver whole tree chipper capable of chipping 12" diameters was analyzed in the report. Residual birch in the timber stands was chipped at a rate of $2.27 per ton. In today's dollars this rate is equivalent to **$7.28 per ton.**

Figure 7. Morbark "Super Beaver" chipper analyzed in Richmond study.

4. Haul Distances and Volumes of Proposed Hazard Fuel Treatment Projects

Hazard fuel reduction projects are generally proposed close to town where development exists. Usually road access is nearby, but some treatment units can be accessed only in winter by winter road. Most units are within a 20 mile haul distance to town.

B. Biomass Facilities and Annual Volume Needs

Biomass-to-energy facilities are wide ranging in size, cost, complexity and raw material requirements. Given current market conditions in Fairbanks as well as the amount of raw material available, a relatively small sized facility that has options to use conventional forms of energy with the biomass may be the best choice.

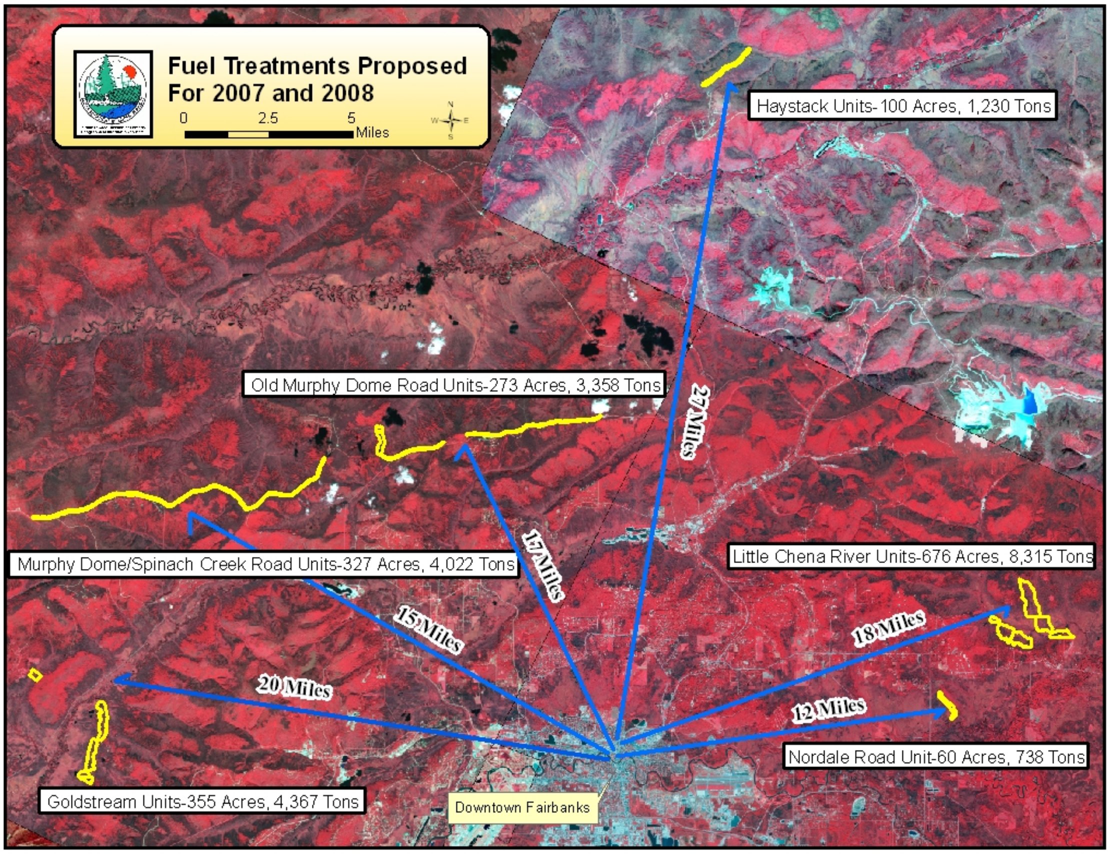

Figure 8. Haul distances and average volumes of proposed treatment units.

1. Wood Combustion

There are many projects throughout the Lower 48 states that use wood fiber to provide heat for public buildings. These projects are successful with a delivered wood price from $25.00 up to $50.00 per green ton. They have also proven cost-effective for both large and small schools and public buildings (Maker 2004). The table below shows where the use of wood chips is likely to be cost effective in the Lower 48 considering price and consumption of fuel oil.

Existing Oil Cost Per Gallon	Annual Gallons Oil Heat Consumption
$2.50 and greater	10,000
$2.00	20,000
$1.50	30,000

Table 6. Rates where use of wood chips is likely to be cost effective.

