

AVAILABILITY OF BIOMASS FUELS ON AHTNA LANDS GAKONA, GULKANA AND TAZLINA VILLAGES



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I. EXECUTIVE SUMMARY

The inventory of timber and biomass resources on Ahtna lands for the villages of Gakona, Gulkana and Tazlina has been initiated to support potential development of biomass energy systems in this rural area of Alaska. Through funding provided by the Alaska Energy Authority and State Division of Forestry, an updated timber and biomass inventory has been conducted using vegetation cover data from previous forest inventories conducted for the villages by the Tanana Chiefs Conference Forestry Program (TCC). The area of individual timber types has been combined with recent volume per acre estimates produced from a State of Alaska forest inventory conducted on state forest classified lands near Glennallen. The inventory provides digital detailed stand type maps and volume data that are available within a Geographic Information System. The volume data primarily has been generated from timber stand data collected in September, 2009.

			<u>Acres</u>
Inventory Area Land Classification			
Timberland			92,163
Dwarf Forests			92,289
Non-Forest			<u>50,210</u>
Total Inventory Area:			234,662
Timberland Area by Timber Type Size Class			
Sawtimber			739
Mixed Sawtimber/Poletimber			1,258
Poletimber			58,480
Reproduction			<u>31,686</u>
Total Timberland Area:			92,163
Timberland Area by Timber Type Species Class			
White Spruce			35,417
Black Spruce/White Spruce			31,686
Aspen			13,486
White Spruce/Aspen			10,316
White Spruce/Balsam Poplar			<u>1,258</u>
Total Timberland Area:			92,163
Total Net Volume			
Cubic Feet ($\geq 5''$ dbh)	Tons ($\geq 5''$ dbh)	Board Feet ($\geq 9''$ dbh)	
71,819,616	1,303,756	112,202,361	

Table 1. Inventory volume and acreage summary.

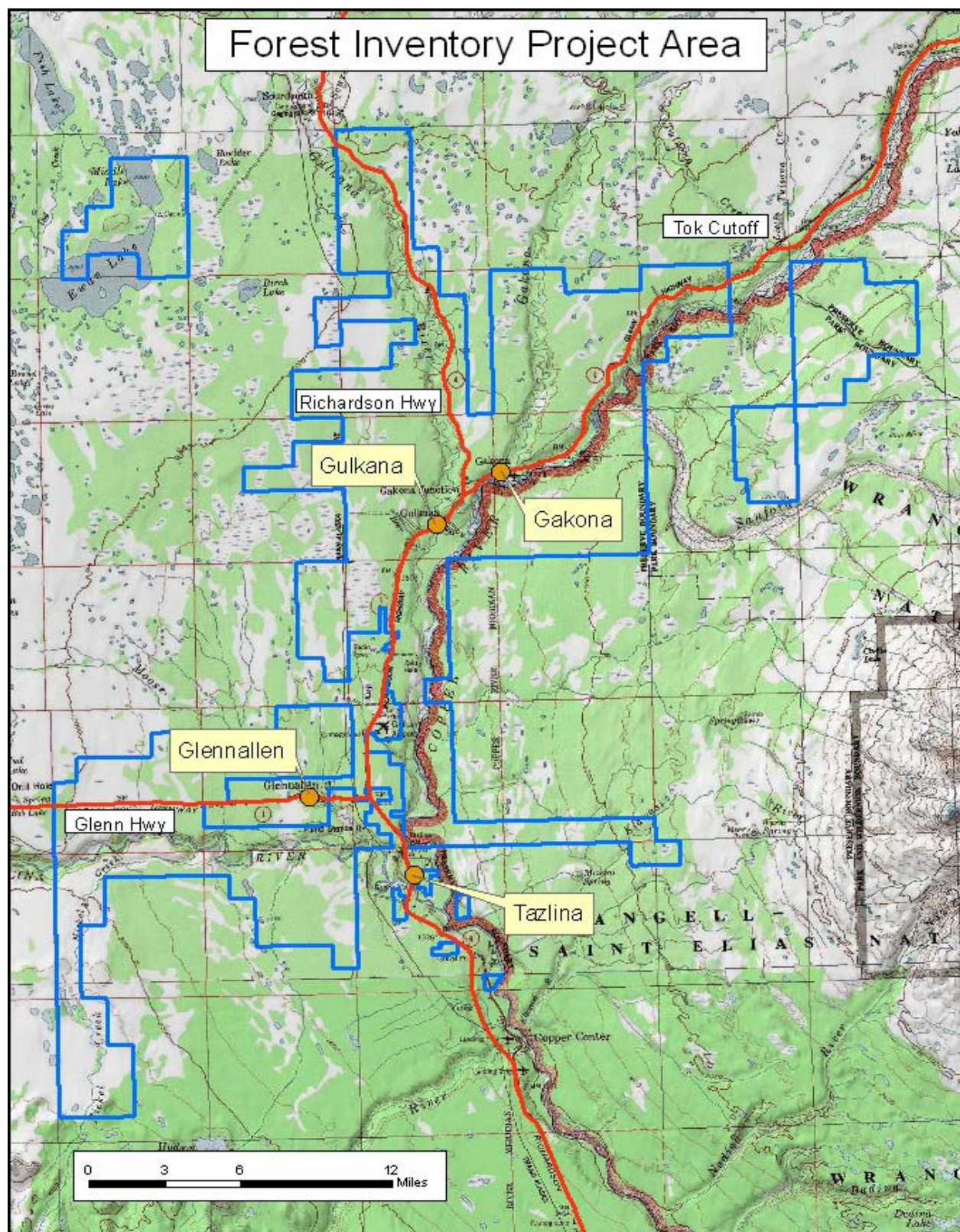


Figure 1. Project area map.

II. OBJECTIVES

The objective of this project is to provide reliable forest inventory data to assist in determining the feasibility of proposed biomass development projects in the central Ahtna region. The village of Gulkana is currently operating a central wood-fired biomass system and small pellet producing machine and is proposing to increase the size and scope of its biomass operation. Tazlina is in the pre-feasibility stage of determining an appropriately scaled biomass system for its health building. There are also biomass proposals in this area for the Glennallen school system as well as Kenny Lake. Determination of an operable land base, sustainable harvest rate and harvest scheduling all require accurate volume data and geographically referenced spatial locations of individual stands. This data, both in spatial and tabular form can be used to assess the availability of timber and biomass resources and determine economic viability of proposed harvest development activities. It is likely that the proposed biomass development projects will source biomass from state lands as well as Ahtna owned lands. The forest inventory on Ahtna lands has been stratified in the same manner as the State of Alaska forest inventory conducted near Glennallen (Hanson, 2010). Thus the two inventories can provide compatible data on a large forested land base in the Copper River Basin.

The inventory on Ahtna lands for the villages of Gakona, Gulkana and Tazlina provide the following items useful for development and planning:

- Geographically referenced stand polygons.
- Acreage determination of forest cover.
- Identification of potentially operable areas.
- Biomass sustainability data to evaluate potential project development.
- Biomass resource information to supplement statewide energy atlas data.

III. METHODS

Forest inventory projects were conducted by the Tanana Chiefs Conference Forestry Program on Ahtna lands for Gakona in 1989, Tazlina in 1990 and Gulkana in 1991. The original forest inventory reports are available on the Tanana Chiefs Conference website (<http://www.tananachiefs.org/forestry.shtm>). Vegetation type maps were created for these projects based on photo interpretation of 1980-1984 high altitude color infrared aerial photography. Vegetation type boundaries were transferred onto topographic base maps and digitized but utilized a very early version of Environmental Systems Research Institute, Inc. (ESRI) software. This data unfortunately was not able to be viewed in the current version of ESRI's ArcGIS suite of software products. To create an updated GIS coverage, the original mylar timber type maps were scanned into raster images and converted into vector-based GIS layers using the ArcScan extension. Vegetation types for the three villages were merged into a seamless coverage and ownership boundaries adjusted for current status of Ahtna owned lands. The acreage of the individual vegetation types was recalculated and forms the basis of area measurements for this report.

In an effort to update the volume figures used in the old inventories, forest inventory field data information collected in 2009 as part of the state's Copper River Basin forest inventory was used

for the new volume per acre figures. This update was deemed necessary due to significant changes in forest types due to spruce bark beetle damage that occurred in the mid 90s. This damage occurred after field sampling took place in the earlier inventories. The updated inventory numbers also include seedling/sapling sized trees (less than five inches diameter breast height) that were sampled with a fixed plot in addition to the variable plot sampling system used for trees greater than five inches. This additional sampling of the smaller trees provides a more accurate estimate of seedling/sapling size class which could potentially be used for biomass.

The individual vegetation types were assigned to the most closely matched volume strata as defined in the Copper River Basin inventory (Appendix A). The inventory contains eight separate sample strata for which estimates of gross and net volume per acre have been calculated (Appendix B). Total inventory volume was calculated by multiplying the average per acre volume figures for each stratum by the number of acres each sample stratum represents. These calculations were performed in a Microsoft Access database and utilize the GIS acreage figures. Output reports written in Access display stand attributes from the associated database tables and queries.

LAND COVER KEY			
SPECIES CALLS			
Forestland		Shrubland	
S	White Spruce	TS	Tall Shrub/Willow/Alder/Other
BS	Black Spruce	DS	Low Shrub/Bog Birch/Other
CW	Cottonwood (bottomland sites)	Tu	Tundra (Herb/Sedge/Grass)
H	Hardwood (Aspen/Birch/Cottonwood)		
Wetland		Special Cover Types	
W	Lakes/Ponds	Ba	Bare Ground/Gravel Bar
B	Bog/Herbaceous Species	Cu(95)	Cultural/Village
DSw	Low Shrub Wet/Bog Birch/Other in seasonably wet area	Cu(98)	Cultural/Road/Airstrips
TSw	Tall Shrub Wet/Willow/Alder/Other in seasonably wet area	Br	Recently Burned Area
STAND DESCRIPTOR CALLS			
S	Sawtimber	≥	9.0 inches DBH
P	Poletimber		5.0 inches to 8.9 inches DBH
R	Reproduction	<	5.0 inches DBH
D	Dwarf	<	25 feet at maturity
STAND DENSITY CALLS			
1	10-24%	Calls are based	
2	25-59%	on crown closure	
3	60-100%	percent.	

Table 2. Land cover key.

Strata Number	Strata Description	Acres
1	White Spruce Sawtimber	739
2	White Spruce Poletimber Closed	19,365
3	White Spruce Poletimber Open	15,313
4	Black & White Spruce Reproduction Closed	1,691
5	Black & White Spruce Reproduction Open	29,995
6	Aspen Poletimber Closed	13,486
7	White Spruce-Aspen Poletimber	10,316
8	White Spruce-Balsam Poplar	1,258
	Total	92,163

Table 3. Volume strata and acreage.

