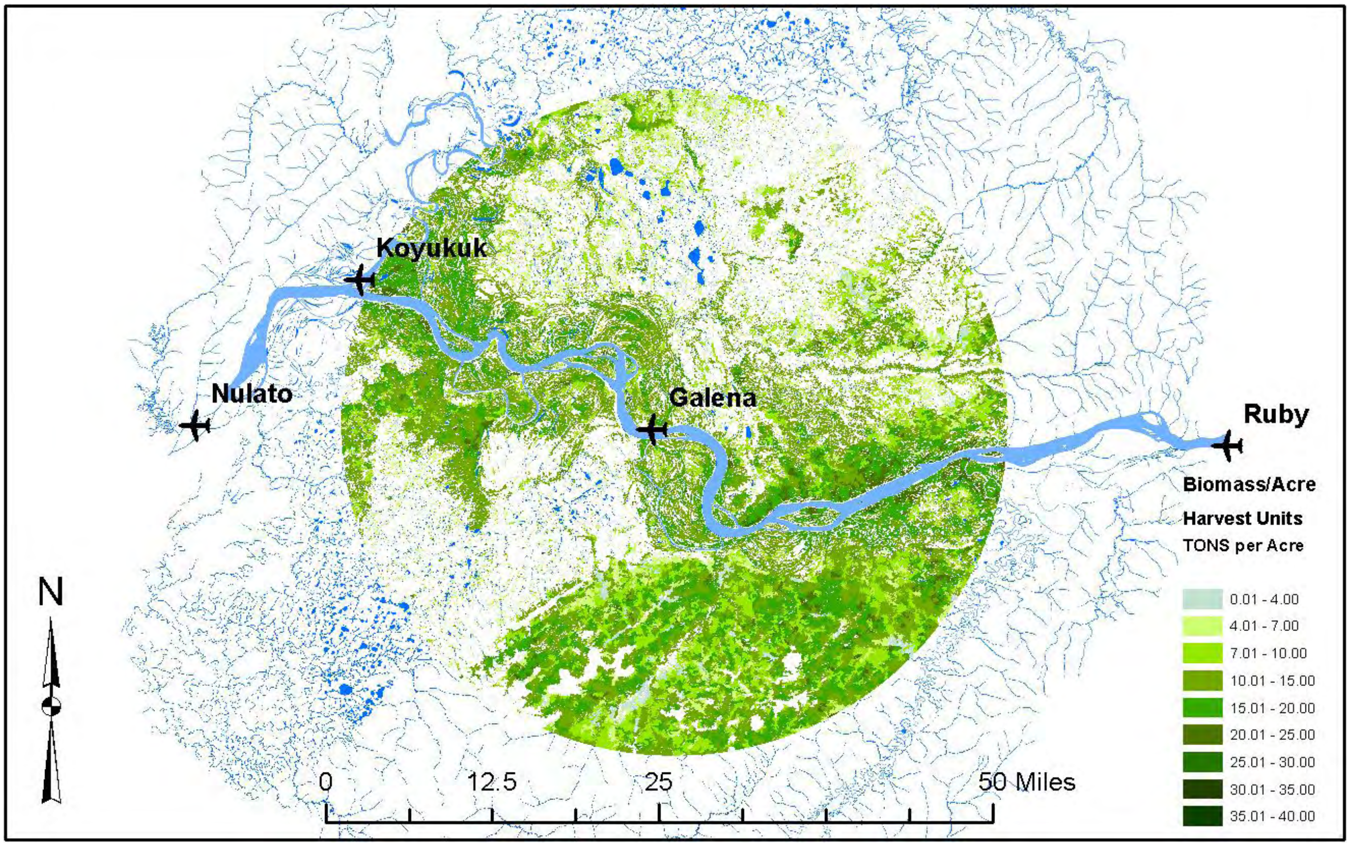
Galena Forest Inventory and Management Plan Report



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Executive Summary

The city of Galena is located along the Yukon River in interior Alaska. Galena is off the Alaska power grid and dependent on outside sources of petroleum-based fuels for the production of heating and electricity. Because of the rising costs of their energy source, a consortium of Galena community leaders obtained a grant from the Alaska Energy Authority in 2011 to evaluate and define the nature and extent of the biomass resource in the Galena area. In early 2012 Geographic Resource Solutions (GRS) was chosen to conduct a biomass resource study within a 25-mile radius of Galena (Galena Vicinity), develop a biomass inventory, and provide a sustainable management plan to potentially utilize that biomass for local energy production.

GRS initially conducted a literature review and acquired as much currently available ancillary geographic, cultural, and natural resource information thought pertinent to this study. This information was all compiled in GRS's geographic information system (GIS). GRS then reviewed vegetation inventory data available for the Galena area and determined that data collected on the two nearby wildlife refuges by Ducks Unlimited (DU) in the late 1990's-early 2000's would be the best available resource information to use as a foundation for inventory efforts. GRS then used recent Landsat 5 satellite imagery to stratify the Galena Vicinity and identify potential field training sites. GRS then visited 63 field data sites at which they collected detailed resource information that they used to verify, refine, update, and replace portions of the DU data set. The updated data set was then applied to the Landsat 5 imagery using GRS's Discrete Classification methodology to generate classification maps. These maps were then aggregated to produce a site-specific Stand Inventory polygon map data set of Viereck types and associated species-specific biomass estimates for all lands in the Galena Vicinity. The total biomass inventory estimated to be in the 25-mile radius of Galena is 5,050,297 Cft3 and 7,820,609 dry tons.

This Stand Inventory was associated with different landscape and cultural characteristics of the Galena Vicinity and evaluated to develop an estimate of Available Biomass Inventory. A site-specific Harvest Unit map data set was developed and five harvest plans (Options) were generated using GRS's application ***harvestBiomass*** to project long-term sustained yield levels for the Galena Vicinity. All five alternative plans met the maximum stated target of 20,000 tons per year for the projection period (2013-2110), however the different alternatives reflect different levels of annual biomass procurement cost that range from approximately $1.56 million to $1.92 million per year. The major cost component of these management plans is Transportation Costs, which ranged from 59% to 70% of the total biomass procurement costs. The estimated cost/ton of harvested biomass ranges from just under $78/ton to over $94/ton depending on the management option.

The different plans represent different levels of harvest intensity near Galena and the Yukon River; acreage harvested and reforested; winter and summer season transportation; transportation system development; and environmental impact. Options can be ranked by cost, but non-market values may play a significant role in which option best fits the community. Ultimately, the choice of how to proceed with future biomass procurement efforts in the Galena Vicinity rests with the path that the community of Galena chooses to follow through the options that are available.

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Introduction

The city of Galena is located in the interior of Alaska, about 270 air miles west of Fairbanks and 330 air miles northwest of Anchorage. Galena is inaccessible by road and is not connected to the Alaska power grid. The major form of transportation in and out of Galena is by plane. Freight and supplies are either barged into Galena on the Yukon River or flown in by aircraft. Heating and electricity are produced by the City by burning petroleum-based fuel that has been transported to Galena. So, except for supplemental home heating provided by burning firewood cut by individuals of the community from the local area, all other heating and electricity is produced by burning petroleum-based fuel acquired from out of the area.

Due to rising costs, unreliable availability, and reliance on external sources of the fuel that is currently being used for both heating and electricity, the local community has become interested in the future use of alternative sources of energy for the generation of their local heating and electricity. A number of alternative sources have been suggested, such as coal, nuclear, hydro, wind, solar, and biomass, and addressed in the 2004 report, Galena Electric Power – a Situational Analysis. That report characterized biomass as not being a viable source of energy. The growth of the biomass industry and its recent acceptance in rural areas of Alaska and Canada has led to a greater interest in biomass as an energy source. Due to the apparent availability of biomass resources in Alaska, the Alaska Energy Authority has provided grants to encourage the further study of the feasibility of using biomass to produce heat and electricity.

A consortium of the Louden Tribal Council in cooperation with the Gana-A'Yoo Ltd., the City of Galena, and the Galena School District acquired such a grant from the Alaska Energy Authority in the fall of 2011 to specifically estimate the nature of the biomass inventory present in the approximate 25-mile area around Galena. The consortium, under the Louden Tribal Council, released a Request for Proposals (RFP) to accomplish such a study in late 2011.

The three stated objectives of the Request for Proposals were:

1. Provide an accurate and credible estimate of the biomass resource in the Galena area suitable for long-term renewable energy development.

2. To complete of the forest inventory in a timely manner.

3. Create a management plan to consider cost and biomass harvest scheduling, with initial estimates of consumption of 3,000 to 20,000 tons of fuel wood per year.

Geographic Resource Solutions (GRS) of Arcata, CA was awarded the contract to perform these services. This report addresses the stated project objectives and provides a basis for decision-making and planning regarding the utilization of the biomass for energy production in the Galena area. GRS assessed the nature and extent of the biomass resource within the vicinity of the City of Galena, Alaska and has estimated how much of this resource could be available to use as a sustainable fuel source for a wood-based power generation facility. In addition, GRS has developed projections of potential sustainable harvest levels of woody biomass now and into the future. The results of this project indicate that many alternative paths to biomass power production exist. While GRS can make recommendations, as it has in this report, the ultimate decision of the actual course to follow may be a hybrid of information presented in this report, or developed at a later time based upon further analysis of new questions regarding the use of this resource. The final decision of how to pursue this matter is going to be up to the community of Galena.

