Cordova Biomass Feasibility Study

The Native Village of Eyak

Funded by
The Alaska Energy Authority

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Executive Summary

For the past several years, interest in has been expressed in converting woody organic material (biomass) waste streams into usable forms of energy in Cordova, Alaska. Studies to date have demonstrated these resource(s) inadequate for the capital required to extract and utilize them for district heating purposes or creating useable products. The Native Village of Eyak, in partnership with the Alaska Energy Authority and the State DNR Division of Forestry has recently assessed timber stands on the Copper River Delta. Forest productivity on Eyak Corp. lands near the airport measured an annual (NET) growth of 4,593 cords per year. This amount of biomass is the equivalent to nearly 500,000 gallons of diesel. An additional amount of 1,632 cords were estimated to be available from Alder overgrowth on old logging roads (cut in the early 1990's). Also on Eyak Corp. land, these resources approximate an additional 179,000 gallons of diesel equivalent. At a delivered cost of $225/cord (for trees in areas with <15% slope), net growth harvest could offset diesel usage at a rate of $2.07 per gallon equivalent, presenting an attractive argument for a local sustainable harvest program in Cordova, to which addition biomass waste stream could be incorporated.

I. Introduction and Objectives

The objective of this report is to provide reliable resource and fuel data in order to determine the feasibility of developing biomass-heating projects in the City of Cordova, Alaska. Approximately 670,000 gallons of diesel are used annually for heating fuel in the Cordova area (Biomass Heating Project, 2009). At present rates, fuel sales amount to roughly $3 million per year. In coastal Alaska, the high cost of fuel remains a continual burden on families and often impedes economic development in these areas. In Cordova, finding stable and low cost sources of energy is of great interest as it can have a prodigious effect on improving the local economy and boosting community resilience. The scope of this analysis is to provide accurate fuel use and resource data so that projects have enough information to proceed to investment grade studies, system design and subsequent implementation.

Studies performed in the past examining available biomass waste streams have claimed the resource too small to be commercially viable. Should these resources be developed, additional harvest of standing biomass (timber) would also need to be looked at (Deerfield, et. al., 2009). For this reason, a forest inventory assessment has been generated along with this report. Doug Hanson of the Alaska State Division of Forestry provided the assessment of standing green tree biomass resources. The methodology used to quantify available forest resources are detailed in the "**Cordova Forest Inventory Final Report**"; they are summarized briefly in Section II.E and findings are addressed in Section IV.C.1-2 results.

In order for a biomass heating system to be implemented, a substantial increase in the amount of harvested timber will need to be addressed. Major land owners and managers of timber resources in the area are the Eyak Corporation, the United States Forest Service and the State of Alaska. For the purposes of this study, only the holdings on Eyak Corp. land are considered to be available for harvest in the near-term. For this reason, all discussion regarding timber harvest, including equipment required for extraction will focus on appropriate technology for Eyak Corp. land (Appendix A).

II. Methods

Information obtained for this report includes both quantified (data) and qualitative information from various sources. Fuel use and building information was gathered from individual interviews and building visits performed in Cordova frpom January 2012 until February of this year. The information was integrated into a Geographic Information System (GIS) dataset and used for characterization of and summarizing geospatial data.

Base imagery was obtained from the United States Forest Service (USFS) and made available to the Native Village of Eyak (resolution: 0.6 m). Digital satellite imagery scenes were gathered over the summer of 2010 and provide detail necessary to navigate individual buildings and individual tree stands. New buildings, built since 2010, are obviously not conveyed in this imagery and may not be expressed by building polygons in the GIS dataset. Relevant cases where building information is known, but not illustrated in the dataset are rare and will be addressed on and individual basis. Building polygons may also be incomplete for certain buildings where new information has not yet been incorporated into the GIS dataset.

A. Project Area (Scope)

For the purposes of this study, the project area is defined as the immediate downtown and central district area of the City of Cordova (Figure 1). Information regarding fuel use data and building infrastructure is generally only discussed within the areas of the immediate downtown (from the harbor to just east of the Community Medical Center), as these areas are generally considered to contain the highest concentration of thermal loads and therefore most likely to receive biomass district heat, should it be developed in the future.

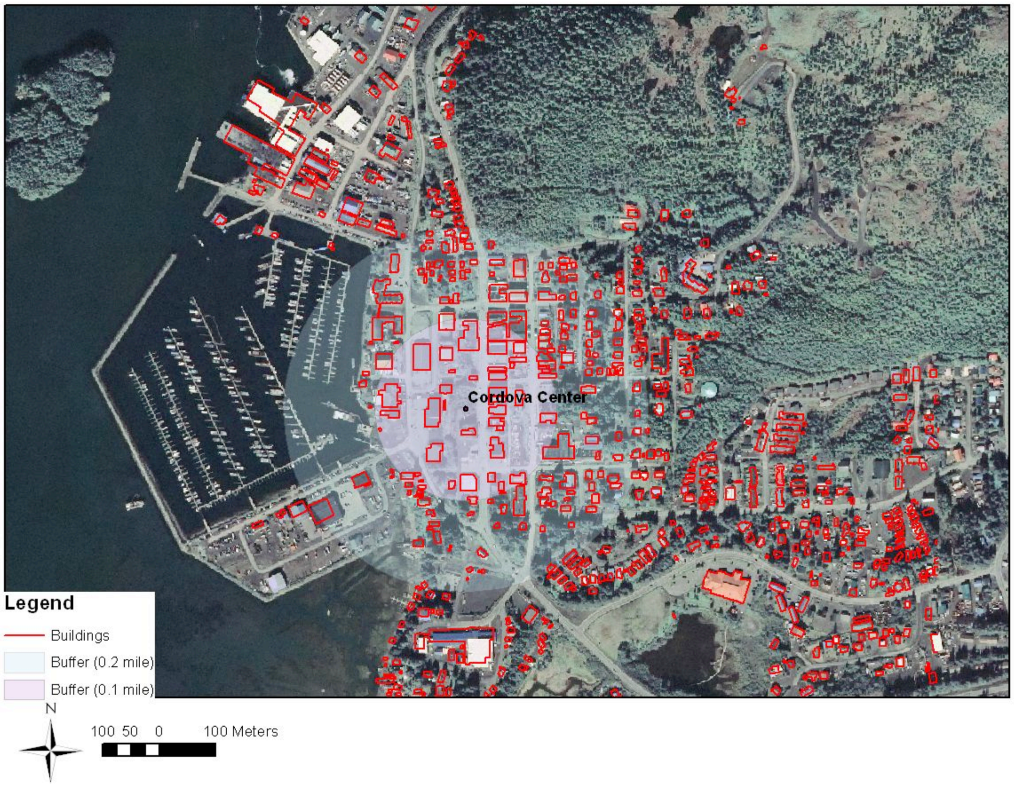


Figure 1. The City of Cordova and harbor (defined project area).

B. Community Information

Information on city-owned buildings was obtained through public records. Privately owned and single-family home information were voluntarily submitted and approved for use in this study. Community breakdown by parcel count is provided below (Table 1).

Table 1. Cordova City Property Parcel Count

Real Property Type	2010	2011	2012
Residential	540	579	
Vacant	841	715	
Farm	0	0	
Commercial	181	258	
Industrial	0	0	
Apartment	21	22	
Condos	0	0	
Mobile Home Parks	11	11	
Mobile Homes	148	152	
Other	2	36	
Total Real Property Count	**1,744**	**1,773**	N/A

Table 2. City of Cordova Population Statistics

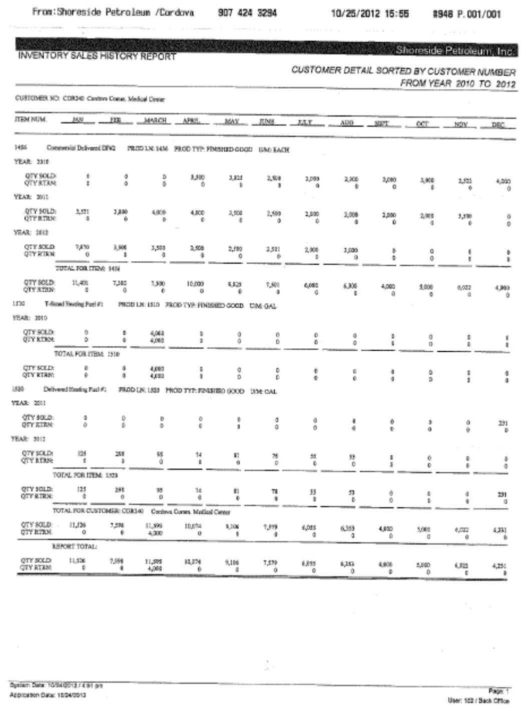
Year	Population	*Census data
1910	1152	
1920	955	
1930	980	
1940	938	
1950	1165	
1960	1128	
1970	1164	
1980	1879	
1990	2110	
2000	2454	
2001	2512	
2002	2434	
2003	2372	
2004	2298	
2005	2288	
2006	2211	
2007	2194	
2008	2161	
2009	2126	
2010	2239	
2011	2289	
2012	Unknown	

Community information was obtained through a variety of public information sources, personal correspondence and interviews, and recent census data (Table 2).