Wood volume required to heat a public building or school is based on climate and square footage. The "Fuels for Schools" program administered by the U.S. Forest Service has installed a wood-fired boiler in Darby, Montana. The buildings have about 82,000 square feet of space and require approximately **500 tons of green wood fuel per year**.

In Moretown, Vermont voters are being asked to approve a bond for the Harwood Union High School to install a wood fired boiler. Current heating demand is 45,000 gallons of number 2 fuel oil at a price of $2.20 per gallon (about $99,000 annual cost). Expected heating costs with the proposed wood fired boiler assume utilization of 85 percent wood chips and 15 percent fuel oil. **Annual consumption is estimated to be 525 tons of wood chips** and 6,750 gallons of fuel oil. Annual costs are estimated at about $41,000 per year (at $50 per ton of wood chips and $2.20/gal heating oil).

2. Cofiring

Cofiring refers to the practice of introducing biomass as a supplementary energy source in coal plants. Past research in Alaska has found that it is possible to use wood at ratios up to 22% of the total fuel mix (Sampson et al. 1991). It can be a near-term, low-cost option for using woody residue, since coal burning facilities already exist. Relatively few equipment modifications would be required. New equipment would mostly be related to the storage and handling of the wood chips (Nicholls et al. 2006). The Eielson Air Force Base has cofired recycled paper on and off again since 1997. They have provided up to a 10% mix (1,700 tons per year) into their coal supply. The four coal fired generators in the Fairbanks area consume about 600,000 tons of coal per year. If 10% by weight was supplemented by biomass then roughly **60,000 tons per year** of biomass would be required.

3. Wood Pellets

Pelletizing of biomass enables wood fiber to be used in a variety of home heating and commercial applications. Pellets are advantageous over wood chips in that they allow for easier automatic feeding of the material into the combustion equipment. Pellets are clean burning, have a high BTU value per cubic foot, and create low amounts of ash residue. Pellet stoves for home use are available for purchase in the state. Pellets can also be manufactured for use in electrical generation facilities as a replacement for fossil fuels. Use of pellets in European countries is increasing due to requirements for non fossil fuel electrical generation. Minimum raw material requirements for a pellet manufacturing plant are **25,000 tons per year** of biomass (Bliss pers. comm. 2006). Production of pellets at this level would be enough material to heat 4,000 homes.

IV. SMALL DIAMETER HARVEST SYSTEMS

A. Forwarding/Skidding

Utilization of black spruce for fuel is hampered by a lack of appropriate harvesting equipment for the small sized material. Poor soil conditions in the black spruce stands allow for only winter operations, which reduce the operating season. Typical biomass utilization involves the use of feller-bunchers, forwarders and chip vans stationed roadside. With the use of feller-bunchers, material can be cut to length, directionally felled and laid on the ground into distinct piles. A forwarder is then able to conveniently travel along the individual piles, load and transport the material to a landing. Forwarders can be specially adapted to haul more residues by making modifications to the forwarder bunk. These operations however, involve pieces substantially larger that those in the fuel treatment projects. More advanced forwarders are available that bundle and compress the material similar to a hay bailer. They can utilize quite small material such as tops and branches and can gather randomly placed material. In the black spruce shearbladed units a bundler may be able to operate effectively in broadcasted material saving windrowing costs. These residue bundlers are efficient, but expensive, with a price of nearly $450,000.00. The extruded bundles (composite residue logs) are quite compact and can be transported more easily (Figure 8). They are successfully being used in Sweden in the production of biomass for electricity generation. Operations however, generally follow traditional harvest where more valuable sawlogs and pulp have been previously removed from the site.

In the proposed treatment stands, problems may arise from the extraction of the biomass from the windrows. The numerous small trees tend to tangle and with highly variable tree lengths, the forwarding process could be slowed. Using a conventional grapple skidder may be quicker, but tangling could still be a problem. Equipment time may also prove to be excessive in terms of volume per load for a forwarder or volume per turn for a skidder. Small diameter material tends to be labor intensive for the amount of volume removed and handled for each pass of a particular piece of equipment. The main cost variables of forwarding and skidding are volume per load, length of skid, soil type, weather conditions and terrain. Whether a forwarder or skidder is used, the material has to be transported to a road accessible landing. Moving along the windrows themselves with a chipper or grinder is not feasible because of rough terrain. Even on relatively level ground movement of chippers through the units is difficult. This was an issue in DOF's Cache Creek trials where movement of the tub grinder along the windrows had to be assisted by a dozer because of uneven ground and wet areas.