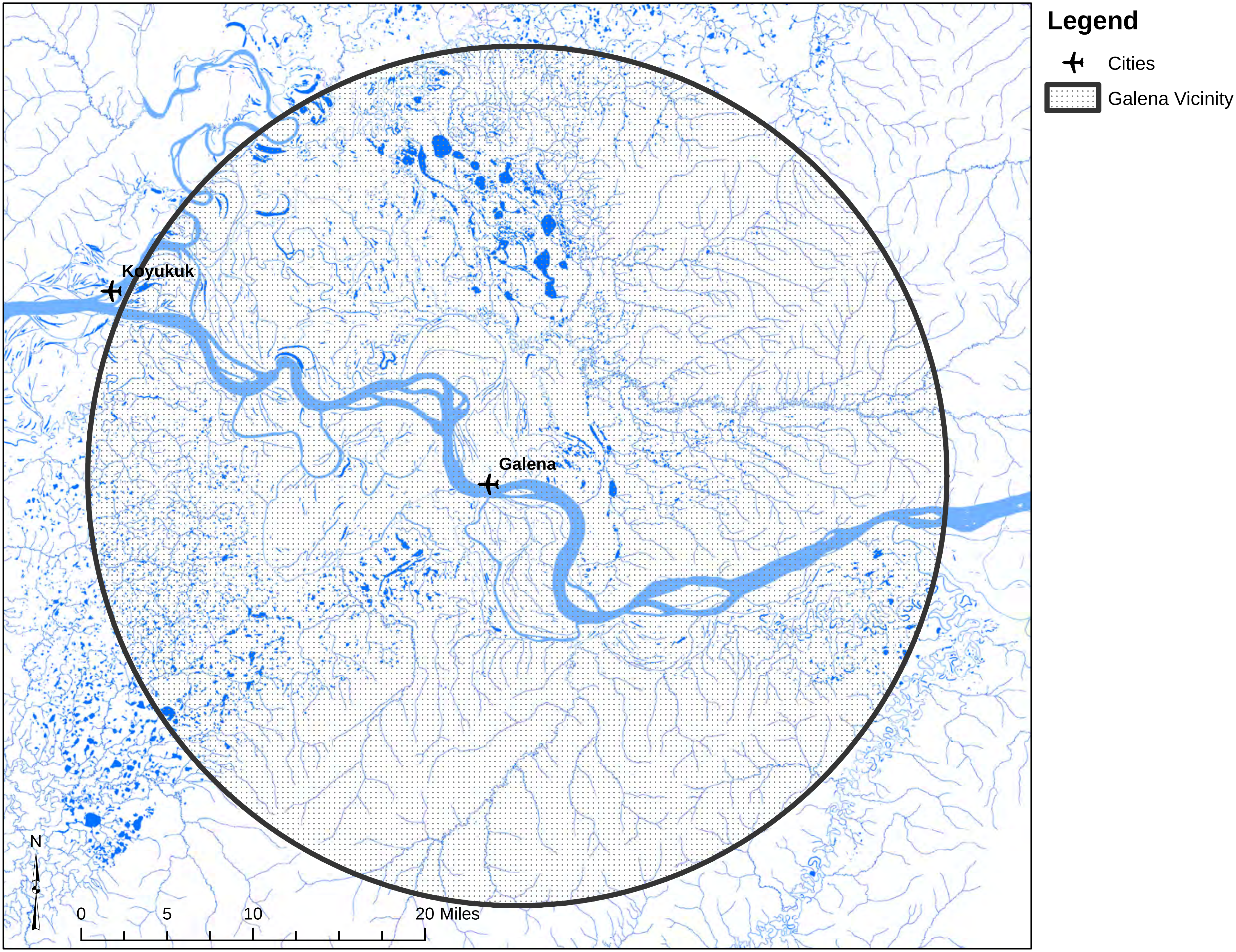
GRS must caution that this assessment is based upon a very limited set of field data that has been applied to a very large regional area using image classification techniques based upon statistical processes and applications. An inventory of this nature is a regional inventory and provides inventory estimates at a regional level. This inventory and site specific projections are subject to human interpretation, verification and adjustment and there will be differences between site-specific estimates and on-the-ground experience. Such site-specific differences however, should balance out over the whole of the area being inventoried and mapped. Projections based upon these inventory data are not "cast in concrete" and will need to be managed as plans and conditions change over time. This inventory and planning information can also be refined using updated and improved inventory and growth information as it is acquired during future operations and studies in the Galena area.

Figure 1 shows the area of the 25-mile radius Galena Working Circle or Vicinity along with lakes, rivers, streams, existing roads, and nearby cities and villages.

Project Methodology

GRS planned to implement an inventory/mapping methodology based upon using as much existing resource inventory data as possible and then supplementing or replacing that data with more current and representative data that met the information needs of this project. The primary sources of existing field data were the cover-based Earth Cover Mapping projects performed by Ducks Unlimited in the late 1990's-early 2000's. As no current forest inventory data existed to accurately represent the forest resources within the Project Area, GRS planned to collect as much forest inventory data as the budget allowed and then merge this more recent inventory information into the older data and information replacing the older unsuitable information with the new detailed information.

Figure 1: Galena Vicinity - 25-mile Radius Working Circle



Data/Information Review

Prior to undertaking this effort, GRS gathered and collected existing information regarding the forest resources, inventories, and forestry management for the interior region of Alaska similar to the Galena Vicinity. These efforts included The Fort Yukon Biomass Resource Assessment Report by TCC Forestry Director Will Putman, as well as other published information about biomass energy production and harvest in Alaska. Alaska DNR projects in the Tok vicinity were also considered. Past studies and papers dealing with northern boreal forest growth and productivity of conifer and hardwoods occurring in the Galena vicinity were reviewed. Tree volume estimation processes were reviewed to determine the most appropriate means of estimating biomass on a species-specific basis. Past mapping and inventory efforts in the Galena vicinity were reviewed, with particular emphasis on the past (late 1990's-early 2000's) mapping efforts by Ducks Unlimited (DU) on the Innoko and Koyukuk National Wildlife Refuges.

Data Sources

Landscape and Cultural Information

A variety of data sets for different landscape and cultural themes or characteristics were acquired and stored in GRS's geographic information system (GIS) to represent planimetric, topographic, hydrologic, transportation, and cultural information for the Galena Working Circle. The USGS digital elevation data (DEM) was used to generate slope and aspect data sets. GRS developed an Access (seasonality of access) theme for the Galena Vicinity using the USGS National Hydrology data set and the slope, aspect, and elevation data. Land ownership and administration, fire history, and city/village locations were downloaded and recreated in GRS's GIS based upon the BLM Spatial Data Information available through their website (BLM-SDMS, 2012 and BLM-AICC, 2012).

Other landscape information that would be used in this project was developed by GRS. Distance information, in terms of miles, was developed using grid data processes based upon the location of Galena (an X,Y coordinate located very close to City Hall). Nine distance zones were created based upon creating concentric bands of distance (miles) from Galena that would represent nearly equal areas. In addition, GRS developed directional information that could be used to focus harvest projections in specific regions of the Galena Vicinity. Thirty-six (36) directional, azimuth zones used in harvest projection efforts were created based upon sweeping an angle (azimuth) clockwise through the Galena Working Circle and identifying 10-degree wide zones that were created. GRS developed Transportation Cost estimates for the entire Galena Vicinity based upon an evaluation of the Access and Distance grid information. All GIS data used or developed during this project were projected to the Alaska Alber's Equal Area Projection, NAD83, units of meters.

Satellite Imagery

Landsat 5 TM image data sets acquired on July 12, 2009 (20090712) and September 24, 2010 (20100924) were reviewed on the USGS GLOVIS website (USGS-GLOVIS, 2012) and downloaded for use during this project. These two 30-meter resolution multi-spectral images were determined to be the best imagery available for use in this project. While the 20090712 image (Path 74, Rows 14 and 15) had what appeared to be the best spectral qualities, as it was acquired in July, there were some cloud cover issues, as well as coverage limitations to the west that limited its application to the entire Galena Vicinity. The 20100924 image (Path 75, Rows 14 and 15) had no such cloud cover or coverage limitation issues, but was potentially of lesser quality if the late season acquisition date (lower sun angle) might limit the spectral separation of different vegetation characteristics, especially if it was acquired during the leaf-off state of the deciduous plants. As much of the Galena Vicinity was relatively flat with little or no terrain shadowing due to the low sun angle and as this imagery provided complete cloud free coverage of the Project Area, the 20100924 image (7515f) was used for most image processing/mapping efforts and the 20090712 image (7415f) was used to supplement processing/mapping efforts. All image data were projected to the Alaska Alber's Equal Area Projection, NAD83, units of meters.

During past similar projects GRS has identified the need to remove/reduce the effects of differential illumination due to slope and aspect on the satellite imagery (while slope and aspect were minimal in most regions of the Project Area there were still a few area where differential illumination was visible in the imagery). The benefits of such a correction effort are twofold in that removal of these differential illumination effects reduces confusion of training classes and decreases the number of field sites necessary to describe the different vegetation/land cover types present in the area. Reduction of the number of field sites is of particular importance to this mapping effort, since so much of the area is either inaccessible or too costly to sample within the budget constraints of this mapping effort. Correction for differential illumination should result in needing fewer field sample sites to describe the vegetation using image classification techniques (Stumpf, 1999). GRS performed the illumination correction on both image data sets used during this project.

Existing Field Data

Past mapping efforts covering the Galena Vicinity have included three mapping efforts by Ducks Unlimited (DU). The Innoko Earth Cover Mapping Project (DU-INNO, 2002), the Northern Innoko Earth Cover Mapping Project (DU-NINNO, 2002), and the Melozitna River and Koyukuk NWR Earth Cover Mapping Project (DU-MELO, 2002) covered significant portions of the 7515f imagery in both the Innoko and Koyukuk National Wildlife Refuges. Field data collection efforts for these projects occurred between 1998 and 2001. These projects included a total of 2,319 field site locations, training area boundaries, and associated vegetation descriptions. GRS reviewed these field training data to determine their usefulness as potential spectral training sites that could be used to represent the many different types of vegetation/land-cover found within the Galena Vicinity. Field training data were reviewed with respect to the vegetation/land-cover types they represented, the accuracy of their locations, and the suitability of using the site in this project. Field sites outside of the current satellite image footprints of images 7515f and 7415f used in this project or which appeared to be inaccurately located were rejected. Field sites of vegetation/land-cover types that appeared to have been burned and significantly altered by fires since data were acquired were deemed unsuitable and rejected. Following GRS's review of these DU field data GRS retained a total of 635 sites for use in this project's mapping efforts. Figure 2 represents the DU field site locations that were used during this mapping effort and the 7515f and 7415f satellite image footprints.