C. Fuel Use and Proximity Data

Fuel records were obtained through several sources. For calculating thermal signatures and heating loads, volumetric delivery and use records are more relevant than annual fuel budget records and were therefore, more desirable to the study. In cases where volumetric data was not available, budget records were used to approximate annual fuel usage.

Fuel delivery volumetric and rate data is readily available from local suppliers; however, this information was regarded proprietary at the time of the study and was therefore only releasable through individual user authorization. Excepting these conditions, property owners and managers had to be solicited on a case-by-case basis to contact the local fuel supplier and request their individual records. Local fuel supplier and business Shoreside Petroleum, keeps a [three] year record of fuel and delivery sales on a per customer basis. In most cases, user fuel data was rarely known for individual buildings. Therefore, records had to be first requested by the individual customer before they were released to the Native Village of Eyak for use in this study (Figure 2).


From:Shoreside Petroleum /Cordova 907 424 3294 10/25/2012 15:55 #946 P.001/001

Shoreside Petroleum, Inc.

INVENTORY SALES HISTORY REPORT

CUSTOMER DETAIL SORTED BY CUSTOMER NUMBER
FROM YEAR 2010 TO 2012

CUSTOMER NO: COR240 Cordova Comm. Medical Center

ITEM NUM.	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1456 Commercial Delivered DF#2 PROD LN: 1456 PROD TYP: FINISHED GOOD U/M: EACH												
YEAR: 2010												
QTY SOLD:	0	0	0	3,800	3,825	2,508	3,000	2,300	2,080	3,900	2,521	4,000
QTY RTRN:	0	0	0	0	0	0	0	0	0	0	0	0
YEAR: 2011												
QTY SOLD:	3,571	3,880	4,000	4,800	3,500	2,500	2,000	2,008	2,000	2,001	3,500	0
QTY RTRN:	0	0	0	0	0	0	0	0	0	0	0	0
YEAR: 2012												
QTY SOLD:	7,830	3,500	3,500	2,500	2,580	2,501	2,000	3,000	0	0	0	0
QTY RTRN:	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL FOR ITEM: 1456												
QTY SOLD:	11,401	7,380	7,500	10,000	9,825	7,501	6,000	6,300	4,000	5,000	6,022	4,000
QTY RTRN:	0	0	0	0	0	0	0	0	0	0	0	0
1510 T-Stand Heating Fuel #1 PROD LN: 1510 PROD TYP: FINISHED GOOD U/M: GAL												
YEAR: 2010												
QTY SOLD:	0	0	4,000	0	0	0	0	0	0	0	0	0
QTY RTRN:	0	0	4,000	0	0	0	0	0	0	0	0	0
TOTAL FOR ITEM: 1510												
QTY SOLD:	0	0	4,000	0	0	0	0	0	0	0	0	0
QTY RTRN:	0	0	4,000	0	0	0	0	0	0	0	0	0
1520 Delivered Heating Fuel #1 PROD LN: 1520 PROD TYP: FINISHED GOOD U/M: GAL												
YEAR: 2011												
QTY SOLD:	0	0	0	0	0	0	0	0	0	0	0	231
QTY RTRN:	0	0	0	0	0	0	0	0	0	0	0	0
YEAR: 2012												
QTY SOLD:	125	298	95	74	81	78	55	53	0	0	0	0
QTY RTRN:	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL FOR ITEM: 1520												
QTY SOLD:	125	298	95	74	81	78	55	53	0	0	0	231
QTY RTRN:	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL FOR CUSTOMER: COR240 Cordova Comm. Medical Center												
QTY SOLD:	11,526	7,598	11,595	10,074	9,106	7,579	6,055	6,353	4,000	5,000	6,022	4,231
QTY RTRN:	0	0	4,000	0	0	0	0	0	0	0	0	0
REPORT TOTAL:												
QTY SOLD:	11,526	7,598	11,595	10,074	9,106	7,579	6,055	6,353	4,000	5,000	6,022	4,231
QTY RTRN:	0	0	4,000	0	0	0	0	0	0	0	0	0

System Date: 10/24/2012 / 4:51 pm
Application Date: 10/24/2012

Page: 1
User: 102 / Back Office

Figure 2. Fuel user data, provided by Shoreside Petroleum.

Cord, chip and pellet wood equivalents were calculated using linear equations provided by CTA engineers (Salmon, N., and Ratz, N., 2012). Btu conversions were performed taking into account relative differences in moisture content (MC). Cordwood moisture content was assumed at 20 percent. Chips at 30 percent and pellets at 7 percent moisture content respectively.

Once obtained, the records were entered into the GIS in order to determine the magnitude and concentration of thermal loads in town. Heat signature (load) values were set as attributes of the building polygon layer and expressed in magnitude units of gallons per year. A buffer layer was then applied in order to clearly illustrate thermal load proximity (Figure 3). Buffers were set 0.1 miles and 0.2 miles respectively, using the newly constructed Cordova Center as the buffer origin.

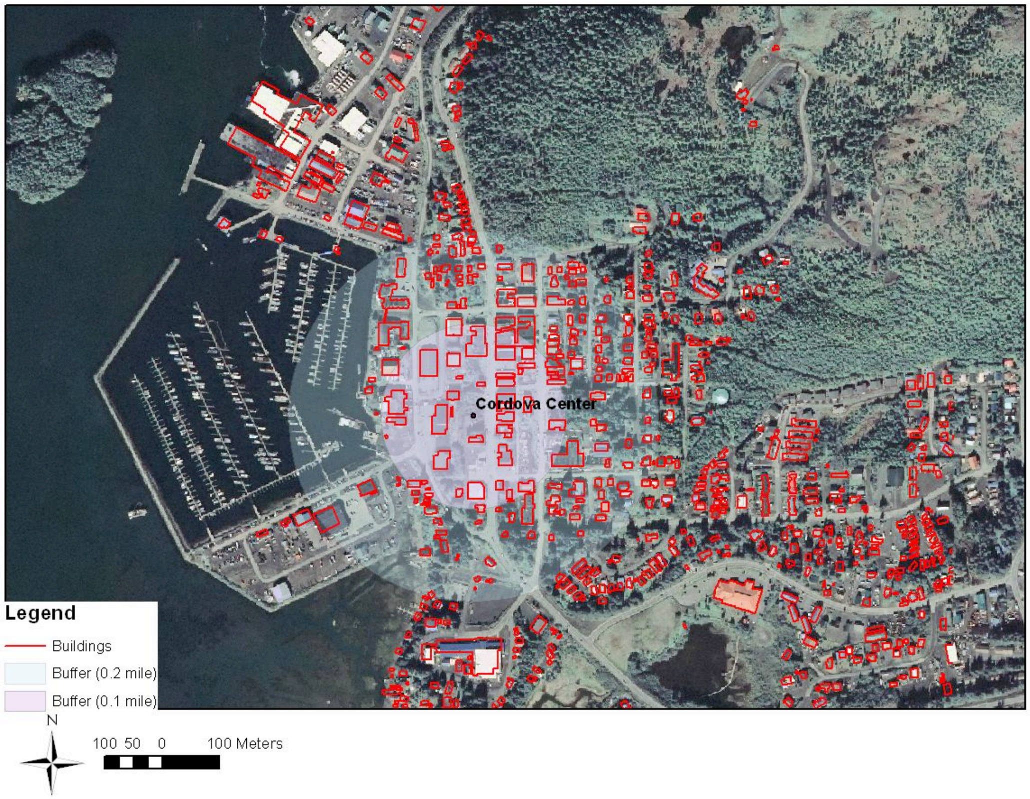


Figure 3. City overview with 0.2 mile proximity buffer.

It is important to note that the fuel oil deliveries provided in this study reflect the quantities of oil delivered to consumer fuel tanks. Though great for reporting overall yearly consumption, this method does not reflect fully accurate daily or monthly fuel usage. In order to quantify daily or monthly totals, tank volumes would have to be verified by volumetric gage line. This method is more than sufficient for use in this study and provides reasonably precise records of overall heat consumption use data.

D. Community Energy Audit

Community information was obtained utilizing a variety of methods in order to provide a profile of heating fuel use among both commercial and residential buildings in Cordova. The information consists of visual and count estimates of energy waste streams, community questionnaire survey(s), and data gathered on individual buildings. For buildings with detailed energy audits performed within the last five years, information was incorporated into this study.

In the summer of 2011, Native Village of Eyak intern Simeon Haynes conducted an in-depth assessment of the community burn pile (Appendix C). In addition, Haynes was responsible for and helped conduct a mail survey of home fuel and energy use among residents of Cordova. The questionnaire used, solicited information regarding seasonal heating use, home condition, wood stove use and square footage.