IV. RESULTS

Inventory volume is reported in the tables below and uses the volume strata of the state's Copper River Basin inventory. Thus the per acre values for each stratum reported for the Ahtna lands are the same as for the state's inventory. Only the overall volume estimates have changed because individual strata acreages are different.

The inventory land classification acreage shown in Table 1 indicates similar areas of timberland forests and dwarf forest (92,163 acres and 92,289 acres respectively). Dwarf forests generally comprise black spruce stands that are less than 25 feet tall at maturity. These stands are considered non-commercial even for the use of biomass and do not have a volume estimate. This ratio of timberland to dwarf forest however is significantly less than in the Copper River Basin inventory even though the geographic land form and forested areas are relatively similar. This discrepancy is mainly a factor of the timber typing process of the earlier TCC inventories where a stereoscope was used to interpret 1:63,360 scale aerial photos. In this manner of interpreting, it was difficult to differentiate between dwarf trees and the somewhat better timber contained within the reproduction types of strata 4 and 5. These strata are considered to contain useable biomass. The Copper River Basin inventory utilized automated object based image classification software as well as Summit Evolution stereo viewing software and was able to differentiate between dwarf forests and the better reproduction types. If a similar ratio of timberland forests to dwarf forests in the Copper River Basin inventory (69% timberland, 31% dwarf) was applied to the Ahtna inventory then there potentially could be an additional 35,108 acres of timberland in the inventory that likely will fall within strata 4 and 5.

A. Forest Volume Definitions

Estimates of timber volume on forested lands have been calculated with three different measurements; cubic foot volume, board foot volume and green tons. The cubic foot measurement includes all timber greater than or equal to five inches dbh and is divided among the live and dead poletimber and sawtimber components of the forest. The board foot measurement is commonly used to determine the amount of lumber that can be sawn from a log. Because the measurement is based on actual boards that can be sawn from a log, it disregards all

material wasted in the process such as slabs and sawdust. The board foot measurement only includes timber equal to or greater than 9 inches dbh.

Volume calculations for both cubic and board foot measurements are based on volume equations produced for Interior Alaska; U.S. Forest Service research notes NOR-5, NOR-6 and PNW-59. Board foot volume is reported in Scribner Decimal C scale and is based on 16-foot log segments (short log scale). For spruce it is reported to a 6-inch top (PNW-59) and for hardwoods to an 8-inch top (NOR-5). Cubic volume is reported in Smalian's rule and for spruce and hardwoods includes volume to a 4-inch top (NOR-6). Both live and dead volume is reported. Dead volume includes recently dead trees estimated to have died within the last 16 years. This time period coincides with the spruce bark beetle outbreak.

Volume Formula Name	Volume Unit	Species	Formula
NOR-6	Cubic Foot 4-inch Top	White and Black Spruce	$(-2.055)+0.2982*(dbh)+0.00181*(dbh)^2*ht$
NOR-6	Cubic 4-inch Top	Birch	$(-2.5767)+0.9524*(dbh)-0.10446*(dbh)^2-0.03303*(ht)+0.00282*(dbh)^2*(ht)$
NOR-6	Cubic 4-inch Top	Aspen	$(-0.5553)-0.02216*dbh^2+0.00246*dbh^2*ht$
NOR-6	Cubic 4-inch Top	Balsam Poplar	$(-3.2187)+0.8281*(dbh)-0.05908*(dbh)^2-0.01985*(ht)+0.00199*(dbh)^2*(ht)$
PNW-59	Board Foot Scribner 6-inch Top	White and Black Spruce	$39.71+4.2659*dbh-0.55865*dbh^2-1.1184*ht+0.016113*dbh^2*ht-437.92/dbh^2$
NOR-5	Board Foot Scribner 8-inch Top	Birch and Aspen	$(-27.263)+0.00995*dbh^2*ht$
NOR-5	Board Foot Scribner 8-inch Top	Balsam Poplar	$(-46.7415)+0.00956*dbh^2*ht$

Table 4. Volume formulas by species for poletimber and sawtimber size classes.

Computation of green tons was derived from weight ratios produced for Alaska wood species (Sturgeon 1979. *Wood As A Fuel*.). *Wood As A Fuel* lists the weight of green cord wood which can be converted into pounds per cubic foot. The inventory cubic foot values are converted to green tons using these ratios (*table 5*). A cord of wood is assumed to contain 90 cubic feet of solid wood.

Species	Pounds per Cubic Foot
White Spruce	34
Black Spruce	34
Birch	50
Aspen	43
Balsam Poplar	43

Table 5. Inventory species and weight for poletimber and sawtimber.

B. Inventory Volume by Species

Table 6 lists volume by tree species across all timber types. When the entire volume by species is summed, a grand total of 718,196 net cunits (1 cunit=100 cubic feet=1 CCF) is present. If this total is divided by the timberland area of 92,163 acres, then overall there is 779 net cubic feet per acre. Similarly, overall there are 14.15 net tons per acre and 1,217 net board feet per acre. The values for cubic feet and tons are reported for trees equal to or greater than five inches dbh. Board foot values are reported for trees equal to or greater than nine inches dbh (MBF=1,000 board feet). *Table 7* reports inventory volume by species and size class across all timber types. The sawtimber size class comprises 39% of the total net cubic volume or about 280,000 cunits. The poletimber size class comprises 61% of the total net cubic volume or about 438,000 cunits. Dead sawtimber trees mostly killed from bark beetles comprise 18% of the total sawtimber net cubic volume.

Species	Net CUFT Per Acre	Total Net CUNITS	Net Tons Per Acre	Total Net Tons	Net BDFT Per Acre	Total Net MBF
<i>Aspen</i>	182	167,390	3.90	359,889	67	6,155
<i>Balsam Poplar</i>	15	13,648	0.32	29,343	40	3,702
<i>Birch</i>	2	1,694	0.05	4,234	1	134
<i>Black Spruce</i>	41	38,154	0.70	64,861	2	211
<i>White Spruce</i>	540	497,311	9.17	845,428	1,107	102,000
Total	779	718,196	14.15	1,303,756	1,217	112,202

Table 6. Total net volume across all strata.

Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

		Gross Cunits	Net Cunits	Gross Tons	Net Tons	Gross MBF	Net MBF
<i>Saw Live</i>	<i>Aspen</i>	31,368	29,843	67,441	64,162	6,430	6,155
	<i>Balsam</i>						
	<i>Poplar</i>	11,938	10,805	25,666	23,230	4,126	3,702
	<i>Birch</i>	1,063	850	2,657	2,126	168	134
	<i>Black Spruce</i>	543	391	924	666	264	211
	<i>White Spruce</i>	199,061	188,278	338,404	320,073	85,925	81,095
	Total	243,973	230,167	435,092	410,257	96,913	91,297
<i>Saw Dead</i>	<i>White Spruce</i>	58,823	49,717	99,999	84,519	24,878	20,905
	Total	58,823	49,717	99,999	84,519	24,878	20,905
<i>Pole Live</i>	<i>Aspen</i>	140,565	137,548	302,214	295,728		
	<i>Balsam</i>						
	<i>Poplar</i>	4,442	2,843	9,550	6,112		
	<i>Birch</i>	1,054	843	2,636	2,108		
	<i>Black Spruce</i>	35,185	32,937	59,814	55,993		
	<i>White Spruce</i>	241,637	237,786	410,783	404,236		
	Total	422,883	411,957	784,997	764,177		
<i>Pole Dead</i>	<i>Black Spruce</i>	5,232	4,825	8,894	8,202		
	<i>White Spruce</i>	22,872	21,530	38,882	36,601		
	Total	28,104	26,355	47,776	44,803		
	Grand Total						
		753,783	718,196	1,367,864	1,303,756	121,791	112,202

Table 7. Volume summary by size class and species across strata.

C. Defect Estimates by Species

Defect renders portions of individual trees unusable or of very limited use as forest products due to insect damage, rot and physical damage such as broken stems, sweep and crook. The net volumes shown however do not take into account all defects because hidden defect has not been estimated. Visible defect is the difference between gross and net volume. Visible defect percentage by species is shown in *table 8*.

Species	Gross Cubic Feet/Acre	Net Cubic Feet/Acre	Percent Defect
<i>Aspen</i>	187	182	2.6
<i>Balsam Poplar</i>	18	15	16.7
<i>Birch</i>	2	2	20.0
<i>Black Spruce</i>	44	41	6.9
<i>White Spruce</i>	567	540	4.8
<i>Totals</i>	818	779	4.7

Table 8. Cubic foot defect estimates by species.

D. Inventory Volume by Strata

Timber inventory results by stratum and species are shown in *figure 2* and *table 9*. Detailed results by stratum are contained in appendices B and C.

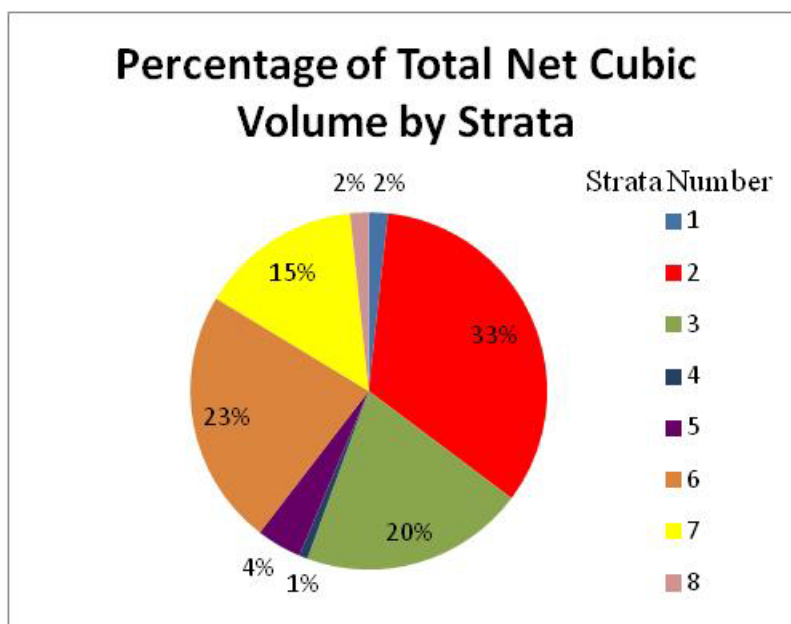


Figure 2. Percent of total net cubic foot volume by strata.

Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

	Net CUFT Per Acre	Total Net CUNITS	Net Tons Per Ac.	Total Net Tons	Net BDFT Per Acre	Total Net MBF
Stratum 1 White Spruce Sawtimber = 739 Acres						
<i>Aspen</i>	0	0	0	0	2	1
<i>Balsam Poplar</i>	10	75	0	161	21	15
<i>Black Spruce</i>	9	65	0	110		
<i>White Spruce</i>	1,661	12,273	28	20,864	4,856	3,588
Totals	1,680	12,413	28	21,135	4,879	3,604
Stratum 2 White Spruce Poletimber Closed = 19,365 Acres						
<i>Balsam Poplar</i>	29	5,626	1	12,097	116	2,253
<i>Black Spruce</i>	94	18,156	2	30,865	11	211
<i>White Spruce</i>	1,120	216,923	19	368,770	2,334	45,187
Totals	1,243	240,705	22	411,732	2,461	47,651
Stratum 3 White Spruce Poletimber Open = 15,313 Acres						
<i>Black Spruce</i>	51	7,797	1	13,255		
<i>White Spruce</i>	904	138,385	15	235,255	2,197	33,639
Totals	955	146,182	16	248,510	2,197	33,639
Stratum 4 Black & White Spruce Reproduction Closed = 1,691 Acres						
<i>Black Spruce</i>	224	3,790	4	6,443		
<i>White Spruce</i>	106	1,794	2	3,049	78	132
Totals	330	5,584	6	9,492	78	132
Stratum 5 Black & White Spruce Reproduction Open = 29,995 Acres						
<i>Black Spruce</i>	12	3,578	0	6,082		
<i>White Spruce</i>	86	25,713	1	43,711	119	3,575
Totals	98	29,291	1	49,793	119	3,575
Stratum 6 Aspen Poletimber = 13,486 Acres						
<i>Aspen</i>	976	131,651	21	283,051	383	5,171
<i>Balsam Poplar</i>	0	11	0	23		
<i>White Spruce</i>	260	35,066	4	59,612	463	6,240
Totals	1,236	166,728	25	342,686	846	11,411
Stratum 7 White Spruce Aspen Poletimber = 10,316 Acres						
<i>Aspen</i>	344	35,451	7	76,220	95	983
<i>Birch</i>	16	1,694	0	4,234	13	134
<i>Black Spruce</i>	46	4,768	1	8,106		
<i>White Spruce</i>	614	63,349	10	107,693	899	9,276
Totals	1,020	105,262	18	196,253	1,007	10,393
Stratum 8 White Spruce Balsam Poplar = 1,258 Acres						
<i>Aspen</i>	23	288	0	618		
<i>Balsam Poplar</i>	631	7,936	14	17,061	1,140	1,434
<i>White Spruce</i>	303	3,808	5	6,473	288	362
Totals	957	12,032	19	24,152	1,428	1,796
Grand Total		718,196		1,303,756		112,202

Table 9. Volume by stratum and species.

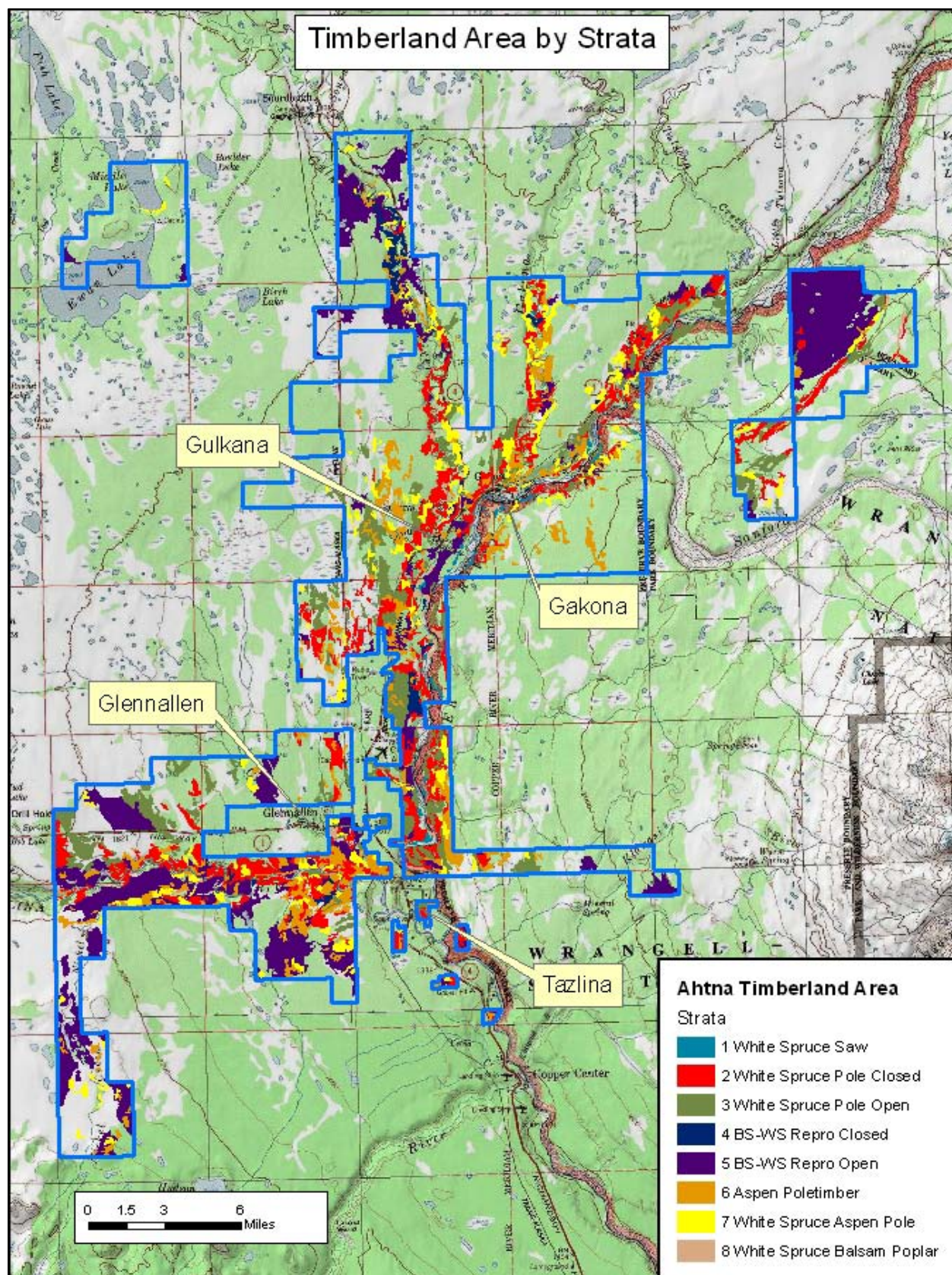


Figure 3. Timberland area by strata.

E. Inventory Volume of Sapling Size Trees

Inventory volume results have been calculated for the sapling component to determine the tonnage of this material that may be available as a biomass resource. These values represent the total above ground portion of the tree including branches and needles and use equations published for Interior Alaska tree species (Yarie 2007. *Aboveground Biomass Equations for the Trees of Interior Alaska*.) White spruce and black spruce equations (table 10) were applied to regeneration diameter and height data to get an estimate of available tons. These equations were compared to wood chip weight recovery data conducted in Tok by the Division of Forestry, Tok Area Office for similar species and size classes. Work continues in Tok to increase the size of the weight recovery dataset and improve accuracy. Due to inaccuracies in projecting weight of very small trees, the equations were only applied to trees with diameters between two and 4.9 inches dbh.

Species	Sapling Aboveground Weight in Pounds
White Spruce, Birch, Aspen Balsam Poplar	$((8628.215 * (dbh * 2.54)) + 525.26667 * (dbh * 2.54)^2 + 6320.94097 * (Ht * 0.3048)) / 453.59237$
Black Spruce	$((2454.230 * (Ht * 0.3048)) / 453.59237)$

Table 10. Inventory sapling species and weight regression equations.

As can be expected, the highest tons per acre values are in the reproduction strata where a greater number of trees less than 5 inches are present. Both strata 4 and 5 contain a significantly higher amount of tonnage in trees less than 5 inches dbh than in trees greater than 5 inches. Depending on accessibility, these stands could be a source of biomass material. If tonnage of sapling, poletimber and sawtimber tree sizes is combined stratum 4 contains 17 tons per acre and stratum 5 contains 7 tons per acre.

	Trees/Acre	Tons/Acre
Stratum 1 White Spruce Sawtimber		
<i>Black Spruce</i>	18	0
<i>White Spruce</i>	95	1
Total Trees Per Acre	114	1
Stratum 2 White Spruce Poletimber Closed		
<i>Black Spruce</i>	78	1
<i>White Spruce</i>	189	3
Total Trees Per Acre	267	4
Stratum 3 White Spruce Poletimber Open		
<i>Balsam Poplar</i>	5	0
<i>Black Spruce</i>	40	0
<i>White Spruce</i>	155	1
Total Trees Per Acre	200	1
Stratum 4 Black & White Spruce Reproduction Closed		
<i>Black Spruce</i>	617	10
<i>White Spruce</i>	50	1
Total Trees Per Acre	667	11
Stratum 5 Black & White Spruce Reproduction Open		
<i>Black Spruce</i>	267	4
<i>White Spruce</i>	167	2
Total Trees Per Acre	433	6
Stratum 6 Aspen Poletimber		
<i>Aspen</i>	130	3
<i>White Spruce</i>	50	1
Total Trees Per Acre	180	4
Stratum 7 White Spruce Aspen Poletimber		
<i>Aspen</i>	38	0
<i>Black Spruce</i>	75	2
<i>White Spruce</i>	138	2
Total Trees Per Acre	250	4
Stratum 8 White Spruce Balsam Poplar		
<i>Aspen</i>	20	0
<i>Balsam Poplar</i>	100	1
<i>White Spruce</i>	180	2
Total Trees Per Acre	300	2

Table 11. Volume summary by stratum and sapling species 2" - 4.9" dbh.

F. Sustained Yield Analysis

Estimates of sustained yield for the entire Ahtna inventory project area have been made to guide future management decisions. The estimates in this analysis only include the timberland acreage and have been calculated using area control, which divides the acreage of each stratum by the rotation age. White spruce and mixed white spruce types use a rotation age of 120 years, which includes 10 years for establishment. The aspen timber type uses a rotation of 80 years, which

includes 10 years for establishment. An annual allowable harvest of 824 acres per year has been calculated for this area. There has been no acreage reductions made for operability concerns. Volume estimates use the current strata volume per acre and do not account for growth in the stands over the rotation period. Estimates of economic sustainable yield based on growth rates and accessible acreage are shown in Section V.