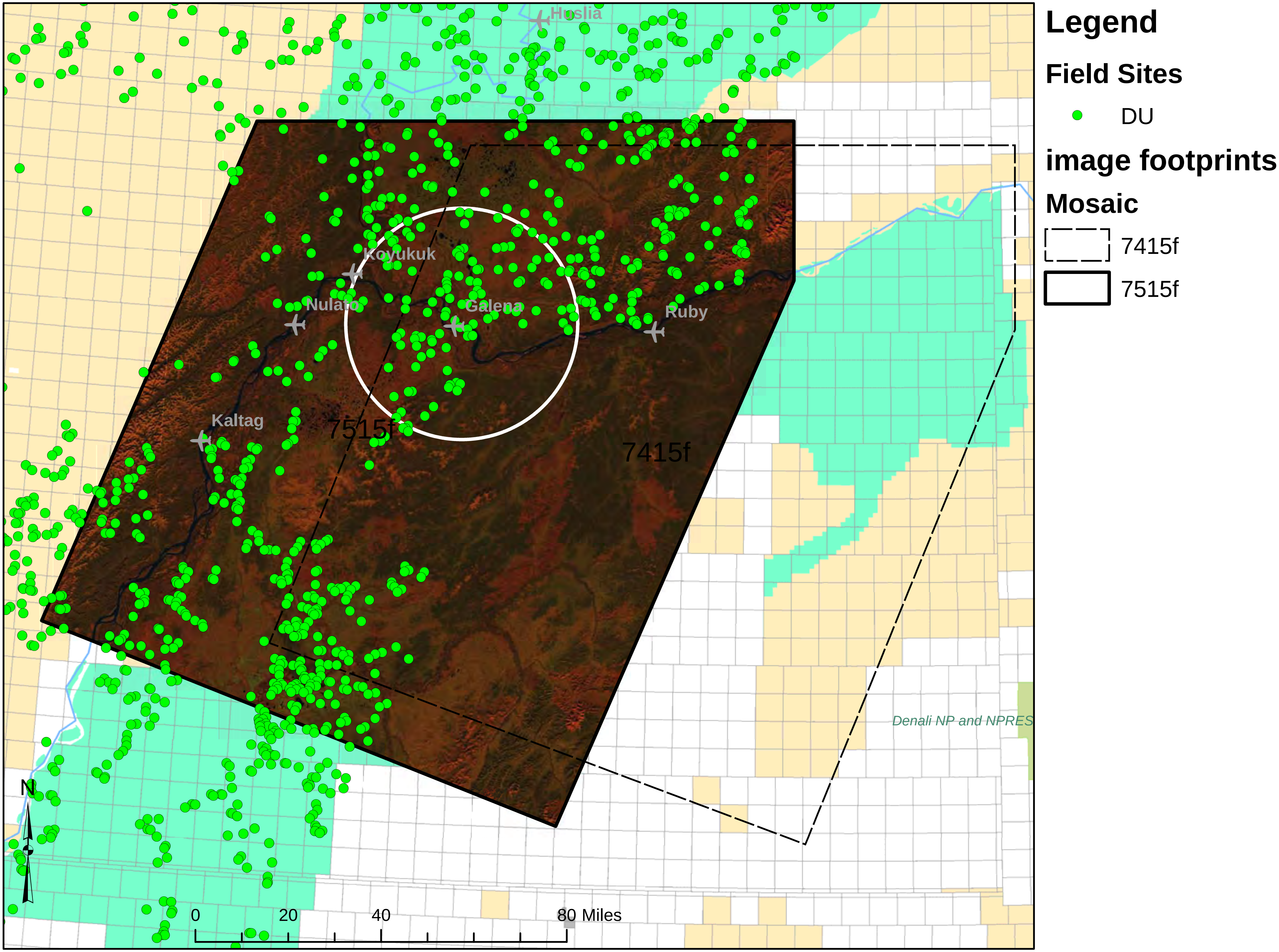
New/Current Field Data Sampling Locations

Field data site locations were selected for sampling based upon the spectral data in the 7515f satellite imagery being processed, the past DU field data collection efforts, and the development and evaluation of a candidate field training site database that GRS developed specifically for this project.

After GRS determined that many of the DU field data sites could be used to represent existing vegetation/land-cover conditions, GRS used these field data to stratify the newly acquired imagery. In other words, GRS developed an image classification training data set using many of the past DU field data site information (locations as well as species-specific cover descriptions) that had been accepted during GRS's review. All suitable sites representing all Viereck types, including tree vegetated types were used. While this DU data set only included cover by species estimates, which are inadequate to develop biomass estimates, these data descriptions were useful in developing a stratification that GRS could use to identify the locations of where Viereck tree type pixels (areas) existed that could be sampled and used to represent tree-vegetated area in the subsequent image classification efforts undertaken during this field data collection effort. As a result, an initial DU classification was performed based upon the newly acquired imagery to create a stratification of the Galena Vicinity and surrounding area (the surrounding area was included because some of the best sample sites might be outside of the Galena Vicinity on nearby lands that were accessible for this project. Confusion among DU sites included in this training data set was reviewed and resolved and an initial Viereck Type Class Map was developed based on the DU data to guide GRS's field sampling efforts.

At the same time the stratification was performed, GRS also developed an unsupervised classification isodata training data set that was used to represent all of the major vegetated strata that GRS thought could be identified in the 7515f imagery. A total of 57 vegetated isodata training classes were identified, which were then used to develop an unsupervised classification map of the Galena vicinity. GRS then related the initial DU Viereck Type class map data to the unsupervised class map data using map overlay processing. Using these spatial relationships and the unsupervised class map data, GRS applied pixel processing programs used during past projects to develop a database of class-specific candidate field training site locations thought to represent

Figure 2: Galena Vicinity, Satellite Image Footprints, and Duck's Unlimited Field Sites



areas of sampling interest. Estimates of vegetation/land-cover type and cover density were developed for each of the unsupervised isodata classification classes. This information would be used to direct GRS's field data collection efforts to sample only stratum that were representative of tree types or other types with at least 5% cover of trees present (these types were thought most significant for sampling to develop the biomass inventory estimates required during this mapping effort).

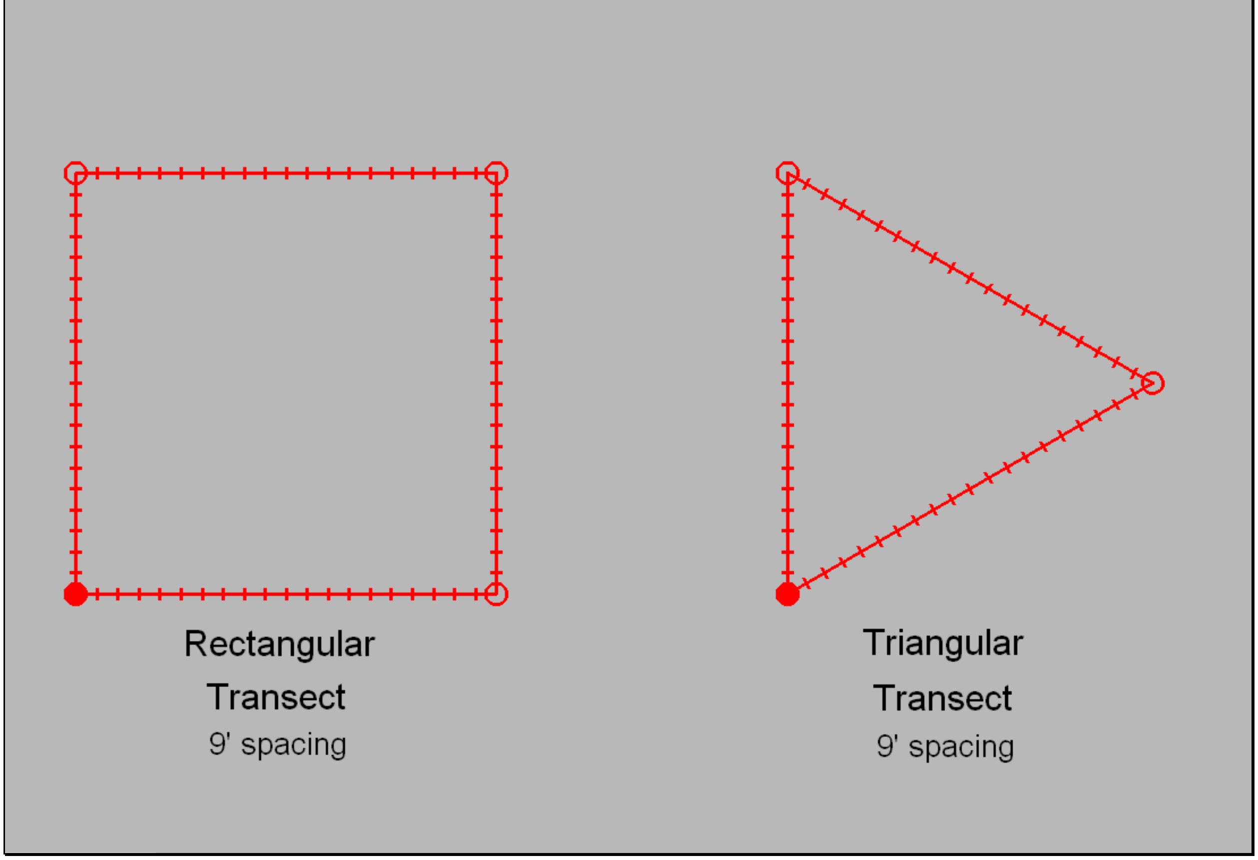
A data set of candidate sample sites was then developed by identifying the largest contiguous areas of each different unsupervised tree-vegetated class (stratum) and storing that information in the GIS. Areas that were too small or too heterogeneous to sample were filtered out of the candidate site data set. This effort not only identified potential field sample site locations, but also resulted in a frequency distribution of all the different unsupervised classes of the sample sites. This class abundance information was used to identify sites in rare (infrequently occurring) or small classes and distinguish them from sites in abundant or commonly occurring larger classes. Such information was instrumental in developing field sampling plans and guiding the selection of field sample sites, so that GRS did not oversample the abundant classes and undersample or miss some of the rarer classes during the very limited field sampling efforts undertaken during this project.