Information was then used to approximate relative building efficiencies by determining energy use per unit area. Annual fuel use along with building square footage was collected and used to calculate a Thermal Energy Utilization Index (EUI_{Therm}). The value of the EUI is that it can be used to compare energy consumption to similar building types or to track consumption from year to year in the same building. Normally expressed in kBtu/sf (Equation 1), EUI_{Therm} units have been simplified for the purposes of this study and are reported in Gallons/Square Foot per Year ($gal/sf*yr^{-1}$) (Equation 2).

EUI is typically a good indicator of the relative potential for energy savings. Interpreted, comparatively high EUI indicates increased inefficiency, as the building requires more energy per unit area compared to other buildings of the same use-type. For each building and facility used in the study, building architectural, mechanical and electrical drawings were utilized to calculate and verify the gross area of each facility. The gross area was confirmed by building owners/managers.

Equation 1. Energy Utilization Index for a particular building.

$$Building\ Site\ EUI = \frac{kBtu_{Electric} + kBtu_{Fuel\ Oil}}{Building\ Area}$$

Equation 2. Modified Energy Utilization Index for thermal use in buildings.

$$EUI_{Thermal} = \frac{Gallons\ Fuel\ Oil}{Building\ Area}$$

It should be noted that information gathered pertained primarily to heating fuel usage and space heating requirements of buildings. Research efforts focused on accurate volumetric fuel consumption and primary method of heating. Additional energy used in the form of electric loads and building use (i.e. foot traffic, set temperature, etc.) data were not studied in depth. Though some information was obtained on other energy uses, it was not expressly relevant to the project scope and therefore not summarized in this report.

E. Cordova Forest Inventory

The Forest Inventory was conducted to provide reliable growth data of timber stands on the Copper River Delta. A Cooperative Agreement was negotiated between the Native Village of Eyak and State Division of Forestry to conduct a forest inventory assessment of standing timber resources on the area of Cordova. Field visits were conducted in the first week of October 2012. For the week of October 1-6, 2012, State Foresters Doug Hanson and Mark Eliot, along with Casey Pape, Energy Coordinator for the Native Village of Eyak, traveled to measure timber stand plots on the Eyak Corp., State of Alaska, and US Forest Service land(s) on the river delta.

For this assessment, a variable plot radius sampling method was used to collect data on poletimber and sawtimber size trees. Using a basal area factor of 40 square feet, ten plots were spaced uniformly on a traverse located systematically through the stand area. Plot traverses were chosen in such a manner to attempt to capture variation within each stand. On five of the ten plots, information on species, tree vigor, crown ratio, defect type and defect percentage, were reordered and tree diameter, total tree height, bark thickness, and ten-year growth were measured (measure plots). Tree diameter was measured at 4.5 feet above ground, commonly referred to as "diameter at breast height" or DBH. Dominate and Co-dominate trees were cored at DBH in order to determine the average age and growth rate of the stand (referred to as 'site index'). The other five plots, relascope measures were made, counting the number of trees by species and size class (count plots). Count plots are used to lower the sample error by increasing the overall plot numbers and economize time spent in the field. Trees with a DBH's of 5 inches or greater were sampled using this method.

Additionally, a fixed plot sampling method was used to count trees with less than five inches DBH. These measures took place at every other plot in the ten-plot traverse (measure plots). Seedling and sapling trees, noting species and quality, were measured along with tree diameter and total tree height. Fixed plot radius was set at 7.45 feet, for a 1/250th acre plot.

For further detail on the methods used to perform the forest inventory, see **"Cordova Forest Inventory Report".**

Fuel equivalence values were then calculated using heating values of individual tree species expressed in millions of Btu's per cord (MMBtu/cord). Sitka spruce was assumed at 16 MMBtu/cord, Hemlock 15.9 MMBtu/cord and Black Cottonwood 13.5 MMBtu/cord respectively (Jenkins, B., 1993, Jenkins, et. al., 1998, Tillman, 1978). The relative proportions of each species stratum were used to assign a general heating value of all wood resources on the delta. The heating value of diesel was assumed at 138,000 Btu/gal.

F. Other Thermal Sources

Though the main objectives of this study were to examine energy use of buildings and the quantity/quality of forest resources, community interest remains high for developing biomass waste resources in town. If these resources are to be pursued for development, volume and quality estimates will need to be known. Using data from the current study and past assessments of biomass waste streams, these volumes are addressed.

1. Alder Resources on Eyak Corporation Lands

Numerous access roads exist on Eyak Corporation land from logging operations conducted in 1995. Located north of the Cordova airport, these roads are presently overgrown with dense coverage of alder sapling and shrub material. Though sufficient funds were not available to measure this resource, an estimate of biomass potential was has been generated for this report using GIS and data from similar studies.

Former logging roads were mapped from base imagery color photos and plotted in the GIS dataset. Area volumes were calculated by applying a geoanalytical buffer to the logging road map layer. The buffer offset was set at 50ft and run for all connecting road segments, summarizing the available area in acres. Density and volume estimates were then given to the available acreage layer.

A recent study of biomass resources in Tok performed by the State Division of Forestry, measured Alder stands of similar size and quality to those present on Eyak Corporation land and determined an average tree weight of 3 pounds with a stocking rate of roughly 5,000 stems per acre, which was used to approximate alder available gross green weight tonnage (Citation). Fuel equivalence values were calculated using an alder heating value of 8.56 MBtu/ton at 50% MC (Hanson and Mullen, 2010). Therefore, 1 green ton of alder resource was considered to be the equivalent to 62 gallons of #2 diesel oil.

2. Cardboard from City Bailer

Cardboard is a common material used for packaging in Cordova. To date, most of this material is discarded as waste at the city landfill as the City bailer does not sort trash. Observations made by staff at the City bailer estimate the cardboard resource at roughly 50-80 bales in a given year at 400 pounds per bale (Deerfield, et. al., 2009). The heat content of cardboard was assigned between 7,428 -7,939 Btu/lb (Dry) (Jenkins, 1993).

3. Community Burn Pile

NVE performed a detailed observational survey of the Community burn pile in summer of 2008. Materials were observed over twenty days during mid-day, when use of the burn pile was assumed to be greatest. 61.7% of waste material at the community burn pile is allowable burnable waste. Daily estimates of burned material are assumed at 500lb per day, therefore the allowable burnable material was estimated at 308lbs per day (Haynes, 2011). Heating value was assigned by multiplying burn pile proportions by their respective heat values (Table 3).

Table 3. Calorific Values of Waste (Engineering ToolBox, 2011)

Type of Material	Calorific Values (BTUs/lbs)
Diesel Fuel (**not burned in burn pile**)	19,300

Gasoline (**not burned in burn pile**)	20,400
Wet wood	4,000
Dry wood	7,000
Newspaper	7,540
Cardboard	7,700
Kraft	6,897
Beverage & Meal Boxes	6,855
Tissue	6,518
Colored Office Paper	6,348
White Office Paper	6,234
Envelopes	6,160
Treated Paper (NCR)	5,983
Glossy Paper	6,370
Mixed Paper	6,477
Solid Municipal Waste (dry)	5,050

III. Results

A. Existing Building Systems

AC Value Center Approx. 28,000 square feet. Heating provided by (2) independent oil-fired boiler units. Both are Johnson&Church Flexaire Furnaces in fair condition (1) 250,000 BTU/hr (Model# SDF-45-OFH) and (2) 188,000 BTU/hr (Model# SDF-15-OFM). Hot water provided by Bock C-glass 173,000 BTU/hr (1.25gal/hr) hot water tank with 62-gallon capacity. Annual fuel consumption: 6,450 gallons, with EUI_{Therm} of 0.23.

Alaska Housing Finance Corporation owns and operates several multi-housing projects in Cordova, AK.

Eyak Manor: Four-plex, (4) separate units (16 separate living units total). Each building is approx. 4400 square feet and has an annual consumption of 1500 gal/yr. EUI_{Therm} of 0.34.

Sunset Apartments: is a 22-unit apartment building. The building is 20,450 square feet, with an annual consumption of 5,200 gallons. EUI_{Therm} of 0.25.

City of Cordova

Cordova Community Medical Center constructed in 1986. The building area is approx. 50,000 square feet (26,545 sq. ft 1st floor, 23,803 sq. ft 2nd). Annual fuel consumption: 28,800 gallons. EUI_{Therm} of 0.573.

Cordova Telephone Cooperative office building (4,000 square feet) and separated warehouse (2,500 square feet). Average fuel consumption of 6,963 gallons. EUI_{Therm} of 1.07.

Cordova Electric Cooperative constructed in 1955. The building area is approx. 20,000 square feet, which includes the recently moved Ilanka Community Health Center. Annual fuel consumption of 8,717 gallons with a EUI_{Therm} of 0.441.

Cordova School District is responsible for multiple buildings: [2] schools (the Cordova Jr./Sr. High School, and Mt. Eccles Elementary), and School Administration building, and separate and adjacent maintenance building(s). Last year, the district administrative offices were relocated to the newly constructed Mt. Eccles School.