	Strata Description	Acres	Rotation	Acres /Yr.	Net CF/Ac.	Net CF/Yr.	Net Tons /Ac.	Net Tons/ Yr.	Net BF/ Ac.	Net BF/Yr.
1	Ws Saw	739	120	6	1,680	10,346	28	172	4,879	30,047
2	Ws Pole Closed	19,365	120	161	1,243	200,589	22	3,550	2,461	397,144
3	Ws Pole Open	15,313	120	128	955	121,866	16	2,042	2,197	280,356
4	Bs-Ws Repro Closed	1,691	120	14	330	4,650	6	85	78	1,099
5	Bs-Ws Repro Open	29,995	120	250	98	24,496	1	250	119	29,745
6	Aspen Pole	13,486	80	169	1,236	208,359	25	4,214	846	142,614
7	Ws-As Pole	10,316	120	86	1,020	87,686	18	1,547	1,007	86,568
8	Ws-Bp	1,258	120	10	957	10,033	19	199	1,428	14,970
	Totals	92,163		824		668,025		12,060		982,543
	Species Totals									
	Aspen					194,343		4,142		72,743
	Balsam Poplar					11,356		308		30,800
	Birch					1,375		0		1,118
	Black Spruce					31,843		593		1,775
	White Spruce					429,107		7,017		876,107
	Totals					668,025		12,060		982,543

Table 12. Sustained yield estimate, total timberland area.

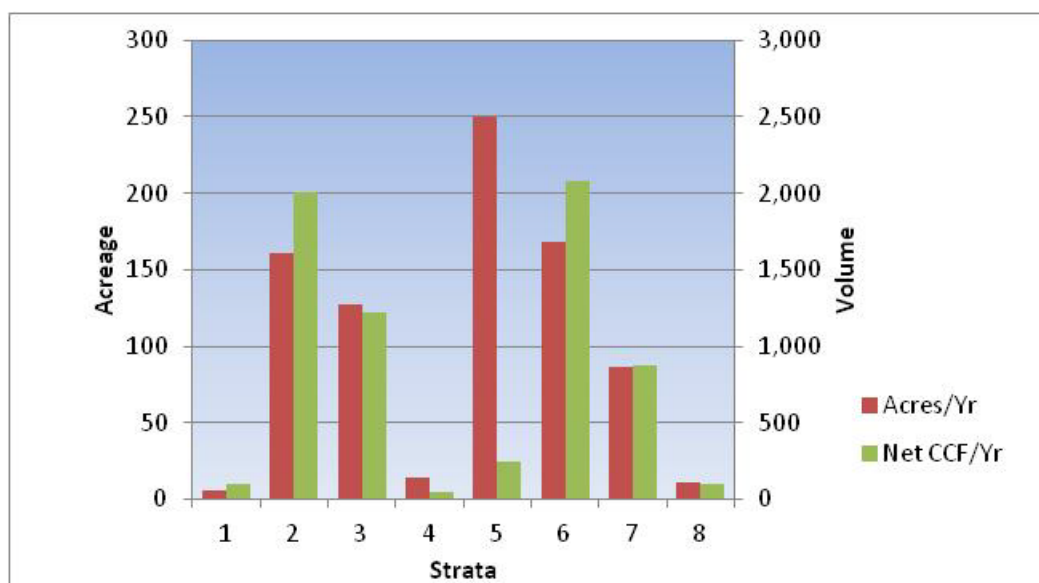


Figure 4. Sustained yield comparison between strata, total timberland area.

V. ECONOMIC AVAILABILITY OF SUSTAINABLE BIOMASS FUELS

The economic availability of biomass was examined in context to the village of Gulkana where the expansion of biomass use is proposed with additional small sized pellet and hammer mills. There are also biomass projects in consideration for Tazlina, Kenny Lake and Glennallen. By conducting an analysis of economic availability the supply of biomass can be further evaluated to help ensure that individual biomass project proposals are sustainable over the long term. This is especially important in Alaska because there is little urban, logging residue or wood manufacturing wood waste available as a supplemental biomass resource. For the most part, the biomass supply for these projects will consist of harvested firewood, commercial grade timber and some wood made available from hazard fuel reduction clearings. When biomass is used in this form it is referred to as “fuelwood”. This is the most expensive of biomass sources (Ashton et al. 2008. *Woody Biomass Desk Guide and Toolkit*). This supply scenario is quite different than the Lower 48 where biomass projects generally rely on a combination of urban wood waste, mill waste and logging residues.

A. Current Delivered Costs

Delivered firewood costs and distance to current supply sources were researched for the Glennallen and Kenny Lake areas for the Copper River Basin inventory. Currently the wood harvests are mostly from State of Alaska timber sales. Delivered prices and distances shown in *Table 13* are from timber sales located at mile 166 of the Glenn Highway. Firewood is hauled and delivered from the harvest site in 8-foot lengths. The timber sale area is in the vicinity of Tolsona Creek which is located on some of the closest state forest lands to Glennallen.

Delivery Location	Delivered Price Per Cord	Cord Configuration	Haul Distance In Road Miles	Working Circle Radius In Miles
Glennallen	\$180	8 Foot Lengths	23	21
Kenny Lake	\$200	8 Foot Lengths	64	47

Table 13. Delivered costs and mileage for firewood sources.

B. Biomass Volume for Five Working Circles

Delivered firewood costs are highly correlated to haul distances. Generally to accurately ascertain the feasibility of a particular biomass project, harvest operation areas defined in working circles can be analyzed for volume quantity, geographic availability and cost of wood. Although the delivered cost and current working circle radius from the two communities to the mile 166 harvest site has been determined, calculating the economic availability of biomass fuels in an entire working circle is difficult because of lack of established infrastructure and barriers to adding new infrastructure. Major barriers to access include the Trans Alaska Pipeline and the numerous incised river systems. To provide a more realistic calculation of the economic availability of biomass, timberland area within the working circles has been reduced to show the

potential operable areas. *Figure 5* illustrates five 5-mile working circles with operable timberland areas identified surrounding Gulkana. The operable area was reduced from the total project area by eliminating areas east of the Copper River and south of the Tazlina River where ice bridge requirements and steep bluffs limit access. The northwest area near Ewan Lake was also eliminated due to extensive winter road access. These areas can be refined through GIS analysis. Operable acreage and volume by stratum for the five 5-mile working circles are shown in *table 15*. Established delivered costs to Gulkana were interpolated to calculate delivered cost per cord by working circle radius mileage (*figure 6*). These values were converted to a green ton basis in *figure 7* by applying the pounds per cubic foot spruce conversion factor (34 pounds/cubic foot).

C. Annual Biomass Yield for Five Working Circles

Volume availability on an annual basis was determined by utilizing the percent growth rates listed by strata in the Copper River Basin inventory (*table 14*). In its simplest form, if timber harvest is equivalent to projected growth, then the harvest would be considered sustainable over the long term. The annual volume availability then is determined by multiplying the live volume within the individual operable working circles by net growth percentage rates by strata.

The delivered cost information was then applied to the operable available volume to develop supply curves in cords and tons for Gulkana. For this analysis it is assumed that delivered cost per cord is equivalent to a cunit basis (i.e. \$/cord=\$/cunit).

Utilizing the maximum radius of 25 miles, a sustainable volume of approximately 7,500 cords would be available for Gulkana on an annual basis. This volume could be available at a cost of about \$200.00 per cord. It should be noted that delivered fuelwood costs are based on current retail rates for the Glennallen area. If suppliers were contracted to deliver to a single location at a fixed price and volume guarantee, it is likely that the delivered cost would be lower than stated here.

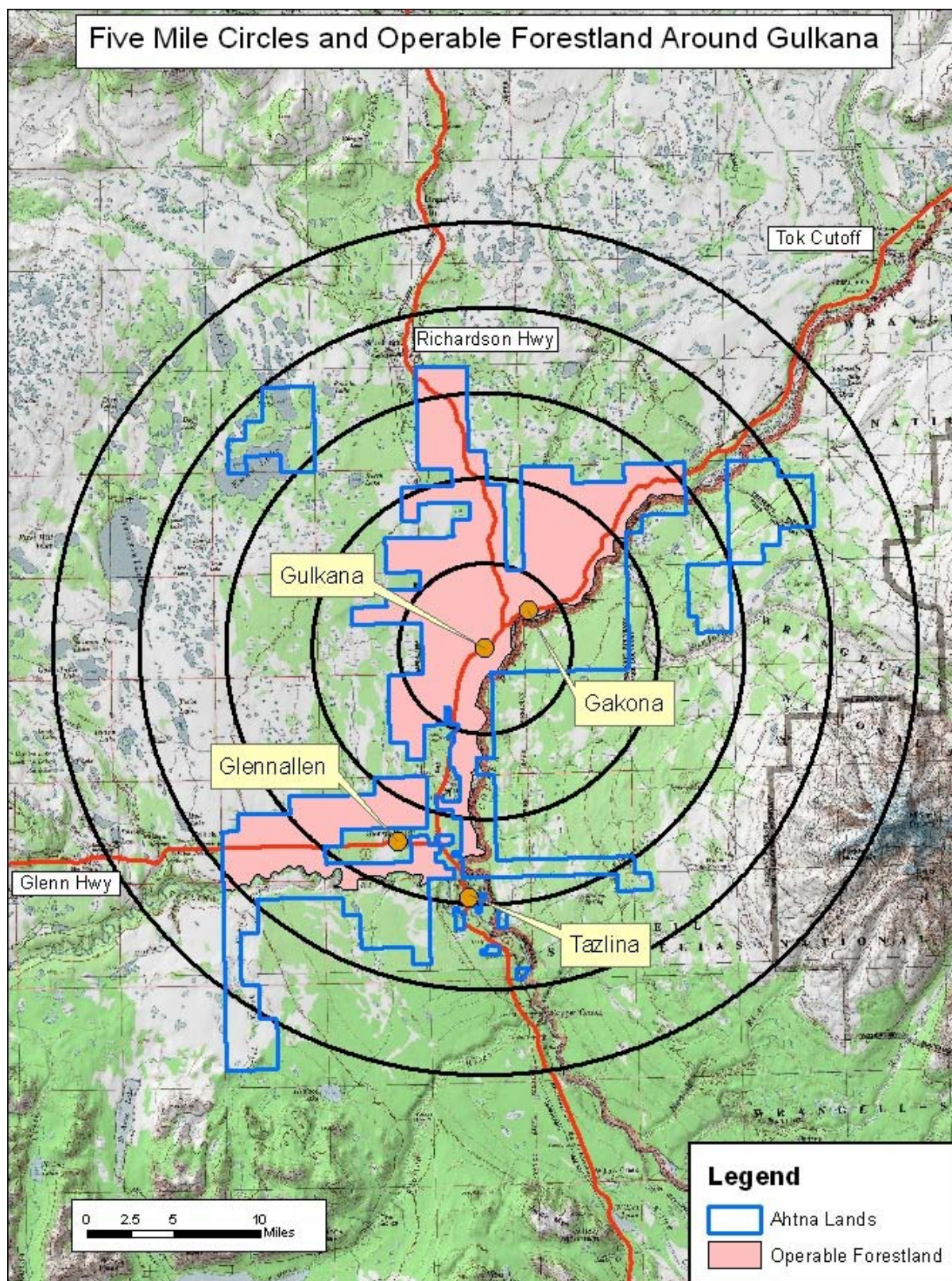


Figure 5. Ten mile circles and operable forestland around Gulkana.

Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

	% Annual Growth	% Annual Mortality	% Annual Net Growth	CF Per Acre Per Year Growth	Total Annual Net Growth Cunits	Tons Per Acre Per Year Growth	Annual Net Growth Tons
Stratum 1 White Spruce Sawtimber	2.57%	1.64%	0.93%	12	91	0.20	156
Stratum 2 White Spruce Poletimber Closed	2.23%	1.26%	0.97%	10	1,938	0.17	3,318
Stratum 3 White Spruce Poletimber Open	1.91%	1.63%	0.28%	2	324	0.03	551
Stratum 4 Black & White Spruce Reproduction Closed	0.98%	0.00%	0.98%	3	55	0.05	93
Stratum 5 Black & White Spruce Reproduction Open	1.79%	0.00%	1.79%	2	524	0.02	891
Stratum 6 Aspen Poletimber	3.94%	0.00%	3.94%	49	6569	1.02	13502
Stratum 7 White Spruce Aspen Poletimber	2.85%	0.13%	2.72%	27	2806	0.52	5240
Stratum 8 White Spruce Balsam Poplar	3.21%	0.04%	3.17%	30	379	0.6	762
Total Live Volume	2.66%	0.85%	1.81%	13	11622	0.23	21,257

Table 14. Growth and mortality estimates, total timberland area.

	0-5 Miles			5-10 Miles			10-15 Miles		
Stratum	Acres	Cunits	Tons	Acres	Cunits	Tons	Acres	Cunits	Tons
1	126	2,112	3,519	53	889	1,482	128	2,150	3,583
2	3,692	45,896	81,233	4,127	51,297	90,791	3,286	40,845	72,292
3	3,272	31,251	52,357	2,795	26,689	44,715	2,422	23,129	38,751
4	105	346	629	477	1,573	2,859	848	2,799	5,090
5	1,492	1,462	1,492	2,116	2,073	2,116	4,993	4,893	4,993
6	2,720	33,613	67,988	2,350	29,044	58,747	1,951	24,114	48,775
7	2,108	21,500	37,940	2,176	22,193	39,163	1,681	17,147	30,259
8	409	3,917	7,777	82	781	1,550	124	1,189	2,361
	13,924	140,096	252,935	14,174	134,539	241,423	15,434	116,268	206,105
	15-20 Miles			20-25 Miles			Totals		
Stratum	Acres	Cunits	Tons	Acres	Cunits	Tons	Acres	Cunits	Tons
1	0	0	0	0	0	0	307	5,151	8,585
2	2,045	25,416	5,592	33	410	725	13,183	163,864	250,632
3	2,342	22,369	3,579	0	0	0	10,831	103,438	139,402
4	53	176	11	0	0	0	1,483	4,893	8,588
5	3,180	3,116	31	177	174	177	11,958	11,719	8,809
6	480	5,928	1,482	35	427	864	7,535	93,127	177,855
7	472	4,812	866	0	0	0	6,436	65,651	108,229
8	0	0	0	7	70	140	622	5,957	11,827
	8,572	61,817	11,560	252	1,081	1,906	52,355	453,801	713,929

Table 15. Gulkana area working circle operable acreage and volume.

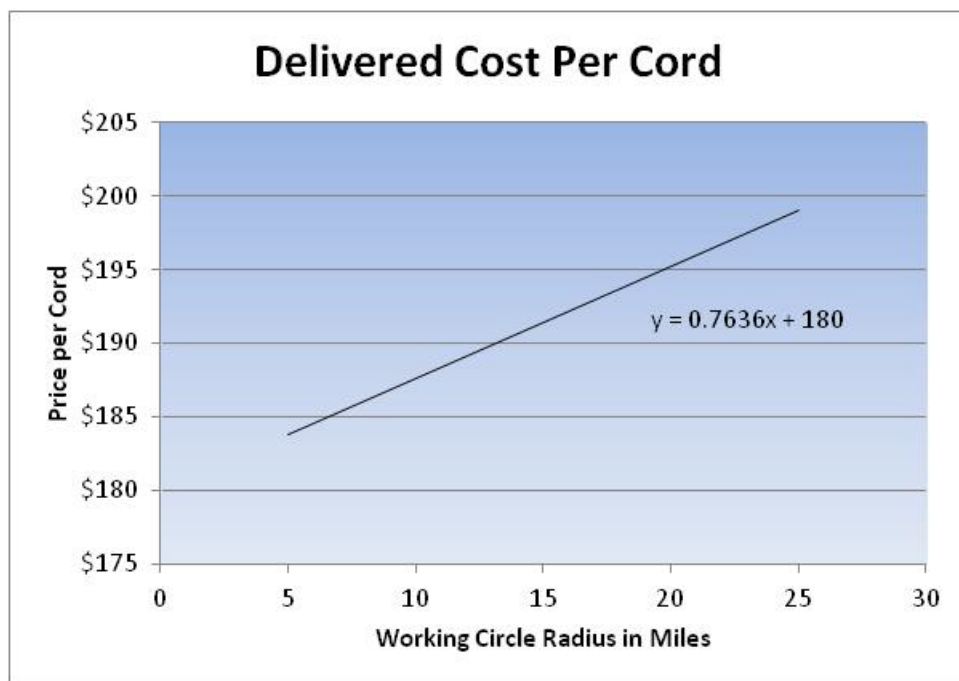


Figure 6. Delivered price per cord by working circle radius.

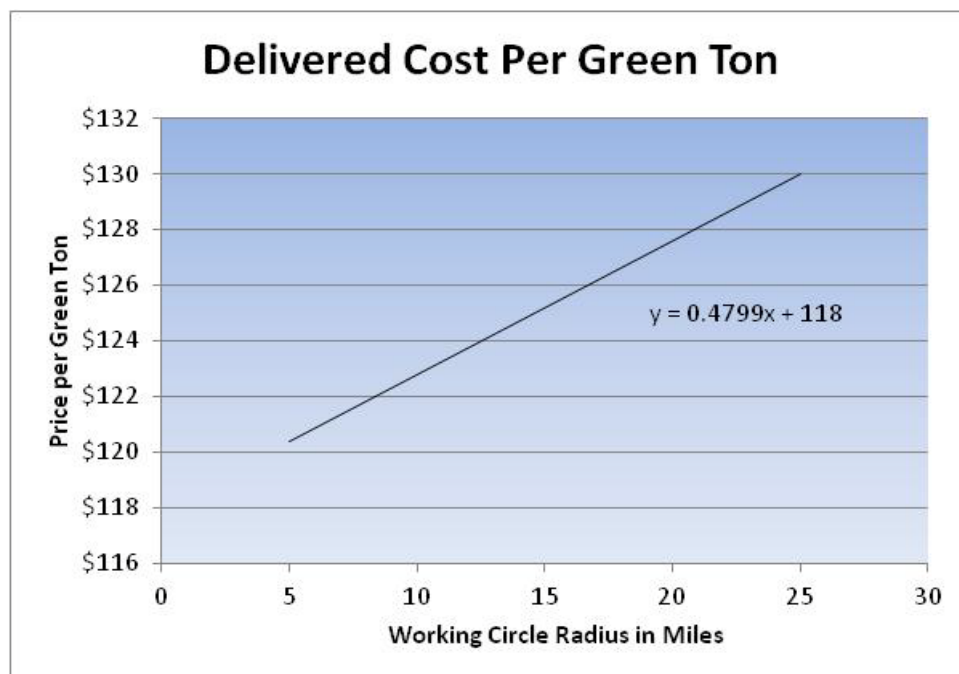


Figure 7. Delivered price per green ton by working circle radius.

Stratum	0-5 Miles		5-10 Miles		10-15 Miles		15-20 Miles		20-25 Miles		Totals	
	Cunits	Tons	Cunits	Tons	Cunits	Tons	Cunits	Tons	Cunits	Tons	Cunits	Tons
1	16	26	7	11	16	26	0	0	0	0	38	63
2	370	645	413	721	329	574	205	357	3	6	1,320	2,302
3	69	110	59	94	51	81	50	79	0	0	230	364
4	3	5	15	23	27	42	2	3	0	0	48	73
5	26	27	37	38	88	89	56	57	3	3	210	214
6	1,324	2,786	1,144	2,407	950	1,999	234	491	17	35	3,669	7,718
7	573	1,089	592	1,124	457	869	128	244	0	0	1,751	3,326
8	123	247	25	49	37	75	0	0	2	4	188	375
	2,505	4,934	2,292	4,467	1,956	3,754	674	1,230	25	49	7,452	14,435

Table 16. Gulkana area working circle annual volume availability.

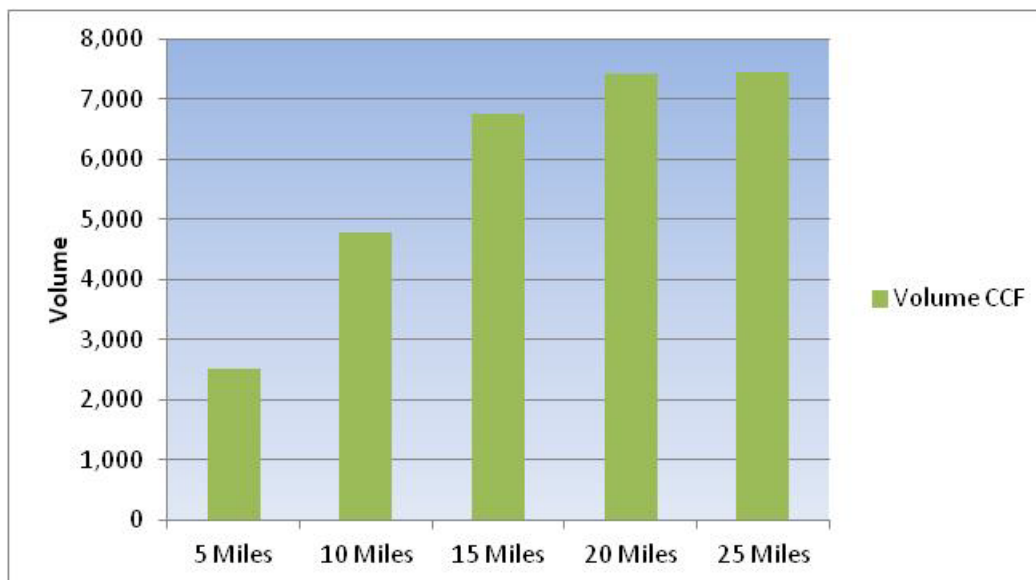


Figure 8. Cumulative volume availability by radii to Gulkana.