GRS anticipated that the project budget would allow for the sampling of approximately 40 field sites during a two week field sampling period. Additional funding through a BLM Challenge Cost Share Grant provided valuable additional funding that enabled GRS to expand field sampling efforts to a 16-day period of field sampling during which we anticipated visiting from 60-80 field sites (this additional funding also required a provision for performing some field sampling on BLM lands either within or near the Project Area, thereby explaining the sampling of some sites to the northeast that are 15 miles outside of the Project Area). The acreage of each tree-type stratum was estimated and field sites were allocated to the different stratum based upon the acreage of each type relative to the total acreage of tree-types that had been identified during our initial stratification efforts. GRS divided the Galena Vicinity into 6 sample regions that represented the lowland areas near Galena, upriver from Galena, and downriver from Galena, and the upland areas in the mountains to the south, to the east, and to the northeast. A minimum of 1 site and a maximum of 6 sites were allowed per stratum/class and sites from the same stratum would typically not be sampled within the same region, unless that was the region in which most of that class's acreage was thought to exist (this provided a means of distributing samples in the same class throughout the Galena Vicinity). GRS then developed the field sample plans necessary to sample the different areas thought to have a significant amount of tree biomass and ignore non-tree areas, such as Carex-dominated Wet Marshes, Low Willow stands, or Dwarf Birch stands that were thought to have little or no tree biomass present either now or in the future. Field sample plans were updated on a daily basis as the plans were implemented and selected sites were either sampled or not sampled, to assure that sampling efforts provided the desired representation of the different tree-vegetated classes thought to be present throughout the Galena Vicinity. After sampling efforts were completed a total of 63 field sites were visited and assessed by GRS field crews.

Ground-Truth/Field Data Collection

At each selected sample site GRS implemented a line-point sampling methodology that was typically comprised of either 80, 60, 40, or 20 point sample locations. Samples of a smaller number of points were only implemented when the vegetation being sampled appeared to be very homogeneously distributed in terms of species, size, and stocking/cover. Sample points were oriented along the sides of a rectangular or triangular shaped transect and established every 9 (nine) feet apart. At each point all of the sample characteristics of the different vegetation present at the point were recorded. For trees this included species, dbh, total height, crown diameter, canopy position, and status (dead, stunted, or alive). For shrubs, herbaceous, and non-vascular plants this included species (genus) and canopy position. Ground surface characteristics were also recorded. A diagram of the field sample transect configurations used during this project is shown in Figure 3. In a few situations in which GRS field crews found that there was little (< 5%) or no tree cover, ocular estimates of cover by vegetation cover characteristics, including tree species, status, diameter and height for trees that were present were made instead of installing a complete transect.

Figure 3: Field Sample Transect Configurations



GRS fully equipped and trained two field crews, with each crew being comprised of one GRS field forester, who would be responsible for all forestry/botany related data estimates and one Galena high school student, who would fulfill GRS's field data collection responsibilities. All crew members were trained in the GRS field data collection procedures during the first three days of field data collection efforts. Due to safety concerns, as well as transportation issues and costs, the two field crews went to each field site and each visited one-half of the sample points and estimated the vegetation characteristics at each of the data collection locations. Field data were recorded using the GRS field data collection software *TransIn* and output to comma delimited files for subsequent processing. All field site locations were documented with digital photography and global positioning (GPS) data. GPS point locations were collected at the origin and corners of the sample transects to verify that the field site was correctly located and oriented with respect to sample plans. GPS tracking data were also collected, as the transects were implemented, to verify that field sampling efforts was correctly positioned within sample unit boundaries. All field data and photography were downloaded and processed on a daily basis to identify and correct any data collection anomalies while in the field rather than when they would be found after returning to the office.

Radial growth increment data were collected from a dominant 'site' tree at sample sites in order to estimate diameter growth rates. In addition, the species, age and total height of each of these trees was recorded. While there was not sufficient information to develop any individual tree growth estimates, these radial growth increment data did show the wide range of growth rates that were present in the sample areas.

GRS then processed the field data using ***transumcov*** to generate species-specific estimates of cover, stocking (stems/acre), dbh, height, and cubic volume for each sampled stand. Cubic volume estimates were developed using whole tree cubic volume functions based on dbh and total height developed for similar species in the Matanuska Valley (Larson and Winterberger, 1984). These volume functions only addressed the cubic volume in the bole of the tree and were found to dramatically overestimate cubic volume estimates for trees less than 4" dbh. Cubic volume estimates for small trees less than 4" dbh were estimated using volumes GRS developed based on dbh, total height, and average taper for the range of small tree dbh and heights found during sampling effort. Stand volumes were developed by summing the individual tree volumes expanded by the number of stems/acre of that species and size tree.

At the completion of field sampling efforts, GRS managed to sample 63 field sites throughout the Galena Vicinity. In addition, knowing that some non-vegetated sample sites would be needed during the mapping efforts, GRS collected ocular information at an additional 14 sites representing different types of water (shallow, turbid, clear, and so forth) visible in the imagery, as well as barren non-vegetated areas (gravel bars, mud flats, cut banks, and so forth), and a couple of sparsely vegetated urban/herbaceous areas near the airport. The locations of these GRS field data collection sites, as well as the nearby DU field sites in and around the Galena Vicinity are shown in Figure 4.

Figure 4: Galena Vicinity; GRS and DU Field Site Locations; GPS Tracks; and Fire History

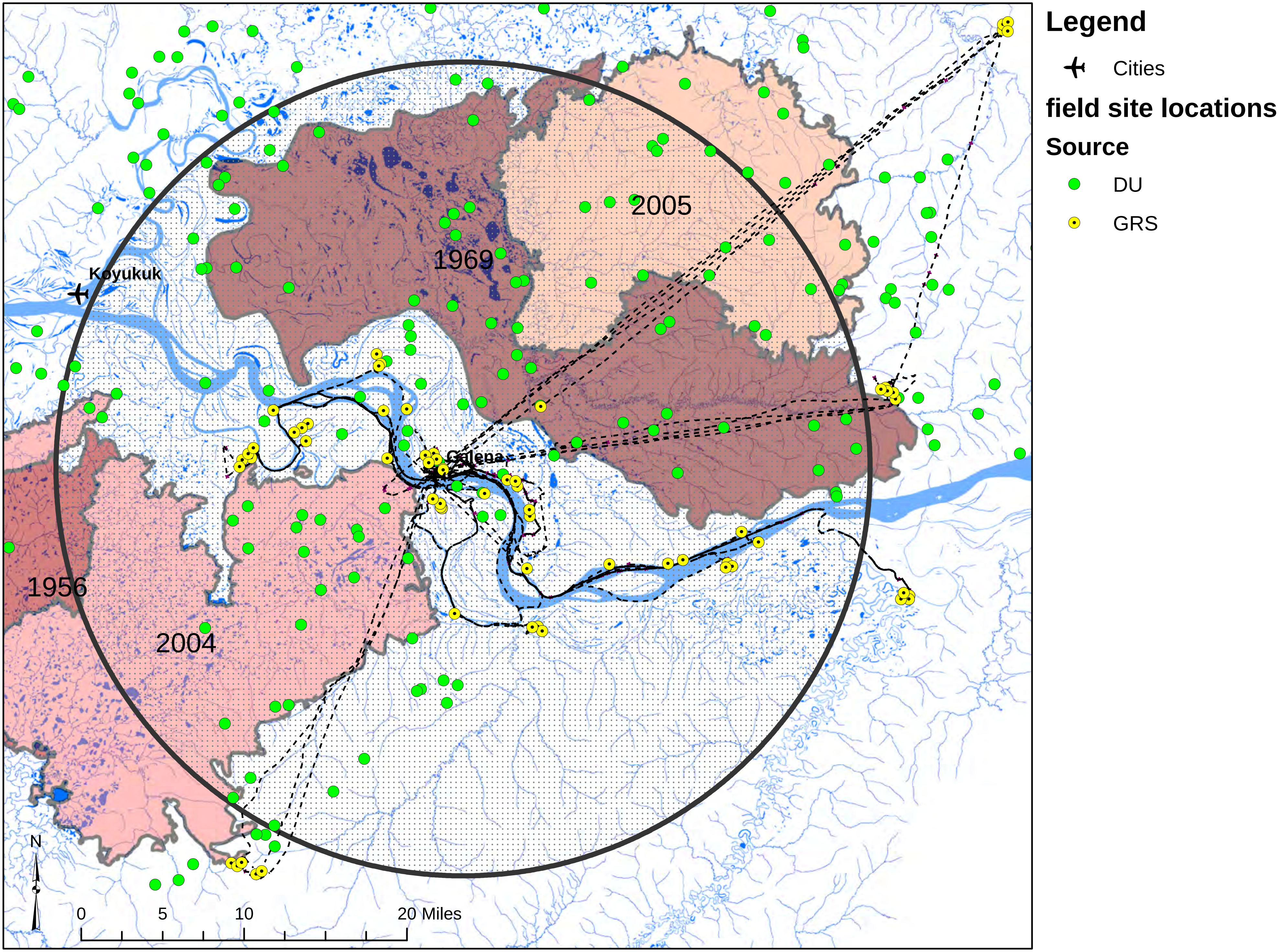


Image Classification

Training Data Set Development

As the field sample data had been collected and processed, these field site locations were added to the original DU spectral training data set to form one comprehensive spectral training data set. The newly acquired tree-vegetated training site information would eventually replace the original DU tree-vegetated areas that lacked tree measurement data, such as diameter, height, or stocking (trees/acre).

GRS performed a review of the spectral confusion as well as the classification fidelity to determine the validity of this combined GRS-DU spectral training data set. For the most part, GRS field data locations collected in tree-type classes corresponded fairly well with DU field site tree-type information. The one exception was that for some of the training areas in which GRS field staff identified the coniferous species as white spruce (*Picea glauca*), the corresponding coniferous species on a "confused" DU field site was identified as black spruce (*Picea mariana*). This difference in species may be an indication of the difficulty in species identification based upon aerial helicopter observations, as was done during the DU field data collection efforts, as opposed to on the ground observations as undertaken by GRS. GRS understood that species identification of white spruce and black spruce would be an issue from the very start and went to great lengths to be certain that field crew members could correctly identify the differences in these species in the field based upon needle characteristics, bark characteristics, cones, smell, and environmental situations. GRS has seen this spruce species identification problem in prior mapping efforts in Alaska and was not surprised to encounter these results in the confusion report. This species confusion was not a problem in this mapping effort, as all DU field sites with greater than 5% tree cover were eventually replaced in the training data set by GRS field sites. Thus tree species designations were based upon the most recent on-the-ground inventory efforts rather than by the older aerial observations. Only a couple of sites of different tree- and nontree-types were actually confused, and this confusion was significant as it involved graminoid dominated marsh type areas and well stocked hardwood stands. This type of confusion could cause incorrect mapping results, as hardwoods might be mapped where there was really a marsh and vice versa. To resolve this confusion, GRS added band 4 (near infrared wavelength) of the 7415f imagery to the 7515f training data set in the hopes that the imagery taken during an active portion of the growing season would enable better differentiation between the marsh and hardwood types. This proved to be the case as the confusion of these different types was resolved after adding band 4 to the image data set.