Mt. Eccles Elementary School is a new building, constructed in 2011. The 51,860 square foot building has an annual fuel consumption of 17,220 gallons, EUI_{Therm} of 0.332.

Cordova Jr./Sr. High School is a 52,956 square foot building, originally constructed in 1966. EUI_{Therm} of 0.442. Boiler #1 is too big, and has not been fired in over 5 years; however, the heating loop was not closed through this boiler until recently.

Boiler 1

Fuel Type:	#2 Oil
Input Rating:	3,588,000 BTU/hr
Rated Efficiency:	80%
Idle Loss:	1.5%
Heat Distribution Type:	Glycol
Boiler Operation:	Not in the last [5] years

Boiler 2

Fuel Type:	#2 Oil
Input Rating:	1,959,600 BTU/hr
Rated Efficiency:	80%
Idle Loss:	1.5%
Heat Distribution Type:	Glycol
Boiler Operation:	Sep-Jun

Boiler 3

Fuel Type:	#2 Oil
Input Rating:	351,900 BTU/hr
Rated Efficiency:	84%
Idle Loss:	1.5%
Heat Distribution Type:	Glycol
Boiler Operation:	All Year

Boiler 4

Fuel Type:	Waste Oil
Input Rating:	300,000 BTU/hr
Rated Efficiency:	80%
Idle Loss:	1.5%
Heat Distribution Type:	Glycol
Boiler Operation:	When available

USPS Post Office was constructed in 1987. It is an 11,879 square feet building. Building maintained by a single oil-fired Weil McLain (Model# 480) boiler (491,000 BTU/hr, 3.55 gal/hr respectively), in good condition, with forced-air heating system. Annual fuel consumption: 3,676.4 gallons, with EUI_{Therm} of 0.31.

Native Village of Eyak was originally built in 1980, with renovations and an additional level being added in 2007. The building area is 9,740 square feet with a EUI_{Therm} of 0.405. Annual fuel oil consumption of 3,946 gallons.

Domestic hot water is currently being stored at 125°F.

USFS Cordova Office Building is a three-story 8,925 sq. foot building originally constructed in the 1920's. The building was upgraded in the 1990's. Reported upgrades include roof upgrades, new windows, and increased insulation in walls and attic spaces.

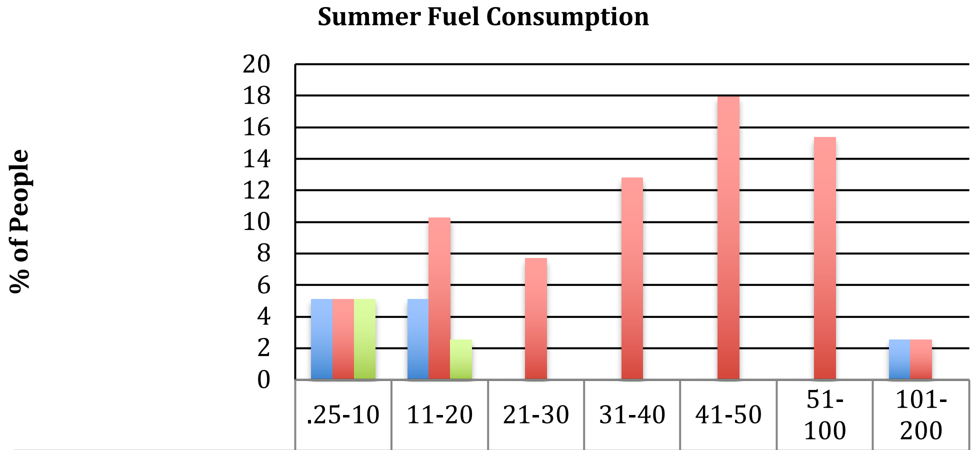
Hot water radiators along the building perimeter heat the building. Building heat and domestic hot water is supplied by a single oil-fired Well McLain (Model# 678) boiler with a rated output of 559,000 Btu/hr. The water temperature is maintained around 165°F, and there is an opportunity to reduce energy consumption through hot water reset or boiler cycling controls (USFS Audit, 2010). The radiators are controlled by wall-mounted pneumatic controls. During the summer, thermostats are turned down to 50°F.

Annual heating fuel consumption for the main office is 4,417 gallons. EUI_{Therm} is 0.495.

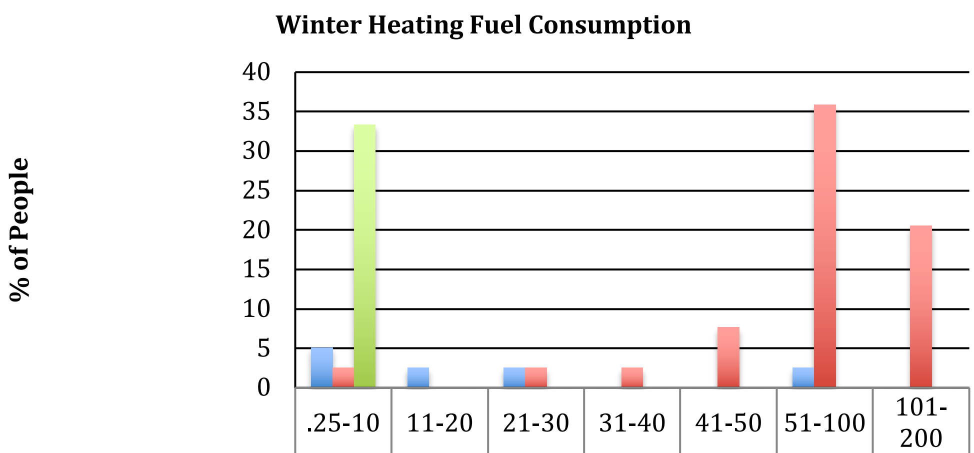
USCG

B. Home Fuel Questionnaire

During the summer of 2011, a total of 1,500 surveys were mailed to residents, of those, the Native Village of Eyak received 39 respondents to the Home Fuel Questionnaire, for a yield of 2.6% (n=39). Given that there are only 579 residences in Cordova, survey responses yield a 6.7% sample, which is assumed to be a representative sample of year-round residents in Cordova.



	.25-10	11-20	21-30	31-40	41-50	51-100	101-200
Propane (lbs/month)	5	5	0	0	0	0	3
Heating Oil (Gallons/month)	5	10	8	13	18	15	3
Wood (cords/month)	5	3					



	.25-10	11-20	21-30	31-40	41-50	51-100	101-200
Propane (lbs/month)	5	3	3	0	0	3	0
Heating Oil (Gallons/month)	3	0	3	3	8	36	21
Wood (cords/month)	33	0	0	0	0	0	0

Figure 4. Survey tally results from the Home Fuel Questionnaire for summer and winter heating fuel usage.

C. Thermal Loads (Commercial Buildings)

Annual building fuel consumption data was gathered from a variety of buildings determined to be representative of the major thermal signatures (loads) in town (Table 4). Fuel matrix conversions were then applied to estimate biomass-heating loads for various fuel types.

Table 4. Annual Wood Fuel Use Summary

Building	Fuel Oil (gal)	Cord Wood (cords)	Wood Pellets (tons)	Wood Chips (tons)
AC Value Center	6,450	56.4	51.4	70.9
AHFC Eyak Manor	6,000	52.4	47.8	66.0
AHFC Sunset Apts.	5,200	45.4	41.4	57.2
CCMC	28,800	251.7	229.5	316.6
CTC	6,963	60.8	55.5	76.6
CEC	8,717	76.2	69.5	95.8
CSD Mt. Eccles Elem.	17,220	150.5	137.2	189.3
CSD Jr./High School	23,400	204.5	186.4	257.3
US Post Office	3,676	32.1	29.3	40.4
Native Village of Eyak	3,946	34.5	31.4	43.4
USFS	4,417	38.6	35.2	48.6
City - City Center*	12,500	109.2	99.6	137.4
Bidarki*	3,300	28.8	26.3	36.3
Pool*	20,000	174.8	159.4	219.9
Harbor Master*	2,200	19.2	17.5	24.2
City Hall & Fire EMS*	14,000	122.3	111.5	153.9
Total	166,789	1,457	1,329	1,834

Assumed: Wood fuel use assumes offsetting 85% of the current energy use.

*Estimated from budget actuals. Unit price assumed at $4.31/gallon.

The information was then plotted on base imagery maps to illustrate scale and relative proximity to one another (Figure 5). A buffer was then applied at 0.1 miles and 0.2 miles respectively in order to illustrate proximity to the Cordova Center, set as the buffer origin of a possible biomass heating facility. Major loads are represented by the magnitude of the 'Heat Signature' radius.