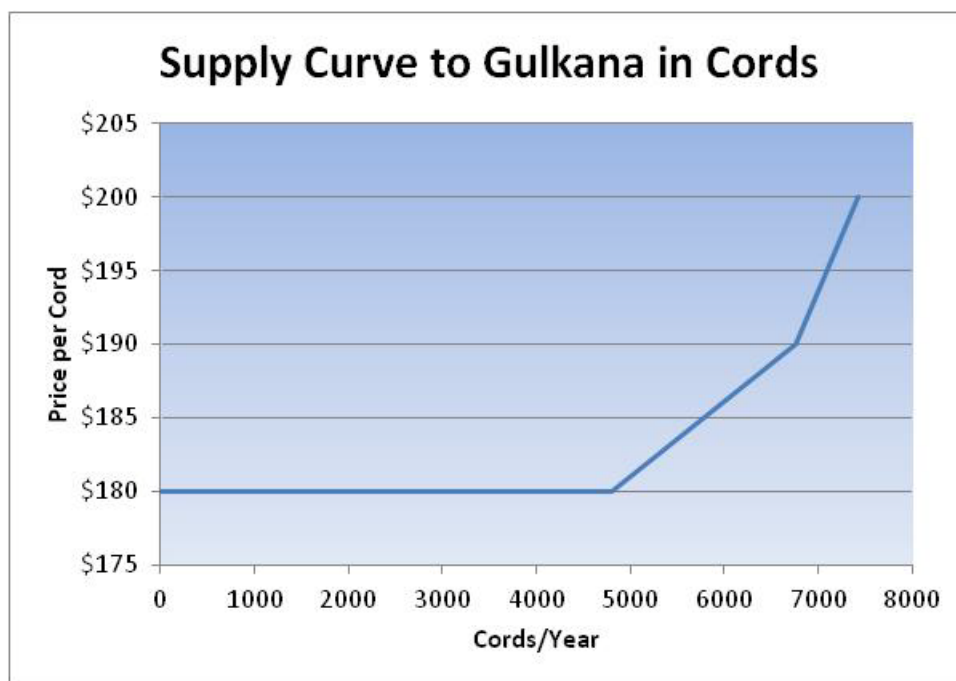


Figure 9. Supply curve for fuelwood in cords to Gulkana.

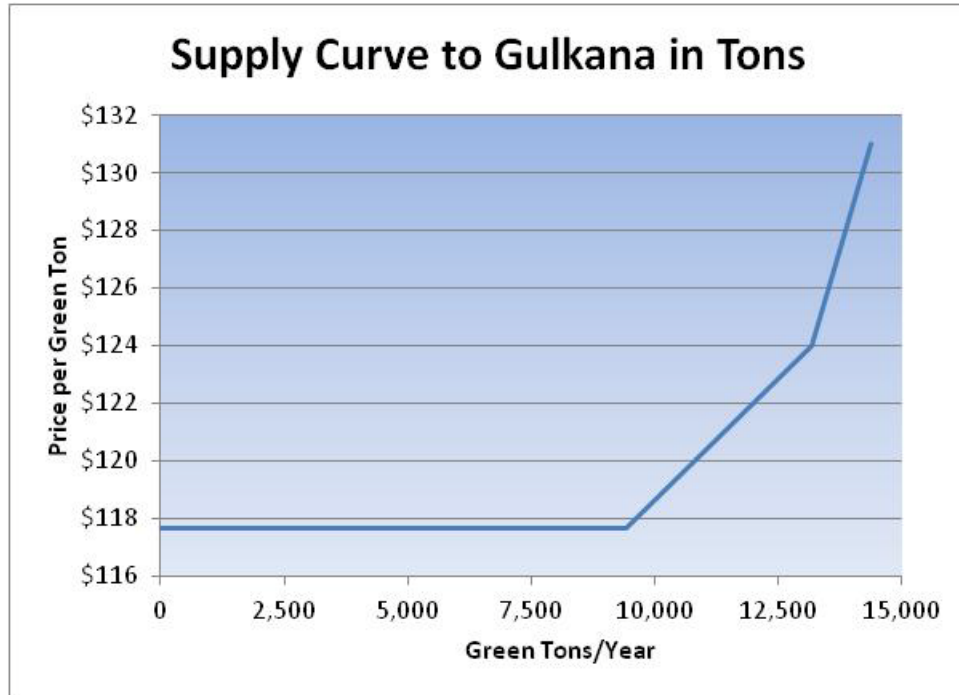


Figure 10. Supply curve for fuelwood in green tons to Gulkana.

VI. LITERATURE CITED

Ashton, S., L. McDonell, and K. Barnes. 2008. *Woody biomass desk guide and toolkit*. National Association of Conservation Districts. U.S. Department of Interior and the USDA Forest Service. 118p.

Sturgeon, J. 1979. *Wood as a fuel*. Series No. R10-40. USDA Forest Service Alaska Region.

Yarie, J., E. Kane, M. Mack. 2007. *Aboveground biomass equations for the trees of interior Alaska*. University of Alaska Fairbanks. AFES Bulletin 115.

Appendix A
Acres by Vegetation Type and Strata

Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

Stratum	Veg. Type	Acres
Non-Forest	B	444.97
	BA	1,032.20
	CU(95)	520.71
	CU(98)	741.61
	DS	2,709.83
	DSw	10,773.66
	DSw_BSD	34.32
	R	9,530.05
	TS	17,898.82
	TS_B	26.53
	TS_BSD	875.99
	TS_HR	36.26
	TS_SR	87.80
	TSw	401.43
	W	5,096.46
Sum Of Acres:		50,210.64
Dwarf Forest		
	BSD	75,016.64
	BSD_DS	3,365.08
	BSD_DSw	5,710.80
	BSDbr	8,195.99
Sum Of Acres:		92,288.51
1	SS1_TS	41.05
	SS2	678.83
	SS3	19.04
Sum Of Acres:		738.92
2	BSP2	844.18
	SP_SP3	106.34
	SP2	9,249.35
	SP3	9,141.29
	SP3_TS	23.41
Sum Of Acres:		19,364.57
3	BSP1	1,904.54
	SP1	2,710.40
	SP1_BSD	9,581.60
	SP1_TS	608.21
	SPbr	508.50
Sum Of Acres:		15,313.25
4	SR	1,328.42
	SR_BSR	362.26
Sum Of Acres:		1,690.68
5	BSD_HR	56.76
	BSD_TS	21,769.59
	SD_HD	51.93
	SR_B	35.39
	SR_BSD	107.68
	SR_HR	6,196.85
	SR_TS	1,777.24
Sum Of Acres:		29,995.44

Stratum	Veg. Type	Acres
6	HP_HP1	108.24
	HP_HP3	202.04
	HP1	1,620.65
	HP1_BSD	28.11
	HP1_SR	25.21
	HP1_TS	106.13
	HP2	3,690.42
	HP3	6,327.93
	HP3_DSw	36.41
	HR	1,340.93
Sum Of Acres:		13,486.07
7	HD	371.86
	HD_B	42.68
	HD_BSD	53.40
	HD_TS	554.57
	HP_SP1	334.35
	HP_SP2	509.69
	HP_SP3	1,803.73
	HR_DSw	129.96
	HR_SR	297.24
	HR_TS	451.77
	SP_HP1	918.18
	SP_HP2	2,368.30
	SP_HP3	2,213.31
	SP_HR3	26.63
	SR_HP3	166.93
	SS_HP1	15.53
	SS_HP2	58.04
Sum Of Acres:		10,316.17
8	CWP1	21.90
	CWP1_TS	75.12
	CWP2	317.93
	CWP3	186.13
	CWR	33.26
	CWR_SR	68.67
	CWR_TS	27.00
	CWS2	148.96
	CWS3	41.89
	SP_CWP2	150.48
	SR_CWR	56.60
	SS_CWP2	43.55
	SS_CWP3	86.35
Sum Of Acres:		1,257.84
Grand Total Sum:		234,662.09

Appendix B
Volume Per Acre and Total Volume by Stratum, Species and Size Class

Stratum 1 White Spruce Sawtimber *Acreage = 739*

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Aspen</i>														
Saw Live	1	0	0	0	0	0	4	2	0	0	0	0	2,997	1,499
Species Totals	1	0	0	0	0	0	4	2	0	0	0	0	2,997	1,499
<i>Balsam Poplar</i>														
Saw Live	1	1	13	10	0	0	25	21	9,637	7,509	207	161	18,536	15,279
Species Totals	1	1	13	10	0	0	25	21	9,637	7,509	207	161	18,536	15,279
<i>Black Spruce</i>														
Pole Live	6	1	9	9	0	0			6,809	6,492	116	110		
Species Totals	6	1	9	9	0	0			6,809	6,492	116	110		
<i>White Spruce</i>														
Saw Dead	19	14	315	253	5	4	1,376	1,084	232,571	187,085	3,954	3,180	1,016,674	801,064
Pole Live	97	26	431	420	7	7			318,522	310,355	5,415	5,276		
Pole Dead	28	8	124	97	2	2			91,384	71,404	1,554	1,214		
Saw Live	66	42	929	891	16	15	3,935	3,772	686,809	658,478	11,676	11,194	2,907,472	2,787,311
Species Totals	210	91	1,799	1,661	31	28	5,311	4,856	1,329,287	1,227,322	22,598	20,864	3,924,146	3,588,375
Strata Totals	218	93	1,821	1,680	31	29	5,340	4,879	1,345,733	1,241,323	22,921	21,136	3,945,679	3,605,152