After the training set was finalized and all DU field sites having greater than 5% tree cover were removed and replaced by GRS field sites, a total of 265 training sites comprised the final 7515f image classification training data set. These 265 training sites were comprised of the 63 newly acquired GRS training sites representing the different tree-type classes, 188 of the original DU non-tree training sites, and the 14 additional newly acquired GRS non-tree training sites. A summary of the field training site data by Origin (GRS or DU) and Viereck Class is shown in Table 1.

Discrete Classification

GRS then applied a supervised classification algorithm based upon this combined training data set to develop pixel classification maps that represented the many different forest types and vegetation classes found in the Galena Vicinity. Class maps were developed at statistical thresholds of 90 and 99%. The result of this discrete classification is that each pixel location in the map has descriptive inventory information associated with it so that each individual area (pixel) in the classification map is joined in the GIS database to its estimated vegetation and inventory characteristics.

Discrete classification results in about 95-97% of the pixels being classified. Thus anywhere from 3-5% of the pixels remain unclassified. GRS next used the original isodata class map to fill in these remaining unclassified areas, as most of them are classified in the 99% threshold classified isodata class map. This results in a final class map that provides nearly 100% coverage of the Project Area. Vegetation characteristics for these added isodata classes are estimated based on the correspondence of the different isodata classes with the discrete classification map data, rather than the previous DU field data set as was done during the stratification efforts. In this way, isodata classes now have species-specific tree characteristics that include dbh, height, crown diameter, and trees/acre and may be processed in a manner comparable to the discrete classification results.

Aggregation

Stand Formation

While the individual pixel data are useful for many GIS applications, a vector based data set that represents polygons or stands of different vegetation characteristics is often more useful, as pixel heterogeneity that often confounds the data user may be reduced and area processing applications can be more easily applied. During this project, the resulting final class map was processed using the GRS pixel aggregation program called ***aggregate*** to group pixels into polygons or stand level map units (Stumpf, 1993).

This aggregation process evaluated individual pixels and small groups of pixels (subject pixels) with respect to nearby adjacent pixels and aggregated the subject pixels into larger groups based on the similarity of a subject pixel(s) to the surrounding pixels. GRS, while mapping national parks in Alaska has developed aggregation logic to merge pixel class data using the Viereck Vegetation Classification. During this project, GRS enhanced the logic to include tree volume/acre, dbh, height, and volume by species in an effort to aggregate pixels and develop stands of similar biomass inventory levels rather than just similar vegetation types. Each pixel in an aggregated group (polygon) retains its descriptive vegetation information, so an aggregated group of pixels (polygon) can be summarized by the weighted average of the vegetation/land-cover

Table 1: Field Training Sites by Viereck Type and Source

Viereck Types	DU Training Sites	DU Average Tree Cover	GRS Training Sites	GRS Average Tree Cover	All Training Sites	All Average Tree Cover
White Spruce:Wdlnd			3	18.4	3	18.4
White Spruce:Open			2	48.8	2	48.8
Mixed Spruce:Wdlnd			1	20.7	1	20.7
Black Spruce:Wdlnd			4	16.3	4	16.3
Black Spruce:Open			10	40.4	10	40.4
Black Spruce:Closed			4	70.2	4	70.2
Larch-Black Spruce Cmplx:Open			1	26.2	1	26.2
Mixed deciduous-conifer:Wdlnd			1	21.3	1	21.3
Mixed deciduous-conifer:Open			9	41.9	9	41.9
Mixed deciduous-conifer:Closed			6	71.8	6	71.8
Balsam Poplar:Open			1	43.8	1	43.8
Balsam Poplar:Closed			1	86.3	1	86.3
Paper Birch:Open			2	54.1	2	54.1
Paper Birch:Closed			6	86.5	6	86.5
Salix-tree:Closed			1	68.7	1	68.7
Mixed deciduous:Open			1	28.8	1	28.8
Mixed deciduous:Closed			2	95.0	2	95.0
Tall shrub:Open:Alder	12	2.1	1	0.0	13	1.9
Tall shrub:Open:Alder-Lichen	1	5.0			1	5.0
Tall shrub:Closed:Alder	4	3.8	2	18.9	6	8.8
Tall shrub:Closed:Willow			3	0.0	3	0.0
Mixed shrub:Open:Birch	2	2.0			2	2.0
Mixed shrub:Open:Willow	3	3.3			3	3.3
Mixed shrub:Open:Willow-Lichen	1	5.0			1	5.0
Low shrub:Open:Ericaceous	2	0.0	1	16.5	3	5.5
Low shrub:Open:Mix	1	0.0			1	0.0
Low shrub:Open:Willow	6	1.7			6	1.7
Low shrub:Closed:Ericaceous			1	4.7	1	4.7
Low shrub:Closed:Willow	3	0.0			3	0.0
Dwarf Shrub:Birch	24	2.1			24	2.1
Dwarf Shrub:Birch-Lichen	8	1.3			8	1.3
Dwarf Shrub:Dryas	1	0.0			1	0.0
Dwarf Shrub:Ericaceous	6	1.7			6	1.7
Dwarf Shrub:Ericaceous-Lichen	1	0.0			1	0.0
Moist Sedge-Shrub Meadow	13	1.2			13	1.2
Moist Sedge-Shrub Meadow-Lichen	4	1.3			4	1.3
Graminoid	39	0.1			39	0.1
Graminoid-Lichen	5	1.0			5	1.0
Herbaceous	2	2.5	2	0.0	4	1.3
Aquatic Forb	3	0.0			3	0.0
Aquatic Mix	15	0.0			15	0.0
Lichen	11	2.7			11	2.7
Moss-Lichen	3	3.3			3	3.3
Moss	15	1.0			15	1.0
Sparse Vegetation	1	0.0			1	0.0
Barren	1	0.0	6	0.0	7	0.0
Water	1	0.0	6	0.0	7	0.0
Grand Total	188	1.2	77	37.4	265	11.8

characteristics of all of the pixels in that polygon. In this manner, as pixels are aggregated into polygons/stands the species-specific characteristics of trees/acre by dbh and height are updated to reflect actual averages rather than just class values (this enables a more accurate estimation of the biomass volume because you know what is actually in the polygon rather than just an average type/class of a polygon).

In addition, minimum mapping limits representing the minimum size area to retain in the map, as the pixels are aggregated into stands, were set so that stands of as small as 1 acre would be retained if they were sufficiently different from the surrounding adjacent stands. Using this approach, small stands of trees, as small as 1 acre in size, could be retained in the stand inventory.

The resulting Stand Inventory map data set, representing the 1.25-million acre Galena Vicinity, contained 173,331 stands. This Stand Inventory map data set forms the comprehensive timber inventory of the Galena Vicinity. Individual stands records that represent specific mapped areas on the ground (in the map) contain attribute information regarding average dbh, height, trees/acre, cubic volume, and tonnage for all species, as well as for just the trees that comprise the top layer of the forest canopy. Tonnage was estimated as dry tons, using the species-specific conversion factors shown in Table 2 (CES-UAF, 2008 and Francescato, et al. 2008) (GRS elected to use units of dry tons as the unit of biomass because the final biomass target level to be converted into energy was thought to be dry tons rather than green tons and selection of the dry ton enabled working with one common unit, rather than species specific green ton values that would still require conversion to dry tons). In addition, inventory values estimating volume and tonnage have been generated for all significant conifer and hardwood tree species for each stand. An example of the mapped Stand Inventory level information, color coded by Viereck Type Classes, is shown in Figures 5 and 6.

Harvest Unit Formation

GRS then developed a Harvest Unit map data set, using the Stand Inventory map data set as the basis of the Harvest Unit theme. The purpose of this theme is to identify site specific areas of a manageable, harvestable size whose inventory attributes have been estimated and whose tree volumes may be projected or grown to future points in time using the current tree vegetation characteristics estimated for each specific harvest unit. When planning current and future biomass harvest activities and formulating different projection outcomes, these harvest units become the basic unit of analysis as they may be prioritized and/or constrained on the basis of their individual characteristics and selected to be part of a specific annual harvest of a long-term plan or projection being developed. The fact that they have specific locations and characteristics, such as volume or tonnage/acre, ownership, species composition, and accessibility enables a model to prioritize and select harvest units in specific years to form the basis of a long-term harvest plan. The development of a Harvest Unit map data set also acts to refine the Stand Inventory, as not all stands may be harvestable due to their smallness in size, species composition, growth potential, or isolation from other harvestable stands. The refinement of the Stand Inventory that results from placing stands into harvest units

Table 2: Volume and Tonnage Conversion Information

	Green/Air Dry Density (lbs/ft3***)	Air Dry Density (lbs/ft3*)	Relative Density Index**	Lbs/cord (85 ft3*)	BTU Energy Content per Cord (85 ft3*)	Lbs/cunit (100 ft3*)	BTU Energy Content per Cunit (100 ft3*)	BTU Energy Content per ft3*	BTUs/lb
White Spruce	36/31	30	0.4	2,550	18,100,000	3000	21,294,118	212,941	7098.039
Black Spruce	32/28	29.2		2,482	15,900,000	2920	18,705,882	187,059	6406.124
Larch/Tamarack	47/37	38.2		3,247	16,000,000	3820	18,823,529	188,235	4927.626
Birch	48/38	41	0.55	3,485	23,600,000	4100	27,764,706	277,647	6771.879
Aspen	43/27	28.4	0.38	2,414	16,600,000	2840	19,529,412	195,294	6876.553
Cottonwood	n/a	24.8	0.34	2,108	14,500,000	2480	17,058,824	170,588	6878.558
Poplar	37/24	25.5	0.34	2,168	15,000,000	2550	17,642,989	176,471	6920.415
Willow	n/a	**22.32**		1,897		2232	0	0	0
Alder	n/a	**28.05**		2,384		2805	0	0	0