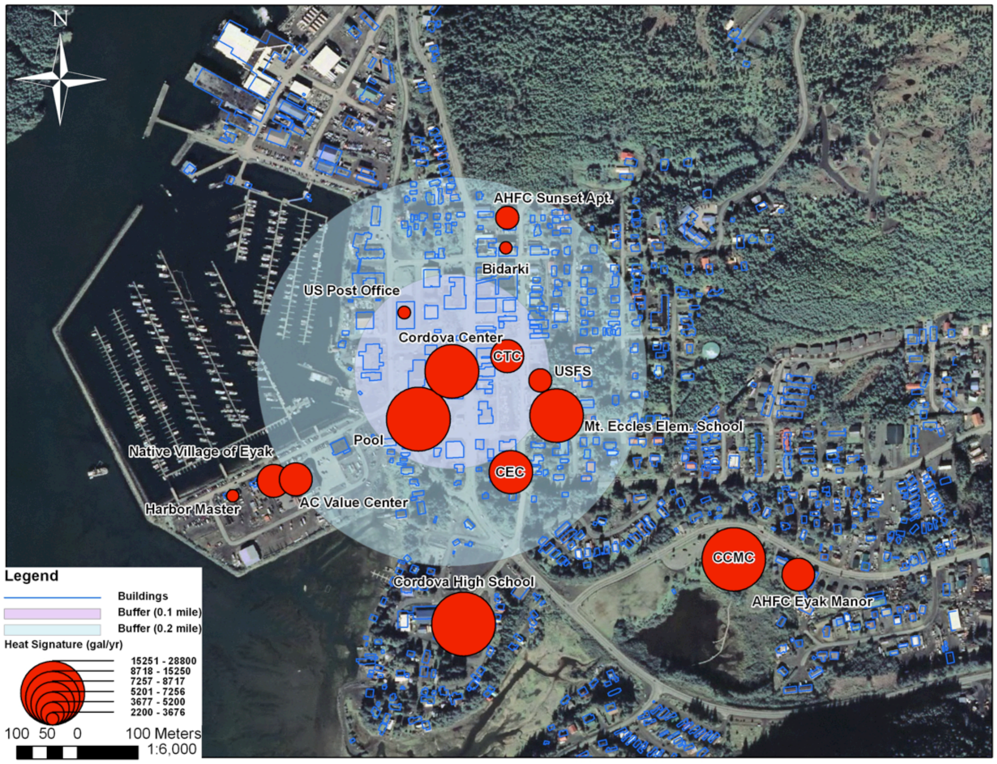


Figure 5. Thermal loads of buildings within central downtown of Cordova.

EUI were assigned by comparing annual fuel consumption to building gross area (Table 5). When compared across different building types, relative efficiencies based on loads can be compared to identify potential energy savings (Figure 6).

Table 5. Energy Efficiency of Buildings based on EUI

Building	Fuel Oil (gal)	Cord Wood (cords)	Area (SF)	EUI (gal/sf*yr)
AC Value Center	6,450	56.4	28,000	0.23
AHFC Eyak Manor	6,000	52.4	17,600	0.34
AHFC Sunset Apts.	5,200	45.4	20,450	0.25
CCMC	28,800	251.7	50,000	0.573
CTC	6,963	60.8	6,500	1.07
CEC	8,717	76.2	20,000	0.441
CSD Mt. Eccles Elem.	17,220	150.5	51,860	0.294
CSD Jr./High School	23,400	204.5	52,956	0.442
US Post Office	3,676	32.1	11,879	0.31
Native Village of Eyak	3,946	34.5	9,740	0.405
USFS	4,417	38.6	8,925	0.495
City - City Center	12,500*	109.2	36,000	0.35
Total	127,289	1,112	313,910	N/A

*Estimated Fuel Usage (Source: Alaska Energy Engineering, LLC.)

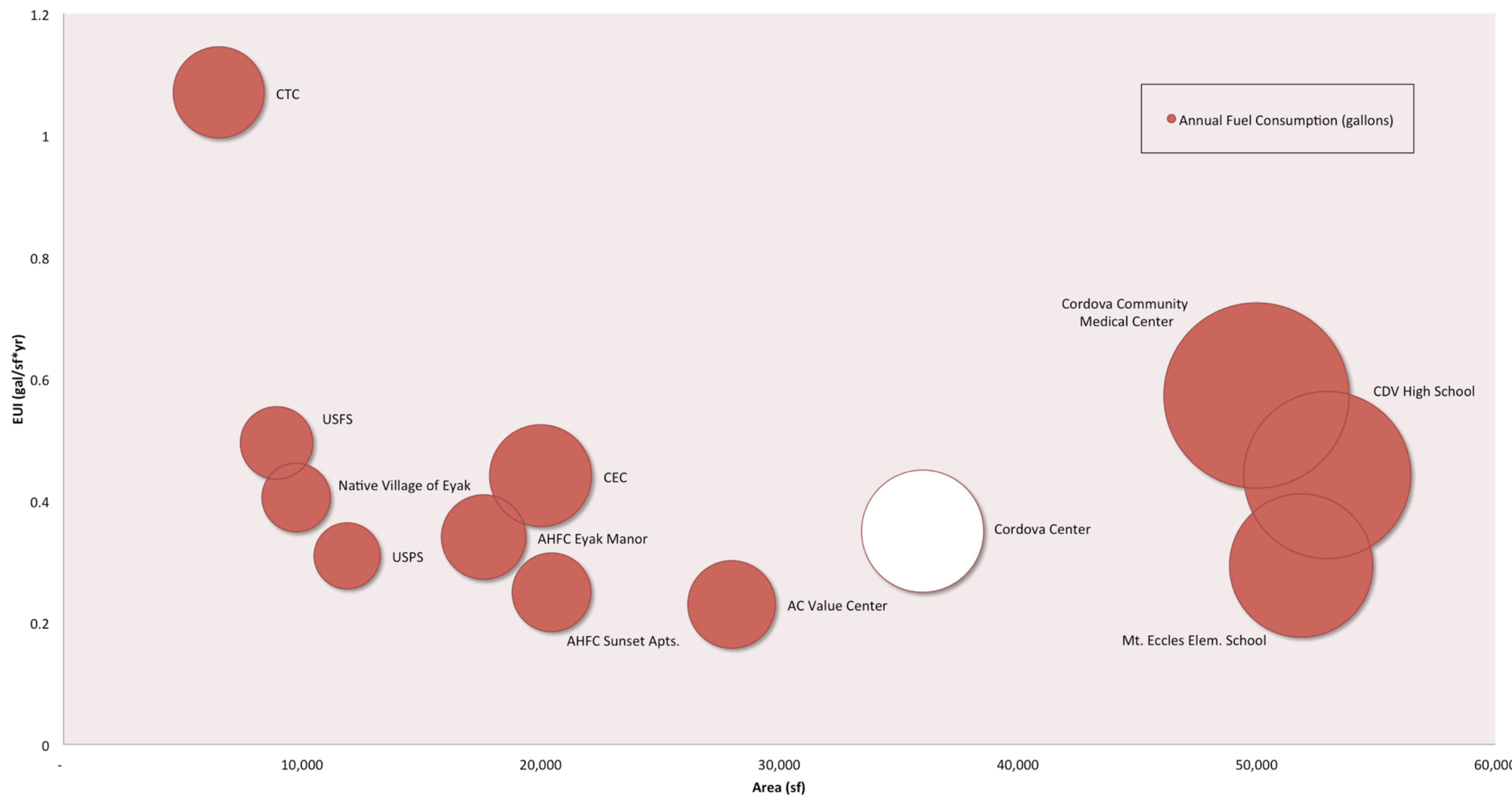


Figure 6. EUI and energy use between surveyed buildings.

D. Thermal (Potential) Sources

1. Forest Inventory

The forest inventory focused primarily on Eyak Corp. Land located north of the Cordova airport. The project area at this site is approximately 21,726 acres. This area was assessed primarily because it thought to be the most likely suited for commercial harvest. The total area of harvestable timber was determined at 3,539 acres. Translated into volume, the acreage amounts to a total volume inventory of roughly 162,335 cords or 294,254 tons respectively (Figure 7).

Sustainable volume availability was determined by multiplying the forest inventory net growth rate percentages with the accessible area volume. When the amount of cutting is performed at or below the forest growth rate, the harvest is considered sustainable. Annual growth on Eyak Corp. land near the airport was determined to be roughly 4,963 cords within areas of <15% slope. This amount translates to nearly 8,150 tons of allowable biomass harvest at or below the forest stocking/replenish rate.

Digital elevation models were also incorporated into the GIS dataset to determine ease of access to timber stands on the river delta and used to rate delivered cost of wood. For stands situated in an area with <15% slope, tree volumes could be delivered at about $225.00 per cord or $147.00 per ton (Hanson, 2012).