B. Chipping/Grinding

The chipping portion of the operation could be reasonably efficient with standard grinding or chipping equipment stationed along the roadside. An open ended type grinder is more effective and is able to take tree lengths of a more random nature, but can be 1.5 times more expensive than whole tree chippers (Figure 9). Winter operations however, may prove to be problematic in that the biomass material is likely to contain large amounts of snow from shearblading across snow covered ground. When trees are plowed into windrows snow is transported and mixed in with the trees. A solution to this may be to let the material either remain in the windrows for a year, or forward/skid during the winter and let the piles sit at the landing for a year. Typically piles reduce in size significantly during the summer after all mixed in snow has melted. Trees chipped the following winter would still have snow on top of the piles, but the mixed in snow would be absent. The piles would also lose some moisture content enabling a greater British Thermal Unit (BTU) value of chipped material to be hauled at one time.

C. Transportation

The most common method of transporting small diameter material is to grind or chip it in the woods and transport it offsite by some sort of chip hauling vehicle. Various types of transport vehicles include small or large dump trucks, dump trailers, roll-on-roll-off containers or self-unloading vans. Self-unloading vans have the advantage of not requiring additional unloading facilities. They are commonly used in the northeast U.S. for delivering chips to wood chip heating systems in use in schools and other public buildings. Self-unloading tractor trailer vans look like conventional tractor trailers except that they have a hydraulically operated floor system that can push fuel out the back and into wood fuel storage bins. Vans have the disadvantage however, of being designed for highway use rather than rough forest roads. This factor can make many log landings inaccessible to chip vans. Vehicle and trailer configurations should consider the end use of the product and combinations chosen that minimize any additional handling of the product.

Figure 9. Timberjack 1490D slash bundler.

Figure 10. Morbark wood hog tub grinder.

V. BUSINESS START UP AND OPERATIONAL COSTS

Minimum delivered volume and production rates are examined to determine what the most feasible type of operation can be sustained. To start a business hauling and processing biomass basic business considerations are 1) how much does it cost to produce, 2) is it profitable, and 3) what is the appropriate type of equipment needed? Table 7 shows an example of the extent of capital investment required for an operation that is chipping biomass on-site at a road side landing and hauling it to a facility in town. The chipper and skidder equipment however, is designed for typical whole tree or merchandized log chipping and transport production. Production rates could be quite different with black spruce pieces averaging 2” in diameter 15’ in length. Item costs are for new equipment and can vary among different vendors. Purchase of equipment assumes a 5 year life span and 10% interest finance charges. The equipment would have a 25% residual value after 5 years (USFS 2006).

Item	Model	Horse Power	Cost
Self-Feeding Whole Tree Chipper	Morbark 30/36	440	$220,000
Wheeled Grapple Skidder	Caterpillar 525B	175	$175,000
Service Truck	Ford F550 4X4	300	$ 70,000
Tractor Trailer Truck	Peterbilt-379	475	$125,000
Self-Unloading Chip Van	Peerless 25 Ton		$ 75,000
Lowboy	Pitts 50 Ton		$ 45,000
Total Equipment Purchase			**$710,000**

Table 7. Equipment purchase cost estimates.

Production rates with this type of equipment could be expected to run about 4 van loads a day or 100 tons of chipped biomass per day. This is based on a 40 mile round trip haul distance. It is about a third of the manufacturer's claim for chipping production (the Morbark 30/36 is rated for chipping production of 40 tons per hour). If production is limited to winter months of access, then biomass harvest would occur during a 4 month period or 80 work days. Allowing for equipment down time and cold weather delays this would equal about 75 working days. The total production of biomass would then be about 7,500 tons per season. Assuming two hours of overtime per day, and an average 8 hours per working day productive machine time, the total productive time is 600 hours per season. With a crew of 3 people working a 10 hour day, wages and benefits are expected to be about $350/person/day. Other operating costs include fuel, lube, parts, insurance, equipment repair and maintenance. Table 8 identifies annual operating costs for hauling and processing biomass.

Item	Description	Cost
Repair and Maintenance	100% of equipment depreciation for a 5 year life and 25% residual value	$ 99,000
Diesel Fuel	10.5 gallons/hour @ $2.90/gallon	$ 18,300
Lube	Assume 40% of diesel costs	$ 7,300
Large Equipment Parts	Tires, chains, etc.	$ 15,000
Crewman Wages & Benefits	$350/day x 3 persons x 75 days	$ 78,750
Insurance Premium Cost	Liability and comprehensive	$ 5,000
Misc. Costs		$ 5,000
Total Operational Cost		**$228,350**

Table 8. Annual operational cost estimates.

Equipment purchase annualized costs are $158,000 per year. The total annual cost is this amount plus $228,350 operational cost or $386,350. If this amount is divided by a biomass production of **7,500 tons per year**, then the average per ton delivered cost is $**51.51**. This breakeven price does not include any payments to the landowner or profit and risk payments to the producer.