Source: Wood Energy Content(Alaskawoodheating.com)

Figure 5: Stand Inventory in the Galena Vicinity

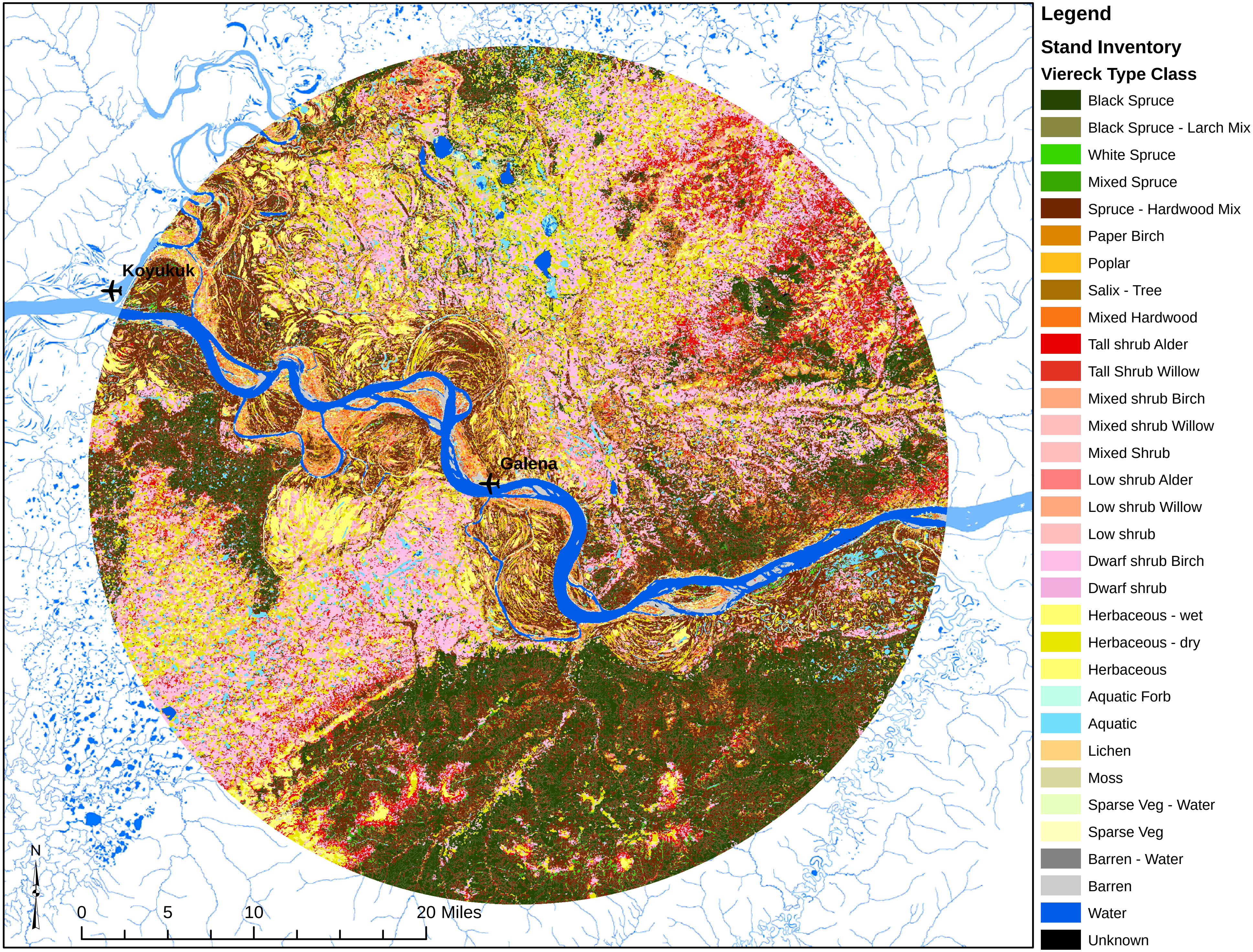
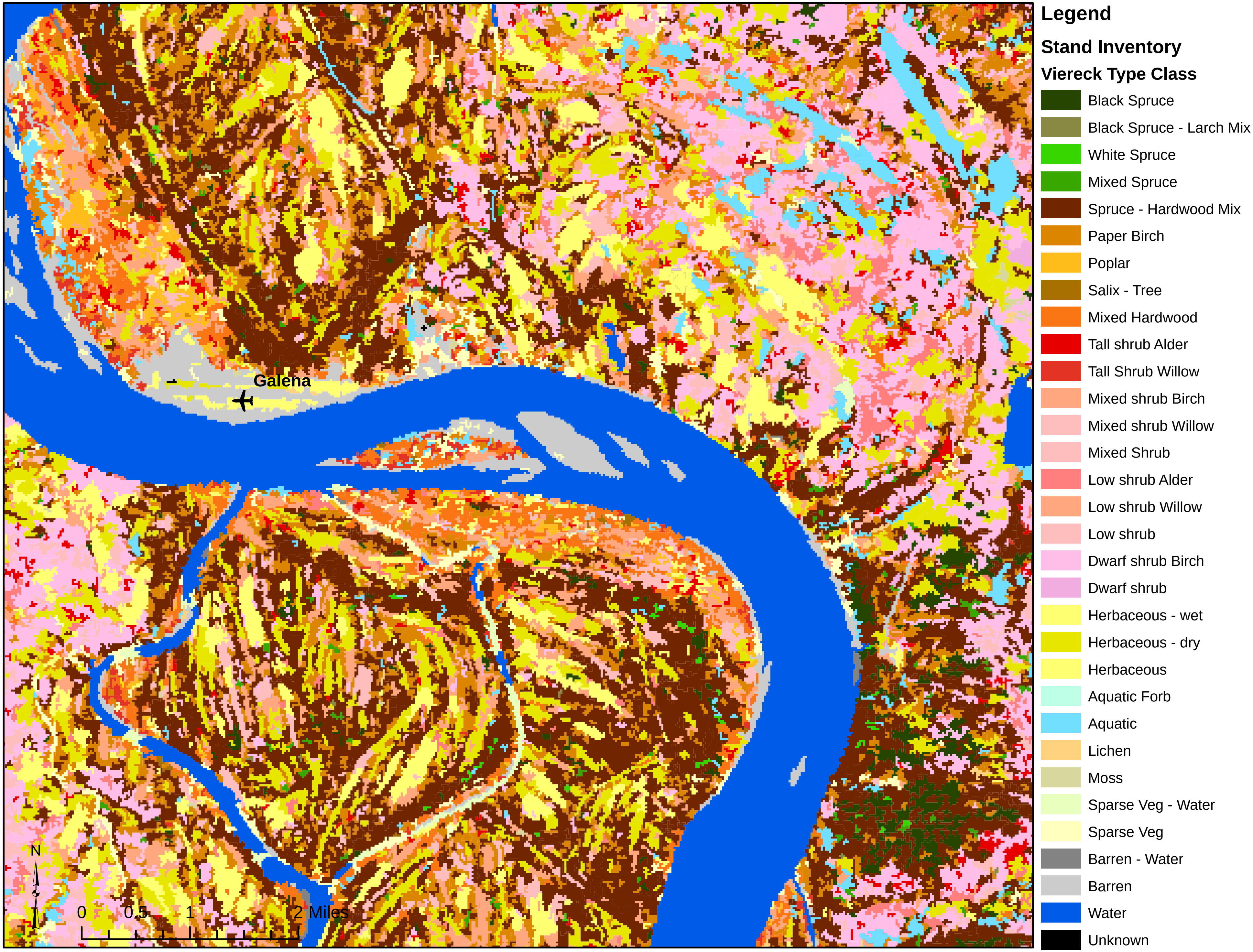