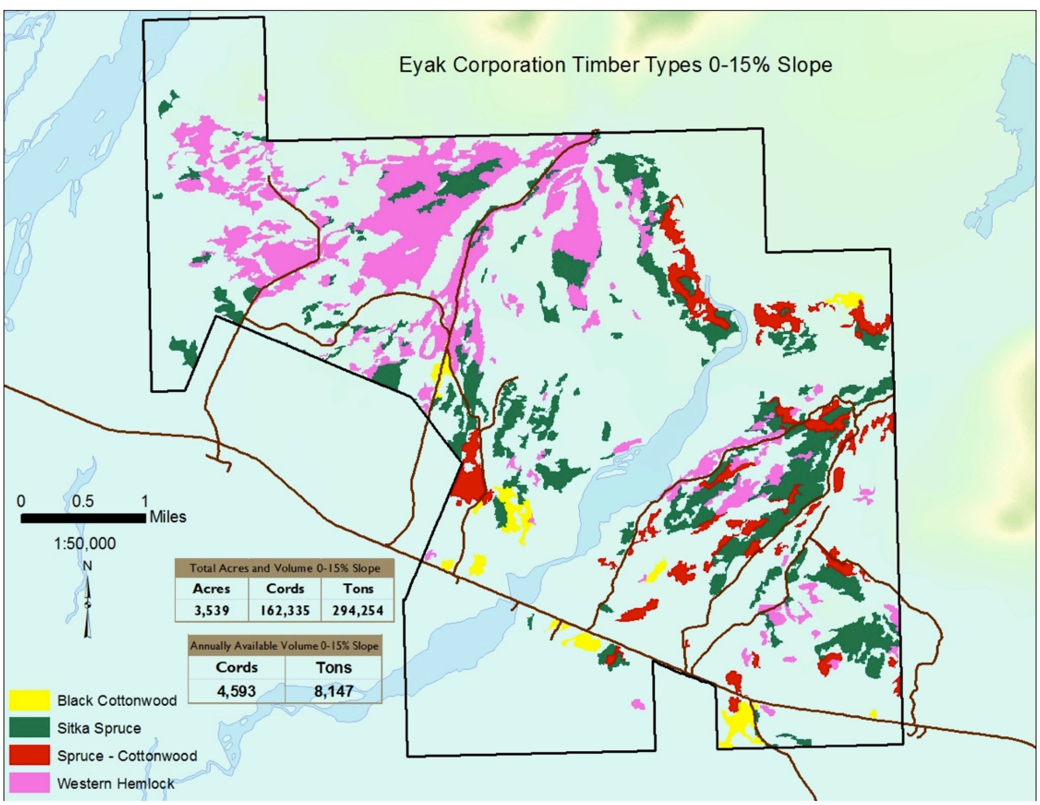


Figure 7. Eyak Corporation timber types 0-15% slope.

Accessible timber proportions were calculated for each of the different timberland strata as described in the **Cordova Forest Inventory Report**. The area distribution was used to determine forest strata percentages and assign a general heating value for forest resources on the Copper River Delta (Figure 8). Timberland strata were assumed to be consistent with timber stands existing within the Eyak Corp. project area. Of the 4,593 cords annually available in accessible areas, 26 percent are of Sitka Spruce (1,195 cords), 35 percent are Western Hemlock (1,608 cords), and 37 percent are of Black Cottonwood (1,790 cords). The remaining 2 percent Spruce-Cottonwood volume was added to the stratum with lowest heating value (i.e. Cottonwood at 13.5 MBtu/cord).

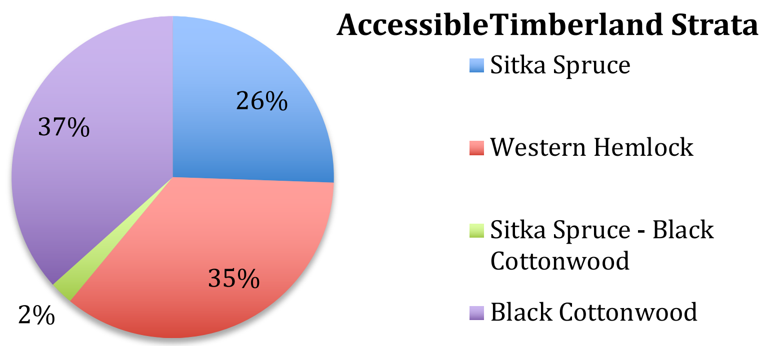


Figure 8. Accessible Timberland Strata Distribution by Area

Fuel equivalence values were calculated by multiplying the available annual volume(s) by specific heating value for each tree species then converting total Btu's into gallons of diesel. An assumed heating value of 138,000 Btu/gal diesel was used for the calculation. Total forest resources available for sustainable harvest on Eyak Corp. land was determined at 68,852.2 MMBtu/yr or 498,928 gallons fuel oil diesel equivalent.

2. Alder Resources

Applying the 50-foot buffer to the original roads layer, logging roads provide an additional harvest area of 386 acres (Figure 9). Based on available data for similar alder stands, a weight of 15,000 pounds per acre or 7.5 tons per acre of material are assumed to be present. Alder stocking rates appeared to be consistent on overgrown roads and assumed uniform across all roads. Multiplied by overall acreage, the value equates to a rough estimate of 2,895 green tons in total alder material on Eyak Corp. timber roads. Assuming a MC of 50%, these resources have a heating value of 24,769 MBtu's or approximately 179,490 gallons of #2 diesel equivalent.

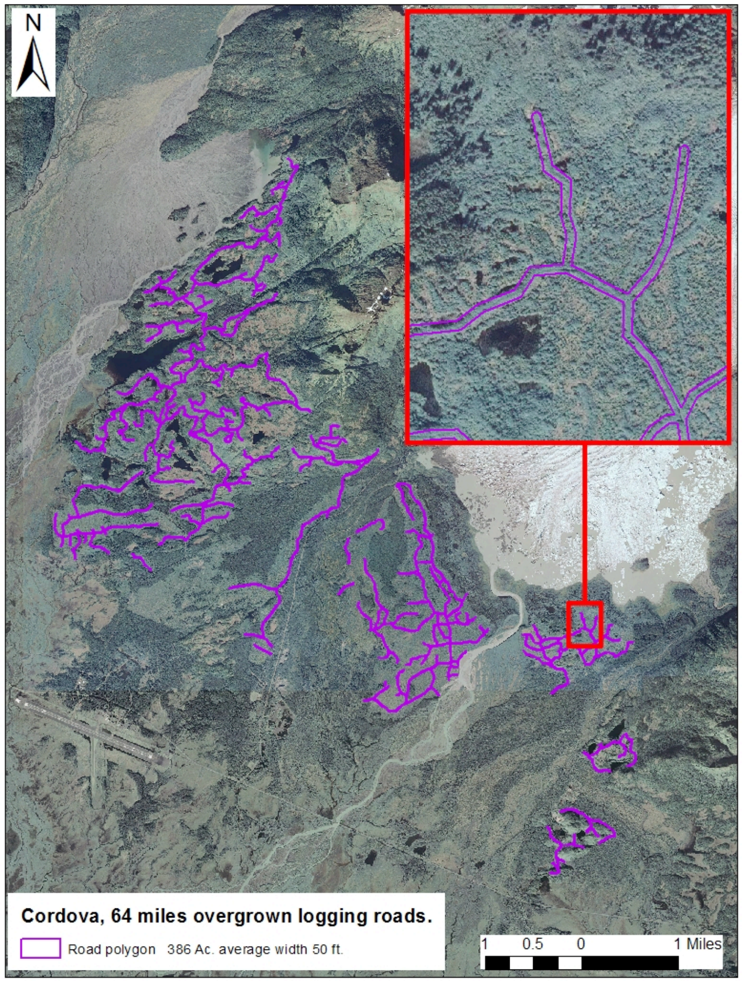


Figure 9. Available acreage of alder overgrowth on former timber cutting roads.

3. Eyak Log Decks

There are [two] sort yards located on Eyak Corp. land, designated after logging efforts took place in 1995. In 2009, the sort yard at Mile 15 contained roughly 1,863 cords (Figure 10); the sort yard at Cabin Lake Road contained approx. 1,358 cords (Figure 11), and the log pile near the airport contains 200 cords (Biomass Heating Project, 2009). The decks consist of Western Hemlock saw and pole timber and mostly untouched since the logging efforts ceased in the area. Though some of the sort yard logs have been processed into firewood since 2009, the vast majority remains in place, unprocessed. Considerable decomposition has been noted of most saw logs.

Samples were cut from protected logs inside an old log deck on Eyak Corporation Land near the airport, in July 2009, and sent for analysis to a certified lab (Deerfield, et. al., 2009). Table 6 shows the logs containing moisture content of 57 percent. When dried, the material demonstrates a heating value of 8,571 Btu/lb (Table 6).

Figure 10. Log decks at the 15-mile sort yard.

Due to the high moisture content of these logs, almost all of the present material would be expected to be consumed by drying efforts as approximately 1% of raw material will be consumed to dry the other 99% of the feedstock by 1% of moisture content assuming no other heating inputs are used (Apted, D., 2011).

If the feedstock contains a moisture content of 57% and has a target (dried) MC of 12% (Δ = 45%), then roughly 90% of all the material will be consumed in order to convert the feedstock into a more desirable (burnable) product.

As a result, the material contained at each of the specified sort yards on Eyak Corp. Land is regarded to be of extreme poor quality, with little to no value for heating use.