Stratum 2 White Spruce Poletimber Closed *Acreage = 19,365*

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Balsam Poplar</i>														
Pole Live	0	0	4	1	0	0			68,703	17,176	1,477	369		
Saw Live	2	2	31	28	1	1	129	116	606,074	545,466	13,031	11,728	2,503,113	2,252,802
Species Totals	2	2	35	29	1	1	129	116	674,776	562,642	14,508	12,097	2,503,113	2,252,802
<i>Black Spruce</i>														
Saw Live	0	0	3	2	0	0	14	11	54,345	39,149	924	666	263,814	211,051
Pole Dead	6	1	15	14	0	0			288,044	270,865	4,897	4,605		
Pole Live	39	8	81	78	1	1			1,570,949	1,505,565	26,706	25,595		
Species Totals	45	9	99	94	2	2	14	11	1,913,338	1,815,579	32,527	30,865	263,814	211,051
<i>White Spruce</i>														
Pole Live	153	37	514	509	9	9			9,958,734	9,860,365	169,298	167,626		
Saw Dead	12	8	157	149	3	3	631	604	3,039,801	2,878,761	51,677	48,939	12,218,857	11,704,130
Saw Live	33	19	422	414	7	7	1,766	1,729	8,170,603	8,007,517	138,900	136,128	34,205,373	33,483,106
Pole Dead	14	4	50	49	1	1			971,983	945,690	16,524	16,077		
Species Totals	212	68	1,143	1,120	19	19	2,397	2,334	22,141,121	21,692,333	376,399	368,770	46,424,230	45,187,236
Strata Totals	259	79	1,277	1,243	22	21	2,540	2,461	24,729,235	24,070,554	423,433	411,731	49,191,158	47,651,089

Stratum 3 White Spruce Poletimber Open

Acreage = 15,313

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Black Spruce</i>														
Pole Live	19	4	55	51	1	1			844,791	779,695	14,361	13,255		
Species Totals	19	4	55	51	1	1			844,791	779,695	14,361	13,255		
<i>White Spruce</i>														
Saw Live	23	18	393	376	7	6	1,725	1,650	6,017,607	5,750,251	102,299	97,754	26,415,308	25,269,763
Saw Dead	8	8	170	124	3	2	758	547	2,601,051	1,898,793	44,218	32,279	11,604,478	8,369,128
Pole Live	97	26	341	330	6	6			5,225,353	5,053,610	88,831	85,911		
Pole Dead	13	5	80	74	1	1			1,223,816	1,135,878	20,805	19,310		
Species Totals	142	57	984	904	17	15	2,483	2,197	15,067,827	13,838,533	256,153	235,255	38,019,786	33,638,890
Strata Totals	162	61	1,039	955	18	16	2,483	2,197	15,912,618	14,618,227	270,515	248,510	38,019,786	33,638,890

Stratum 4 Black & White Spruce Reproduction Closed

Acreage = 1,691

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Black Spruce</i>														
Pole Live	158	27	233	224	4	4			393,339	379,002	6,687	6,443		
Species Totals	158	27	233	224	4	4			393,339	379,002	6,687	6,443		
<i>White Spruce</i>														
Pole Live	34	8	92	88	2	1			155,363	148,930	2,641	2,532		
Saw Live	0	1	18	18	0	0	78	78	30,440	30,440	517	517	132,052	132,052
Species Totals	34	9	110	106	2	2	78	78	185,803	179,370	3,159	3,049	132,052	132,052
Strata Totals	192	36	343	330	6	6	78	78	579,142	558,372	9,845	9,492	132,052	132,052

Stratum 5 Black & White Spruce Reproduction Open

Acreage = 29,995

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Black Spruce</i>														
Pole Live	14	2	12	12	0	0			357,752	357,752	6,082	6,082		
Species Totals	14	2	12	12	0	0			357,752	357,752	6,082	6,082		
<i>White Spruce</i>														
Pole Live	23	5	60	60	1	1			1,796,094	1,796,094	30,534	30,534		
Saw Live	5	3	43	26	1	0	199	119	1,291,943	775,166	21,963	13,178	5,958,361	3,575,017
Species Totals	28	8	103	86	2	1	199	119	3,088,036	2,571,259	52,497	43,711	5,958,361	3,575,017
Strata Totals	41	10	115	98	2	2	199	119	3,445,789	2,929,012	58,578	49,793	5,958,361	3,575,017

Stratum 6 Aspen Poletimber

Acreage = 13,486

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Aspen</i>														
Saw Live	27	13	188	180	4	4	395	383	2,532,700	2,430,354	54,453	52,253	5,322,936	5,170,911
Pole Live	258	56	818	796	18	17			11,026,820	10,734,794	237,077	230,798		
Species Totals	285	69	1,005	976	22	21	395	383	13,559,520	13,165,148	291,530	283,051	5,322,936	5,170,911
<i>Balsam Poplar</i>														
Pole Live	3	1	8	0	0	0			107,661	1,077	2,315	23		
Species Totals	3	1	8	0	0	0			107,661	1,077	2,315	23		
<i>White Spruce</i>														
Saw Live	10	6	105	105	2	2	463	463	1,418,115	1,418,115	24,108	24,108	6,240,282	6,240,282
Pole Live	36	11	159	155	3	3			2,150,223	2,088,501	36,554	35,505		
Species Totals	46	17	265	260	4	4	463	463	3,568,338	3,506,617	60,662	59,612	6,240,282	6,240,282
Strata Totals	334	87	1,278	1,236	26	25	857	846	17,235,519	16,672,842	354,506	342,686	11,563,218	11,411,193

Stratum 7 White Spruce Aspen Poletimber

Acreage = 10,316

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Aspen</i>														
Pole Live	55	16	291	290	6	6			2,997,710	2,991,221	64,451	64,311		
Saw Live	9	4	59	54	1	1	107	95	604,097	553,909	12,988	11,909	1,103,574	982,542
Species Totals	64	20	349	344	8	7	107	95	3,601,807	3,545,129	77,439	76,220	1,103,574	982,542
<i>Birch</i>														
Pole Live	3	1	10	8	0	0			105,424	84,339	2,636	2,108		
Saw Live	1	1	10	8	0	0	16	13	106,289	85,031	2,657	2,126	168,103	134,482
Species Totals	4	2	21	16	1	0	16	13	211,713	169,370	5,293	4,234	168,103	134,482
<i>Black Spruce</i>														
Pole Live	18	3	33	26	1	0			344,855	265,204	5,863	4,508		
Pole Dead	7	2	23	21	0	0			235,144	211,629	3,997	3,598		
Species Totals	25	5	56	46	1	1			579,999	476,833	9,860	8,106		
<i>White Spruce</i>														
Saw Live	23	13	214	205	4	3	942	899	2,209,932	2,111,916	37,569	35,903	9,715,248	9,276,204
Pole Live	119	29	412	409	7	7			4,253,607	4,222,970	72,311	71,790		
Species Totals	142	42	627	614	11	10	942	899	6,463,538	6,334,886	109,880	107,693	9,715,248	9,276,204
Strata Totals	235	68	1,052	1,020	20	19	1,065	1,007	10,857,058	10,526,219	202,472	196,254	10,986,925	10,393,228

Stratum 8 White Spruce Balsam Poplar

Acreage = 1,258

	<i>Trees/ Ac</i>	<i>BA/ Ac</i>	<i>Gross CF/ Ac</i>	<i>Net CF/ Ac</i>	<i>Gross Tons/ Ac</i>	<i>Net Tons/ Ac</i>	<i>Gross BF/ Ac</i>	<i>Net BF/ Ac</i>	<i>Total Gross CF</i>	<i>Total Net CF</i>	<i>Total Gross Tons</i>	<i>Total Net Tons</i>	<i>Total Gross BF</i>	<i>Total Net BF</i>
<i>Aspen</i>														
Pole Live	13	3	25	23	1	0			31,954	28,758	687	618		
Species Totals	13	3	25	23	1	0			31,954	28,758	687	618		
<i>Balsam Poplar</i>														
Saw Live	39	29	460	419	10	9	1,276	1,140	578,047	527,505	12,428	11,341	1,604,555	1,434,060
Pole Live	44	13	213	212	5	5			267,844	266,046	5,759	5,720		
Species Totals	83	42	672	631	14	14	1,276	1,140	845,890	793,551	18,187	17,061	1,604,555	1,434,060
<i>White Spruce</i>														
Saw Live	3	3	64	60	1	1	279	263	80,684	75,940	1,372	1,291	351,309	331,025
Saw Dead	0	0	7	6	0	0	30	24	8,843	7,074	150	120	38,319	30,655
Pole Live	87	19	243	237	4	4			305,791	297,743	5,198	5,062		
Species Totals	90	23	314	303	5	5	310	288	395,318	380,757	6,720	6,473	389,628	361,680
Strata Totals	185	68	1,012	956	20	19	1,585	1,428	1,273,162	1,203,067	25,594	24,153	1,994,183	1,795,740

Grand Totals = 92,163 Acres	75,378,257 Gross Cubic Feet	71,819,616 Net Cubic Feet
	121,791,362 Gross Board Feet	112,202,361 Net Board Feet
	1,367,865 Gross Tons	1,303,756 Net Tons

Appendix C
Stand Tables Per Acre by Stratum and Species

Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

<i>DBH</i>	<i>Trees/Ac.</i>	<i>BA</i>	<i>Gross CF</i>	<i>Net CF</i>	<i>Gross BF</i>	<i>Net BF</i>
Stratum	1 White Spruce Sawtimber				<i>Acreage =</i>	738.92
<i>Aspen</i>						
9	1	0	0	0	4	2
<i>Totals</i>	1	0	0	0	4	2
<i>Balsam Poplar</i>						
10	0	0	3	2	3	2
11	1	1	6	4	6	4
13	0	0	4	3	16	14
<i>Totals</i>	1	1	13	10	25	21
<i>Black Spruce</i>						
5	1	0	1	1		
6	5	1	8	8		
<i>Totals</i>	6	1	9	9		
<i>White Spruce</i>						
5	16	2	22	22		
6	29	6	73	71		
7	40	11	177	166		
8	28	10	181	167		
9	34	16	321	301	841	801
10	30	16	350	325	1,441	1,337
11	13	9	197	181	843	769
12	10	8	186	176	819	781
13	5	5	125	97	572	440
14	2	3	80	79	378	376
15	2	3	48	43	223	194
16	2	2	38	32	194	157
<i>Totals</i>	210	91	1,799	1,661	5,311	4,856
<i>Totals for stratum</i>	<i>White Spruce Sawtimber</i>					
	218	93	1,821	1,680	5,340	4,879

Stratum	2 White Spruce Poletimber Closed				<i>Acreage =</i>	19,364.57
<i>Balsam Poplar</i>						
13	1	1	14	10	40	36
15	0	1	10	9	43	39
16	0	1	10	9	46	41
<i>Totals</i>	2	2	35	29	129	116
<i>Black Spruce</i>						
5	21	3	24	24		
6	16	3	34	33		
7	5	1	19	18		
8	3	1	18	17		
10	0	0	3	2	14	11
<i>Totals</i>	45	9	99	94	14	11

Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

<i>DBH</i>	<i>Trees/Ac.</i>	<i>BA</i>	<i>Gross CF</i>	<i>Net CF</i>	<i>Gross BF</i>	<i>Net BF</i>
<i>White Spruce</i>						
5	33	4	35	35		
6	62	13	158	156		
7	40	11	173	171		
8	19	7	104	102		
9	23	11	196	193	395	381
10	16	9	188	185	772	758
11	8	4	84	79	344	325
12	5	4	102	102	445	445
13	3	2	54	54	242	237
15	2	1	33	32	151	147
17	0	0	9	8	49	40
19	0	0	6	3		
<i>Totals</i>	212	68	1,143	1,120	2,397	2,334
<i>Totals for stratum White Spruce Poletimber Closed</i>						
	259	79	1,277	1,243	2,540	2,461

Stratum 3 White Spruce Poletimber Open *Acreage = 15,313.25*

<i>Black Spruce</i>						
5	8	1	9	8		
6	4	1	12	11		
7	6	2	21	20		
8	2	1	14	12		
<i>Totals</i>	19	4	55	51		
<i>White Spruce</i>						
5	22	4	28	27		
6	24	5	54	52		
7	25	7	96	92		
8	29	10	160	155		
9	16	7	133	128	200	199
10	6	3	61	52	262	223
11	3	2	49	47	209	199
12	7	5	115	109	502	476
13	4	4	74	64	315	269
14	2	2	43	40	192	180
15	2	2	52	49	237	224
16	1	1	18	9	86	41
17	1	1	26	18	121	86
18	1	1	21	10	98	46
19	0	1	16	15	75	69
23	0	1	19	18	92	91
24	0	1	19	19	93	92
<i>Totals</i>	142	57	984	904	2,483	2,197
<i>Totals for stratum White Spruce Poletimber Open</i>						
	162	61	1,039	955	2,483	2,197

<i>DBH</i>	<i>Trees/Ac.</i>	<i>BA</i>	<i>Gross CF</i>	<i>Net CF</i>	<i>Gross BF</i>	<i>Net BF</i>
Stratum 4 Black & White Spruce Reproduction Closed						
					Acreage =	1,690.68
<i>Black Spruce</i>						
5	108	16	105	101		
6	33	6	64	61		
7	12	3	41	40		
8	5	2	23	22		
Totals	158	27	233	224		
<i>White Spruce</i>						
6	21	4	40	38		
7	13	4	48	46		
8	0	0	4	4		
10	0	1	18	18	78	78
Totals	34	9	110	106	78	78
Totals for stratum Black & White Spruce Reproduction Closed						
	192	36	343	330	78	78

Stratum 5 Black & White Spruce Reproduction Open						
					Acreage =	29,995.45
<i>Black Spruce</i>						
5	14	2	12	12		
Totals	14	2	12	12		
<i>White Spruce</i>						
6	12	2	18	18		
7	7	2	25	25		
8	4	1	17	17		
10	5	3	43	26	199	119
Totals	28	8	103	86	199	119
Totals for stratum Black & White Spruce Reproduction Open						
	41	10	115	98	199	119

Stratum 6 Aspen Poletimber						
					Acreage =	13,486.07
<i>Aspen</i>						
5	91	13	162	160		
6	83	16	211	206		
7	51	14	228	221		
8	27	10	176	167		
9	17	7	116	110	95	88
10	12	4	47	45	74	72
11	5	3	58	58	188	186
12	0	0	8	8	38	37
Totals	285	69	1,005	976	395	383
<i>Balsam Poplar</i>						
8	3	1	8	0		
Totals	3	1	8	0		

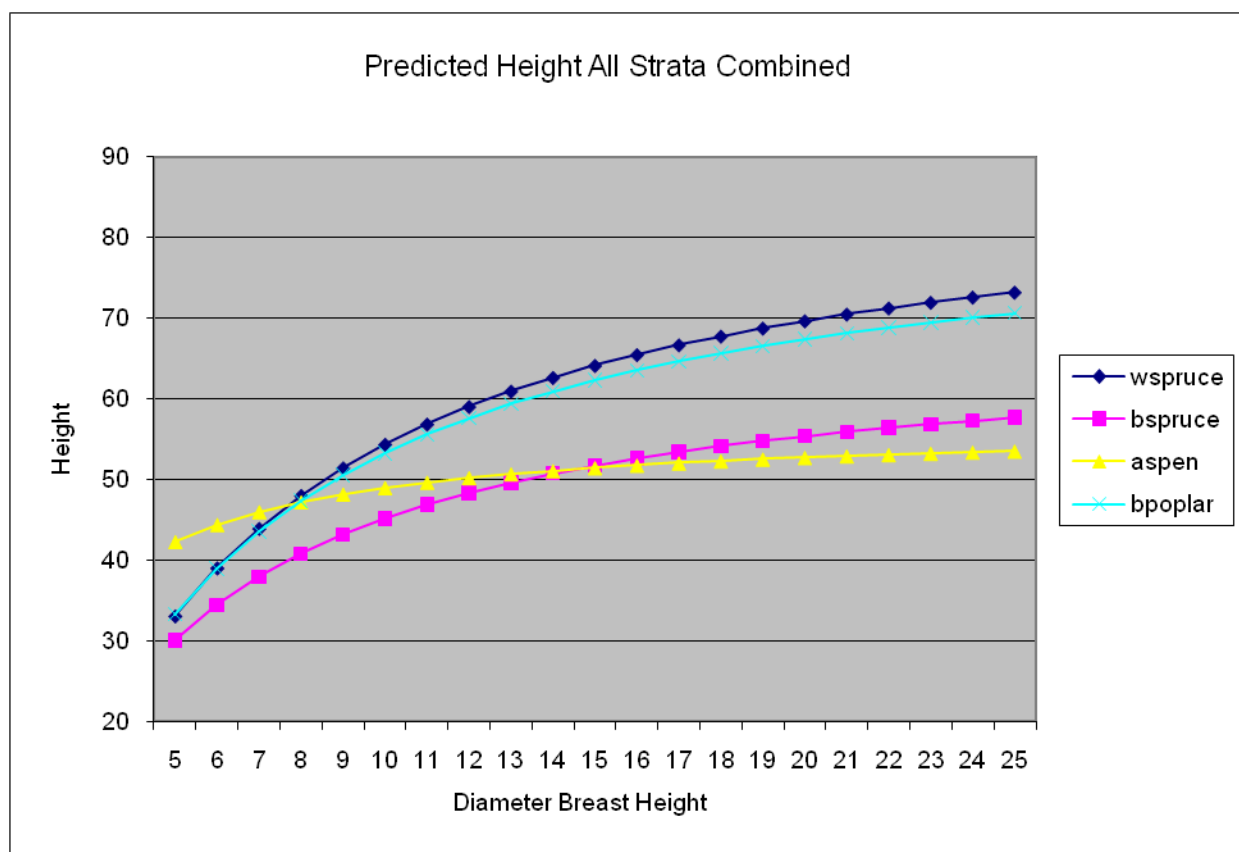
Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

<i>DBH</i>	<i>Trees/Ac.</i>	<i>BA</i>	<i>Gross CF</i>	<i>Net CF</i>	<i>Gross BF</i>	<i>Net BF</i>
<i>White Spruce</i>						
5	3	0	0	0		
6	7	1	14	14		
7	5	1	26	25		
8	14	5	73	71		
9	9	4	60	58	53	53
10	2	1	17	17	74	74
11	5	2	24	24	107	107
13	2	2	31	31	137	137
15	1	1	20	20	92	92
<i>Totals</i>	46	17	265	260	463	463
<i>Totals for stratum Aspen Poletimber</i>						
	334	87	1,278	1,236	857	846
Stratum 7 White Spruce Aspen Poletimber					<i>Acreage = 10,316.16</i>	
<i>Aspen</i>						
6	24	5	83	83		
7	12	3	64	64		
8	15	5	109	109		
9	8	4	66	65	39	39
10	4	2	28	23	68	56
<i>Totals</i>	64	20	349	344	107	95
<i>Birch</i>						
7	3	1	10	8		
9	1	1	10	8	16	13
<i>Totals</i>	4	2	21	16	16	13
<i>Black Spruce</i>						
5	7	1	4	4		
6	3	1	4	4		
7	15	4	48	39		
<i>Totals</i>	25	5	56	46		
<i>White Spruce</i>						
5	12	2	17	17		
6	59	12	143	141		
7	34	9	139	138		
8	11	4	75	75		
9	10	5	83	75	277	239
10	5	2	40	40	178	178
11	5	3	48	48	209	209
12	6	4	60	60	179	179
13	1	1	22	21	99	94
<i>Totals</i>	142	42	627	614	942	899
<i>Totals for stratum White Spruce Aspen Poletimber</i>						
	235	68	1,052	1,020	1,065	1,007

Availability of Biomass Fuels on Ahtna Lands Gakona, Gulkana and Tazlina Villages

<i>DBH</i>	<i>Trees/Ac.</i>	<i>BA</i>	<i>Gross CF</i>	<i>Net CF</i>	<i>Gross BF</i>	<i>Net BF</i>
Stratum	8 White Spruce Balsam Poplar				<i>Acreage =</i>	1,257.85
<i>Aspen</i>						
6	7	2	13	12		
7	6	2	12	11		
<i>Totals</i>	13	3	25	23		
<i>Balsam Poplar</i>						
6	17	3	29	29		
7	4	1	24	23		
8	15	5	85	84		
9	19	9	139	136	21	20
10	15	8	138	134	185	183
11	7	5	98	92	244	235
12	2	2	41	34	157	146
13	2	3	55	52	220	212
14	2	4	48	32	253	178
17	1	2	15	13	195	167
<i>Totals</i>	83	42	672	631	1,276	1,140
<i>White Spruce</i>						
5	29	4	35	35		
6	36	7	86	86		
7	8	2	28	27		
8	11	4	74	70		
9	3	1	20	18		
11	1	1	22	19	98	84
12	2	1	28	27	120	118
13	0	0	7	6	30	24
14	0	1	14	14	61	61
<i>Totals</i>	90	23	314	303	310	288
<i>Totals for stratum White Spruce Balsam Poplar</i>						
	185	68	1,012	956	1,585	1,428

Appendix D
Diameter/Height Relationships



Reciprocal dbh height prediction model:

$$ht_{top} = ae^{\frac{-b}{dbh^c}}$$

Species	A Coefficient	B Coefficient	C Coefficient
White Spruce	89.28	-4.9598	1
Black Spruce	67.86	-4.0686	1
Aspen	56.78	-1.4744	1
Balsam Poplar	85.23	-4.7001	1

"e" is a numerical constant that is equal to 2.71828

The corresponding Excel equation appears as follows:

Height = A Coefficient*POWER (e, B Coefficient/dbh)