Figure 6: Stand Inventory Around the City of Galena

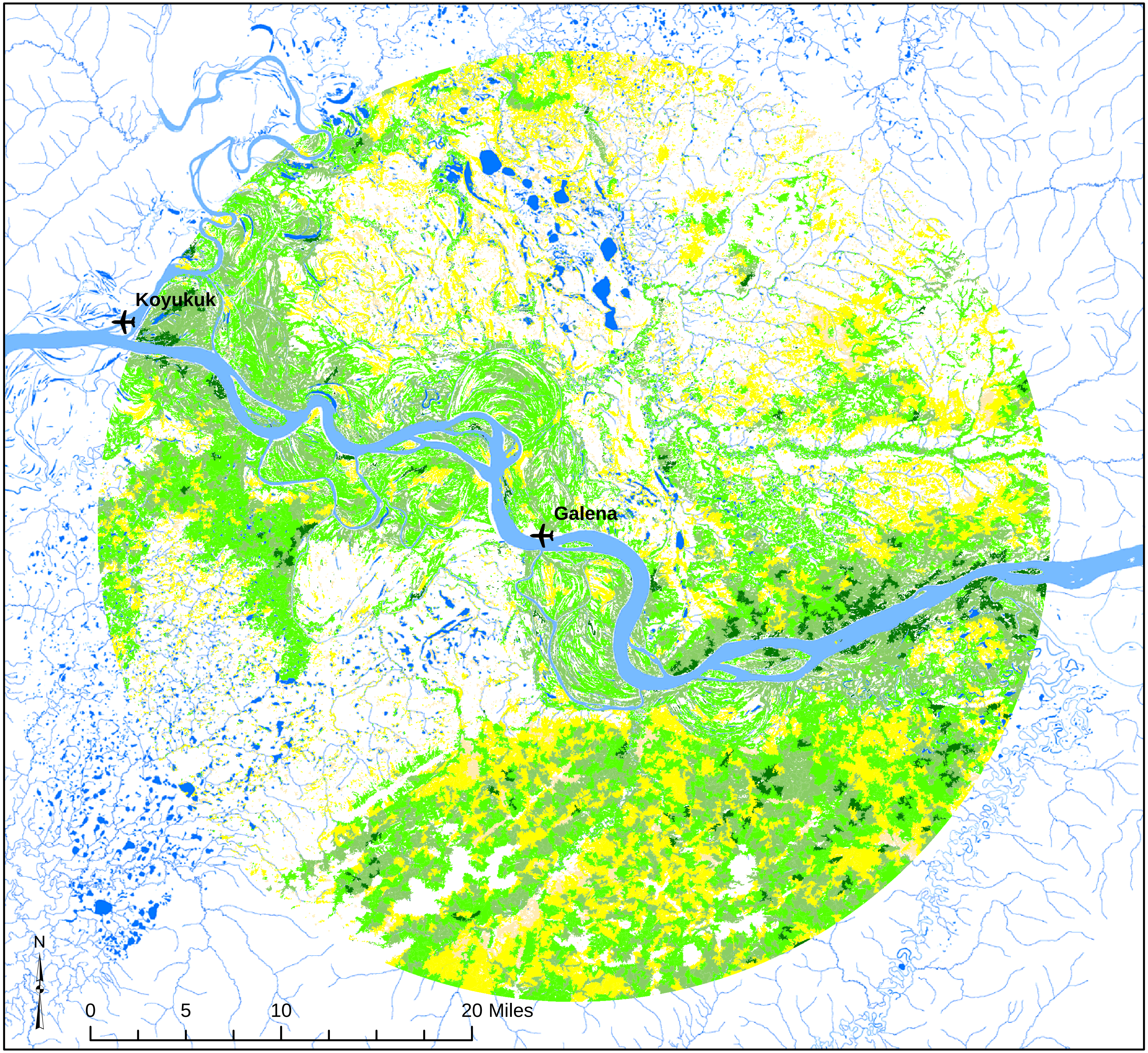


enables the estimation of more accurate future growth levels as it eliminates consideration of volume and growth from stands that are unlikely to ever be harvested. Such refinement helps in establishing what may be considered the upper limits of future harvest levels, if total harvest is never going to exceed growth, because only harvestable volume is considered in the planning process rather than total volume.

GRS used an aggregation process to build stands into harvest units that was similar to the way the GRS aggregated classified pixels into stands. In order to limit harvest units to areas that could potentially be modeled and harvested during biomass production activities, GRS started with the Stand Inventory map data set and filtered out all stands that were either not tree-types and which had low tree cover and low estimates of tons/acre. Any stand with less than 10 percent tree cover and an estimated inventory of less than 2.0 tons/acre was filtered out of the Stand Inventory map data set. GRS then developed harvest unit boundaries by aggregating the remaining stand polygons into harvest units (HUs) of roughly 90 acres or more in size. Many isolated groups of stands did not reach the 90 acre size target, but they were maintained as a harvest unit if they were at least 10 acres in size and had at least 100 tons of biomass in the unit. Similarity was judged on the basis of volume/acre and total acreage. Subject stands were merged in an attempt to create many (smaller) 90+ acre units rather than a few very large acreage units encompassing thousands of acres, as the smaller units enable more flexibility in the planning process than do the larger units. In addition, stands were aggregated based upon similarity in their tons/acre values. The result of this aggregation process was a Harvest Unit map data set that represented approximately 641,140 acres of forestlands in 20,260 harvest units. Examples of the Harvest Unit map data set are shown in Figures 7 and 8. Each harvest unit in this data set is attributed with location specific information as well as stocking information that enables the current and future estimation of its harvest levels in terms of cubic volume and tonnage.

All harvest units were then spatially related to several of the other map themes that represented the different landscape and cultural characteristics of the Galena Vicinity. As a result, harvest units also have attributes that indicate land ownership, land administration, accessibility, distance from Galena, direction (azimuth) from Galena, and how much of their harvest unit is buffered in stream and lake protection zones.

Figure 7: Harvest Units in the Galena Vicinity



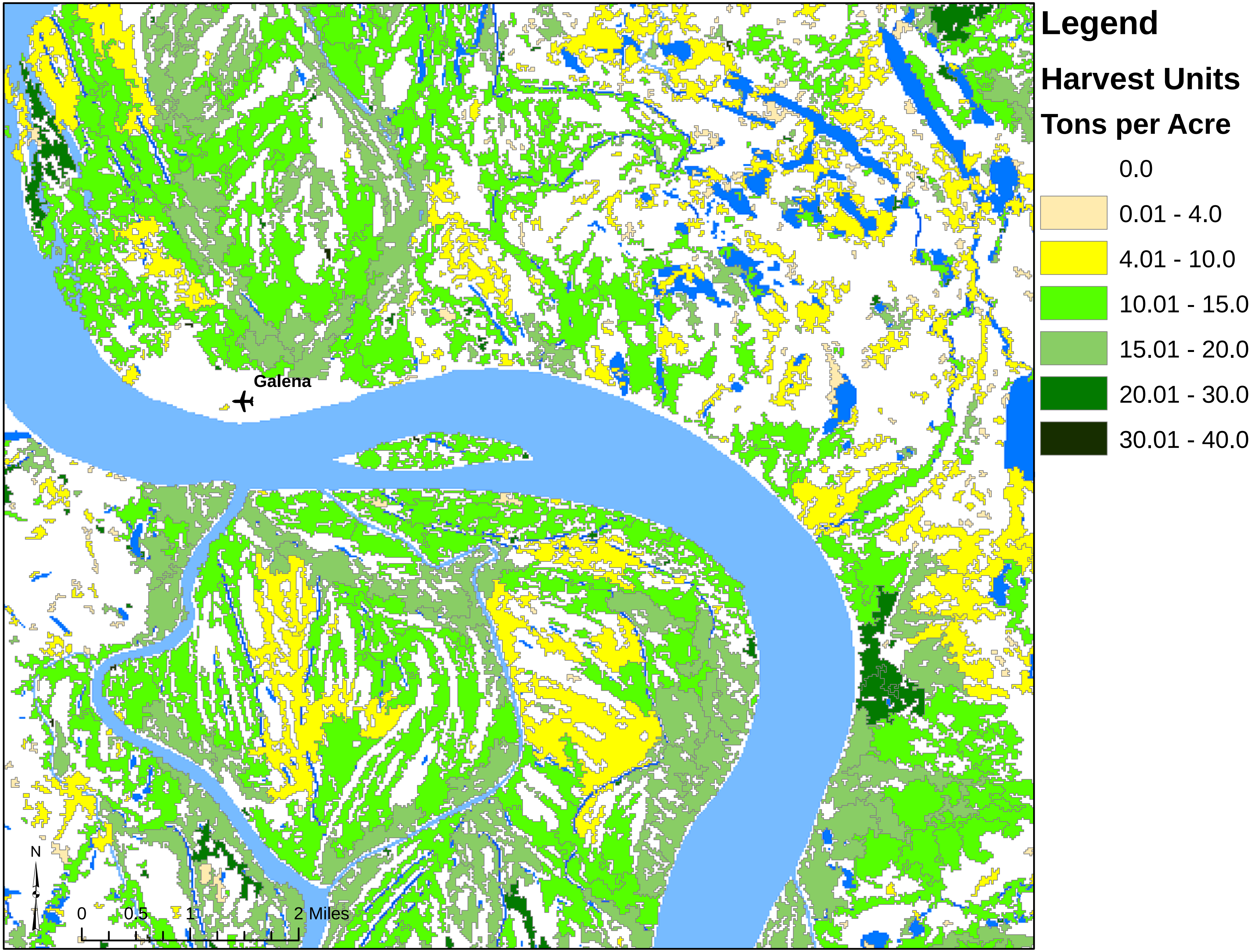
Legend

Harvest Units

Tons per Acre

- 0.0
- 0.01 - 4.0
- 4.01 - 10.0
- 10.01 - 15.0
- 15.01 - 20.0
- 20.01 - 30.0
- 30.01 - 40.0

Figure 8: Harvest Units Around the City of Galena



Biomass Inventory Results

Biomass inventory are expressed in terms of two different units of measure; one measure is Cunits (Cft3), or units of one hundred cubic feet, and the other measure is dry (air) tonnage. The Galena Working Circle as mapped in the Stand Inventory map data set encompasses approximately 1,254,262 acres. The total volume in Cunits (100 ft3 or Cft3) for this area is estimated at 5,050,194 Cft3. The dry tonnage for the area mapped in the Stand Inventory map data set is estimated at 7,820,554 tons of biomass.

In their entirety, these inventory numbers do not mean a lot except to show that if maximum sustainable harvest levels of 20,000 per year are being considered, then there appears to be ample standing volume to support those potential levels, as the 7,820,554 tons of tree biomass would provide **391** years of harvest without consideration of any future growth in existing stands or regeneration and growth of harvested areas.

Of course, it is completely unrealistic to consider such an approach, as there are many different constraints that will affect the ability to harvest some of this material. Land ownership, vegetation type, reforestation concerns, land administration, accessibility, proximity to other biomass stands, distance from Galena, environmental laws and concerns, community concerns, and cost will all likely influence how much of this material might actually be available for harvest now and in the future and help determine the location and quantity of future harvest operations. Some acres and volume will need to be "Reserved" from harvest due to environmental constraints and regulations. Some acres and volume will need to be removed from consideration due to land ownership and/or administration. Some acres and volume will need to be removed from consideration due to the nature of the existing vegetation and/or limited harvest available from those lands.

Therefore, in order to better understand these biomass inventory values, as they relate to these potential limiting factors that may influence their harvest availability, the inventory values will be presented with respect to some of the different landscape features and Galena Vicinity characteristics that may influence the number of acres and amount of biomass that may be available for harvest now and in the future.

Note that some tables also include a subcategory called "Reserved." GRS added this subcategory to reflect the acres and biomass found within approximately 100-foot wide buffer zones created along streams, rivers, and lakes that represent streamside and water-body protection zones required on all public lands by the Alaska Forest Practices Act. The source of the water features buffered in this manner was the National Hydrology data set (USGS-NHD, 2012). These buffers were also created on private lands, although private land owners have options to harvest portions of the volume present in these areas under certain conditions. However, for the purposes of this assessment, GRS has put all the biomass in these buffered protection zones into the "Reserved" subcategory rather than make assumptions about what portion could or could not be harvest on certain lands.