Figure 11. Log decks on Cabin lake road.

Table 6. Log Deck Lab Test results

Species	MC (%)	Ash Content (%)	Volatile Matter (%)	Heat Value (Btu/lb)
Hemlock	57	0.08	34.68 (wet) 82.09 (dry)	3,620 (wet) 8,571 (dry)

4. Cordova Community Burn Pile

61.7% of waste material at the community burn pile is allowable burnable waste (Table 7). Daily estimates of burned material are assumed at 500lb per day therefore the allowable burnable waste is 308lbs per day. When burned, this accounts for 1,846,176 BTU's rejected to the atmosphere. This is equivalent to 13.3 gallons of diesel per day, 4,872 gallons annually (Haynes, 2011).

Table 7. Cordova Burn Pile Survey Assessment data

Item	# of days observed	% of days observed	frequency (# of days observed / total # of observations)	
Burnable Items				
Brush/Trees	19	79.17%	20.21%	
Cardboard Boxes	9	37.50%	9.57%	
Ciggerette Cartons	1	4.17%	1.06%	
Lumber	2	8.33%	2.13%	
Pallets	8	33.33%	8.51%	
Paper	1	4.17%	1.06%	
Plywood	2	8.33%	2.13%	
Scrap Wood	12	50.00%	12.77%	
Wooden fishing spool	1	4.17%	1.06%	
Wooden furniture	3	12.50%	3.19%	
				61.70%
Unburnable Items				
Air Tank	1	4.17%	1.06%	
An old fishing net	1	4.17%	1.06%	
Beer Cans	1	4.17%	1.06%	
Foundation	1	4.17%	1.06%	
Garbage	3	12.50%	3.19%	
Garbage Bags	6	25.00%	6.38%	
Glass Bottles	2	8.33%	2.13%	
Nails	1	4.17%	1.06%	
Plant Pot	1	4.17%	1.06%	
Plastic Bags	8	33.33%	8.51%	
Plastic shrink wrap	1	4.17%	1.06%	
Plastic Wire Spool	1	4.17%	1.06%	
Shovel	1	4.17%	1.06%	
Tin Cans	3	12.50%	3.19%	
Tin Roofing	2	8.33%	2.13%	
Tires	2	8.33%	2.13%	
Wire Spool	1	4.17%	1.06%	
				38.30%

5. City Bailer Cardboard Waste

50-80 bales of cardboard per year (Deerfield, 2009). At 400lb of cardboard per bale (NVE Biomass Heating Project, 2009), with a heating value of 7,428 -7,939 Btu/lb (Dry) (Jenkins, 1993). This resource is therefore rated at roughly 1,080 – 1,840 gallons diesel equivalent.

IV. Discussion

Data suggests that biomass availability on Eyak Corp. land can appropriately match loads and target markets in town. Several large users are located within close proximity and could potential be linked to in a 'mini' heating loop (<0.1mile) (Figure 5). Unfortunately, the largest loads in town are located outside of this radius circle (i.e. the Cordova High School and Cordova Community Medical Center, etc.). Additional heat losses and capital cost required for added piping may be feasible for heated water systems, but typically distances over 0.25 miles steam is used due to higher heating capacity. District heating of this type is probably not available at a scale appropriate for a community like Cordova.

Based on obtained information of buildings in town, resources on the Copper River Delta appear to be adequate for supplying fuel wood for heating (Table 8). Based on the magnitude of customer thermal needs, capital cost of processing equipment and operation and handling requirements needed to develop biomass products, the study confirms the need to further develop (standing) tree timber resources if biomass thermal energy is to be utilized. Waste stream resources simply do not have yearly potential to support development efforts alone. Of the major landowners in the project area, the Eyak Corporation appears to be the only owner with the ability to open up cutting privileges of areas with significant acreage. For this reason, Eyak Corp. land has been examined most thoroughly for the purposes of this study and is reasoned that Eyak Corp. will be the only likely developer of biomass in the near term.

Table 8. Thermal Resource Summary

Thermal Source	Heating Value (gallon diesel equivalent)
Net Growth (Eyak Corp.)	498,000
Alder Overgrowth	179,000
Cordova Burn Pile	4,500
City Bailer (Cardboard)	1,080-1,800

The most common fuel wood product in Cordova is cordwood. Cord and split wood are prevalent in the community and, though no commercial suppliers currently exist, equipment already exists in town to further increase the production of cordwood. Should a land holder such as the Eyak Corporation chose to further develop and sell timber for fuel wood in town, little would be needed to increase the amount of firewood production in the community; however, with the amount of annual rainfall and seasonal weather that cut wood would be exposed to, adequate storage and drying facilities will need to be secured in addition to increasing cutting efforts.

Should cordwood be available on a consistent basis, biomass heating could be implemented for individual and multiple-adjacent building/offices with relatively little capital cost. Garn boilers and individual building cord wood boilers are relatively inexpensive compared to more complex mechanically-fed system. Garn is owned by Dectra Corporation, located in St. Anthony, Minnesota. Garn boilers have already been installed at several sites in Alaska (Alaska Energy Authority, 2012).

If multiple buildings are to be selected for biomass heating building re-commissioning and programing of current boiler systems will be of major importance. Materials such as flexible plastic piping system, manufactured by Rehau, which uses PEX carrier pipes could be used as substitutes for more expensive insulated piping.

Waste materials, those that do not cut easily into firewood, are currently underutilized. As sufficient mechanical equipment does not currently exist to extract, process and burn the material, these resources are not available for useful heating. The simplest form of processing would be that of mechanical chipping wood and woody debris material and storing/drying it in bulk. Of the potential chipped resource, alder sapling and shrub land areas are considered to be of highest interest for development. Operations are presently underway by the US Forest Service to cut alder as a supplement for Moose habitat. These operations could easily be incorporated into a fuel wood product if, at the same time, chipping and collection took place by way of an industrial chipper with attached covered trailer or bin (*word choice?). Such a method of extraction is ideal as it greatly reduces the amount of dirt and debris material that needs to be sorted prior to burning.

Pellets are by far the most efficient and fitting crossover material compared to fuel oil burners. Pellet stoves are relatively simple to operate, programmable by thermostat, and can heat large spaces with a single unit. At present, pellet products are not commercially available in Cordova and shipping costs have not been demonstrated to be cost competitive with diesel due to barging costs. A few hobbyists exist in town and bio-briquette products are beginning to appear in minute amounts, though heating value has not yet been tested thoroughly yet (Chris Grimwood, Kiwi Mechanical).

At this point in time, apparent community awareness of a biomass-heating loop is low and efforts to develop biomass will likely need to increase and demonstrate viability of a sustainable harvest protocol first. More public awareness and support would have to be obtained before a district-heating loop should be entertained.

V. Economic Analysis

Forest resources in easily accessible areas (i.e. <15% slope, over alluvial outwash) are estimated to be available at $225.00/cord or $147/ton. For this assessment, chips are also assumed to be available at a rate of $147/ton. Based on the relative proportions of each of the stratum available on the Copper River Delta (Figure 8), an equation can be used to assign a general heating value per cord (Equation 3).

$$Heat\ Value\left(\frac{MMBtu}{cord}\right) = 0.39x + 0.26y + 0.35z$$

$$Where\ x\ is\ the\ heating\ value\ of\ Black\ Cottonwood\ \left(13.5\,\frac{MMBtu}{cord}\right)$$
$$y\ is\ the\ heating\ value\ of\ Sitka\ Spruce\ \left(16\,\frac{MMBtu}{cord}\right)\ and$$
$$z\ is\ the\ heating\ value\ of\ Hemlock\ \left(15.9\,\frac{MMBtu}{cord}\right)$$

Equation 3. Calculated heating value of cordwood resources on the Copper R. Delta.

From this equation of above, a generic cord of firewood cut on the is thought to have a heating value of 14.99 MMBtu/cord. At a delivered rate of $225/cord, forest timber products can be estimated at approximately 66,622 Btu/$. Assuming the heating content of fuel oil at 138,000 Btu/gal, fuel wood resources are estimated to be deliverable at a rate of $2.07/gallon diesel equivalent. It should be mentioned that this estimate does not take into account the relative efficiencies of the different technologies and is therefore somewhat misleading. To more accurately compare fuel-type efficiency and price point, equalized costs should be examined.

For engineering purposes, equalized cost estimates are perhaps the more useful form of measure for determining fuel option viability as cost estimated take into account process efficiencies (Salmon, N. and Ratz, N., 2012). Table 9 illustrates the equalized costs of fuel wood types compared to diesel, with system efficiencies taken into account.