VI. DISCUSSION AND ANALYSIS

Is this breakeven delivered wood price reasonable to pay in lieu of the most common forms of energy in Interior Alaska i.e. coal and fuel oil? Converting these values to a BTU basis allows comparison of costs of the competing energy sources. Green wood chips with a 50% moisture content contain about 4,500 BTUs per pound. Coal from the Healy area contains approximately 7,800 BTUs per pound and number 2 fuel oil contains approximately 140,000 BTUs per gallon. Displacing 10,000 gallons per year of fuel oil is the equivalent of displacing 1,400 million BTUs (MMBTUs). The cost of 10,000 gallons of fuel oil is $23,300 versus the breakeven cost for 156 tons of wood at $8,035. Delivered wood then, can be competitive to fuel oil at the current Fairbanks price, which is directly linked to the world price of oil. Competing against coal is a more difficult prospect given that a highly mechanized extraction, delivery and transport system is already in place. Also, the price of coal is significantly more stable than the price of oil. Displacing 10,000 tons per year of coal is the equivalent of displacing 156,000 MMBTUs. The cost of 10,000 tons of coal is $400,000 versus the breakeven cost for 17,333 tons of wood at $892,822.

Fuel Type	Delivered Cost	Net Energy Content	Fuel Cost Per MMBTUs
Number 2 Fuel Oil	$ 2.33/gallon	140,000 BTUs/gal.	$16.64
Coal	$40.00/ton	7,800 BTUs/pound	$ 2.56
Wood Chips	$51.51/ton	4,500 BTUs/pound	$ 5.72

Table 9. Fuel type cost and energy value.

Investment in biomass operations has to be closely aligned with available volume and demand. Biomass supply constraints could prove to derail any efforts for biomass recovery in that a long term source is not available unless additional grant funds are procured for future hazard fuel reduction activities. Obviously, obtaining grant funds can become political and is subject to the winds of change in the allocation of public dollars. Large scale operations appear unlikely at this time if the biomass resource is strictly limited to defensible space hazard fuel reduction sources. Other sources of material such as sawmill waste, landfill waste and commercial timber harvest non merchantable material such as tops have the potential to increase supply and make larger operations more feasible. Biomass hauling that can occur throughout the year or that is in combination with commercial timber harvest activities could substantially improve economics by allowing greater productive machine time. Business start up and operation costs assume that windrowed biomass material can be collected, chipped and hauled with reasonable efficiency. **The small individual piece size however, could severely affect the estimated cost estimates. Biomass material processed in successful Lower 48 operations does not compare to the small size of Alaska black spruce.** It is recommended that a rigorous economic study of potential harvest systems for applicability to black spruce piece size be undertaken to achieve more accurate cost estimates. A bundler/forwarder operation would be a worthy candidate.

Space heating of buildings with wood chips appears to be a potential cost effective use of the biomass. Biomass can compete in terms of price with oil, but minimum guaranteed supply and demand thresholds have to be met in order for production to be profitable. A single public building is unlikely to have enough demand to warrant investment into biomass production unless creative alternatives to manpower and equipment needs are employed.

Production of wood chips for a wood pellet facility may also be feasible in terms of delivered cost of biomass, but significant additional sources of supply would need to be added to the hazard fuel reduction sources. This may include the purchase of timber sales from the state or other landowners. Higher value logs from these sales could be merchandized out and the lower end material utilized as a biomass source.

VII. LITERATURE CITED

Bliss H. 2006. Pellet production volume requirements, Bliss Industries. pers. comm. August 7, 2006.

Maker Timothy M. 2004. Wood-chip heating systems, a guide for institutional and commercial biomass installations. The Coalition of Northeastern Governors Policy Research Center, Washington, D.C. Revised by Biomass Energy Resource Center Montpelier, Vermont. 93p.

Nicholls, D.L., Patterson, S.E., Uloth, E. 2006. Wood and coal Cofiring in interior Alaska: utilizing woody biomass from wildland defensible-space fire treatments and other sources. USDA Research Note PNW-551. 13p.

Ottmar, R.D., Vihnanek RE. 2002. Stereo photo series for quantifying natural fuels, Volume IIa: Hardwoods with spruce in Alaska. Boise, ID: National Wildfire Coordinating Group, National Interagency Fire Center PMS 836.

Richmond, A.P., Sampson, G.R., Gasparro, A.F. 1987. Estimation of potential timber volume in the Tanana Valley available for conversion to wood chip fuel. Report 86-11. Fairbanks, AK. University of Alaska-Fairbanks, Agriculture and Forestry Experiment Station. 53p.

Sampson, G.R., Richmond, A.P., Brewster, G.A. 1991 Cofiring of wood chips with coal in interior Alaska. Forest Products Journal. 41(5): 53-56.

St. Clair, Tom B. 2006. An evaluation of fuels conversion treatments in interior Alaska. Master’s thesis, University of Alaska-Fairbanks, May, 2006.

USFS, 2006. Machine rate calculator. Forest Operations Research, USDA Forest Service, Southern Research Station. Auburn, Alabama 36849.