Table 9. Equalized Fuel Costs to $/MMBtu

Fuel Type	Units	Gross Btu/unit	System Efficiency	Net System Btu/unit	$/unit	Delivered $/MMBtu	Gross $/MMBtu
Fuel Oil	gal	138,000	0.8	110,400	$4.00	$36.23	$28.99
					$4.25	$38.50	$30.80
					$4.50	$40.76	$32.61
Cord Wood	cords	14,990,000	0.65	9,743,500	$200	$20.53	$13.34
				*	$225	$23.09	$15.01
					$250	$25.66	$16.68
Pellets	tons	16,400,000	0.7	11,480,000		No Local Supplier	
				**	$279	$24.30	$17.01
Chips	tons	11,925,000	0.65	7,750,800	$100	$12.90	$8.39

*	$\boxed{\$147}$	\$18.97	\$12.33
	\$200	\$25.80	\$16.77

* Estimated delivered cost for Cordova, Alaska (Hanson, 2012)
** Price of pellets from known suppliers in Anchorage, Alaska (Source: Home Depot)

Biomass resources are therefore considered a favorable heat fuel resource compared to diesel at present rates (\$4.69 #1, \$4.67 #2, assumed around \$4.31 for bulk fuel deliveries). Due to the comparatively low price of biomass products from local resource, it is determined that sufficient margins exist for developers to realize profit and demonstrate business viability.

Considering a biomass thermal heating project could have a capital investment on the order of \$1.5 – 4 million for a small district-heating loop, project buy back analysis is necessary to determine feasibly. In order to demonstrate the long-term viability and pay back of the project a Cash Flow Analysis (CFA) will need to be generated. Due to the lack of information on project construction costs, a cash flow analysis was not produced for this report; however, sufficient information exists to perform this estimate should building costs be known.

VI. Recommended Actions

The data supports the idea that there is sufficient source and market for biomass heating development. At present, Eyak Corp. is the only reasonable supplier of feedstock fuel and milled wood in the area. If a sustainable harvest program is to be developed in the Cordova area, it is likely that the Eyak Corporation will be responsible for supplying fuel wood until other lands can be opened up/ leased/ secured from the State and US Forest Service. Harvesting at or below the net annual growth rate documented in this report, Eyak Corporation has the opportunity to improve the health and quality of its forests while generating sales from use of its biomass waste and timber. Wood processors can easily absorb waste stream materials once forest resources are utilized to increase overall market volume and market share supply.

"A healthy forest often requires some active management. An enlightened manager may wish to remove small numbers of logs from the forest without damaging what is left behind." (Schroeder, 2012). Thinning practices are thusly encouraged for tree stands on Eyak Corporation Lands (Hanson, 2012). Large-scale and clear-cut harvest is not encouraged as large equipment operators are "inclined to remove the largest and best trees, which is frequently inadvisable for the continued propriety of the forest." There are many advantages in using smaller and less expensive log-moving equipment, but such equipment is just now becoming available in this country (Schroeder, 2012).

A list of available small-scale harvesting products is provided in **Appendix A**.

In order to pursue further development and implementation, funding sources will need to be identified and secured first. Most grant programs will likely require a full feasibility assessment, which funds were not available to complete during this project. A full assessment would provide more detail on the air quality issues, wood fuel resources, review the pipe routing and potential underground conflicts, and develop a schematic design of the boiler plant including wood storage size, and schematic design of the heating systems integration. These schematic designs will also help obtain accurate costs. Since several options appear to be viable, more investigation should be engaged to demonstrate the best project to proceed with.

VII. Cited Literature

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Schroeder, T., **2012**. Forest Info: Logging Equipment Appropriate to Backyard Logging. Forest information for the San Juan Islands. Accessed: 11/14/2012. <http://www.rockisland.com/~tom/tools.html>

Appendix A

Forestry Products:

1. Nova Jack - http://www.novajack.com/en/0101_01.htm#
2. Forestry Future Products - http://www.futureforestry.com/log_arches.php
3. Virginia Tech - http://web1.cnre.vt.edu/harvestingsystems/
4. Small-scale harvesting - http://www.rockisland.com/~tom/tools.html
5. Tremzac - http://www.tremzac.com/OXTRAC/Debusqueuse-OXTRAC/Debusqueuse-OXTRAC.aspx
6. Agroforteka Company - http://www.afa-machinery.lt/
7. Farmi Products - http://www.farmiforest.fi/en/index.php?option=com_tuotekatalogi&view=tuotekatalogi&Itemid=4&page=tuote&tuote=89
8. Rictec - http://www.rictec.com.sg/grinder/pallet-grinder/
9. Schutte Buffalo - http://www.hammermills.com/size-reduction-product-categories-schutte-buffalo-hammermill/wood-grinders-1

Appendix B

Heating Degree Days
http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?akcord

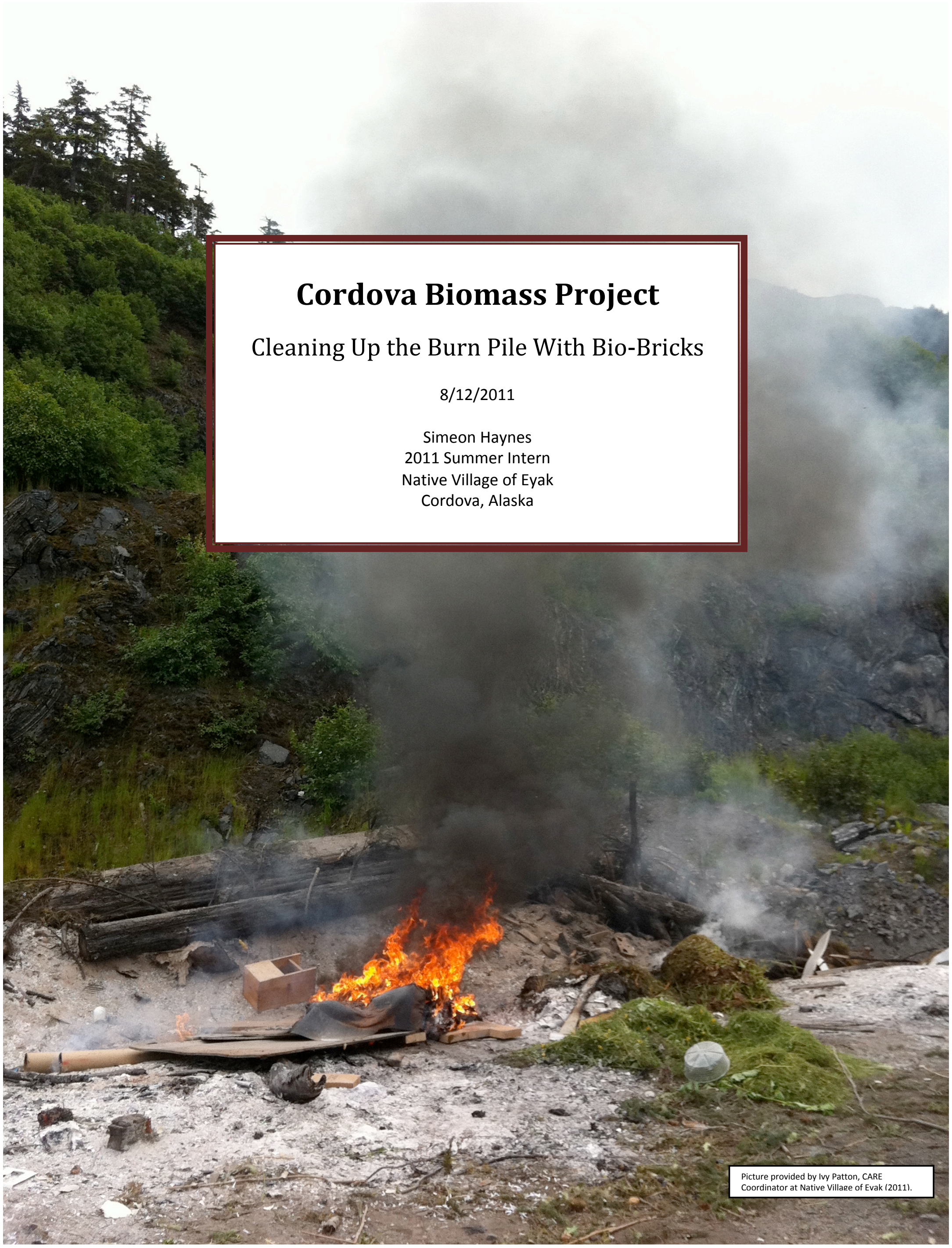
Biomass Products

Chris Grimwood – Kiwi Mechanical

Paper brick maker

1. PelHeat Biomass boilers - http://www.pelheat.com/Products.html#.ULfvPoWmC50
2. BioBriquettes Weima - http://www.weimaamerica.com/pages/briquetting-press/briquetting/briquetting.htm
3. Alaska Pellet Mills (Apted Technologies Inc.) - http://alaskapelletmill.com/
4. Wiseway Pellet Stoves - http://zephyrgreenhousesystems.com/

Appendix C


Cordova Biomass Project
Cleaning Up the Burn Pile With Bio-Bricks
8/12/2011
Simeon Haynes
2011 Summer Intern
Native Village of Eyak
Cordova, Alaska
Picture provided by Ivy Patton, CARE Coordinator at Native Village of Eyak (2011).