Therefore, the "Reserved" category represents the area, volume, and tonnage that are contained within 100-foot wide buffers constructed along all water features represented in the National Hydrology Data Set for the Galena Vicinity. These buffer areas are shown in Figure 9.

Biomass Inventory by Viereck Vegetation Type Class

The first way to view this inventory is with respect to the different vegetation/land-cover types present in the Stand Inventory. Tables 3 and 4 show the Biomass Inventory Cft3 and tonnage values by Viereck Vegetation Type Class. Examples of the Viereck Type Map drawn from the Stand Inventory map data set are shown in Figures 5 and 6. Tables 3 and 4 list the acreage and inventory figures by species and in total for the major Viereck Vegetation/land-cover Types mapped in the Galena Vicinity.

The conifer cover types mapped in this assessment total 205,773 acres and 1,462,000 dry tons of biomass which is 19% of the total Galena Vicinity Biomass Inventory. These acres average 7.1 tons/acre. 95% of these acres are Black Spruce type averaging 6.5 tons/acre, while there are roughly 6,800 acres of White Spruce averaging 28.5 tons/acre and 6,400 acres of Mixed Spruce types averaging 3.4 tons/acre. Biomass in these coniferous type classes is almost 50% black spruce, while the rest of the biomass is primarily split between white spruce (34%) and paper birch (13%). These figures show that while the Black Spruce type dominates in terms of acreage (95%), black spruce biomass is only about half of the total coniferous type biomass. This illustrates how the larger and taller white spruce and paper birch trees in the coniferous types contribute far more biomass than do the more numerous but smaller black spruce trees (tree volume increases geometrically with tree size, typically with respect to the tree radius squared. This results in trees that are twice as large having as much as than four to five times the biomass).

The Mixed Spruce-Hardwood type mapped in this assessment totals 309,391 acres and 4,585,005 dry tons of biomass which is 59% of the total Galena Vicinity Biomass Inventory. Nearly two-thirds of this biomass is coniferous tonnage and nearly all of that (90%) is white spruce. Of the remaining one-third hardwood tonnage in this type class, 87% is paper birch and the rest is balsam poplar. These Mixed Spruce-Hardwood type stands average 17.1 tons/acre.

The remaining hardwood vegetation types comprise 80,188 acres and amount to 1,469,484 tons of biomass. This accounts for about 6% of the total area of Stand Inventory and 19% of the total tonnage. Approximately 75% of this acreage is in Paper Birch stands which account for 81% of the total tonnage in hardwood types. The rest of the hardwood acres and tonnage are in the Mixed Hardwood type, with a small portion, 3,620 acres and 79,215 tons found in Balsam Poplar type acres. Overall, hardwood type acres average 18.3 tons/acre, with the Paper Birch type averaging 20.2 tons/acre and Balsam Poplar averaging 21.9 tons/acre.

Figure 9: NHD Water-features and Protection Zone Buffers

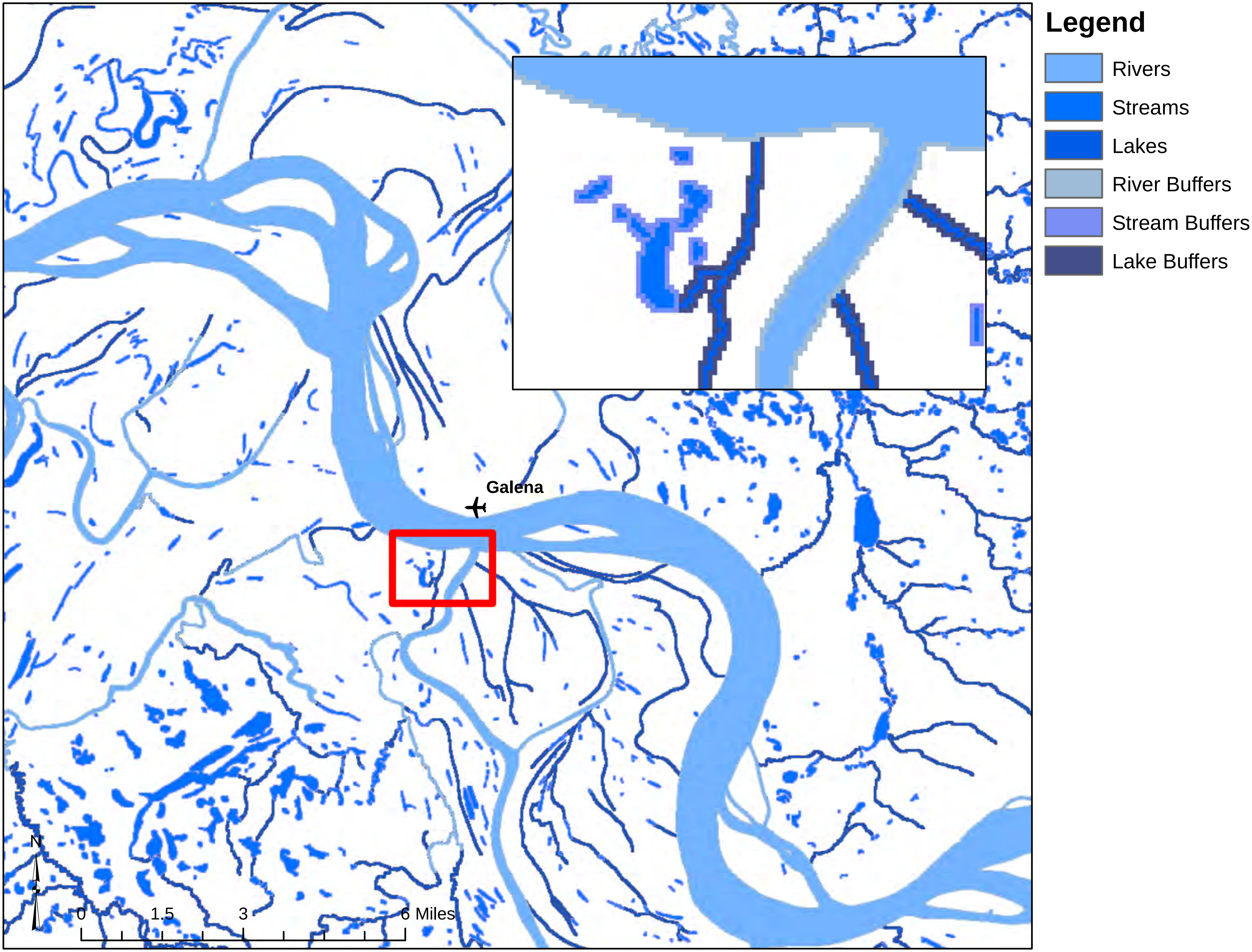


Table 3: Volume (Cft3) By Viereck Type - based on Stand Inventory

Species/ Viereck Type	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total	Cft3 Per Acre
White Spruce	6,794	128,755	721	3	129,479	4,063	1,257	1	106	5,427	134,906	3%	19.9
Black Spruce	192,326	211,957	572,480	289	784,726	87,251	31,591	517	3,084	122,443	907,169	18%	4.7
Mixed Spruce	6,402	9,752	3,680	130	13,562	1,222	133	5	74	1,435	14,997	0%	2.3
Spruce-Larch Mix	251	20	82	29	130	12	1	-	1	14	144	0%	0.6
Total Conifer	**205,773**	**350,485**	**576,962**	**451**	**927,897**	**92,548**	**32,982**	**524**	**3,265**	**129,319**	**1,057,216**	**21%**	5.1
Spruce-Hardwood Mix	**309,391**	**1,861,667**	**248,244**	**2,350**	**2,112,261**	**666,186**	**143,553**	**4,203**	**13,240**	**827,182**	**2,939,443**	**58%**	9.5
Paper Birch	59,032	220,269	3,600	262	224,131	401,597	15,669	6,870	8,024	432,159	656,290	13%	11.1
Poplar	3,620	457	19	2	477	944	57,389	150	2,679	61,162	61,639	1%	17.0
Salix-Tree	314	68	9	1	78	60	74	2	1,046	1,183	1,261	0%	4.0
Mixed Hardwood	17,222	14,106	424	44	14,573	26,270	65,072	7,706	24,298	123,346	137,919	3%	8.0
Total Hardwood	**80,188**	**234,900**	**4,051**	**308**	**239,259**	**428,871**	**138,204**	**14,728**	**36,047**	**617,850**	**857,109**	**17%**	10.7
Tall & Low Shrub	162,184	25,534	2,277	272	28,083	28,590	41,002	3,475	9,700	82,767	110,850	2%	0.7
Dwarf Shrub	182,813	6,475	2,875	143	9,492	7,798	1,489	851	520	10,658	20,150	0%	0.1
Herbaceous	215,705	13,024	3,425	111	16,560	15,494	9,484	2,657	2,678	30,313	46,873	1%	0.2
Aquatic	26,450	2,656	223	1	2,881	1,203	219	426	107	1,955	4,835	0%	0.2
Non-vascular	8,717	978	302	1	1,282	1,783	132	796	45	2,756	4,037	0%	0.5
Sparse Vegetation	14,754	2,039	208	3	2,250	2,580	1,691	1,110	406	5,786	8,035	0%	0.5
Barren	8,310	162	40	0	202	277	374	174	53	877	1,080	0%	0.1
Water	39,978	163	30	0	193	139	102	71	61	372	565	0%	0.0
Grand Total	**1,254,262**	**2,498,082**	**838,637**	**3,640**	**3,340,359**	**1,245,469**	**369,230**	**29,014**	**66,122**	**1,709,835**	**5,050,194**	**100%**	**4.0**

Table 4: Tonnage (Dry) By Viereck Type - based on Stand Inventory

Species/ Viereck Type	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total	Tons Per Acre
White Spruce	6,794	182,688	1,008	4	183,700	8,329	1,602	2	144	10,077	193,777	2%	28.5
Black Spruce	192,326	306,873	715,659	220	1,022,752	178,863	40,278	734	3,989	223,865	1,246,617	16%	6.5
Mixed Spruce	6,402	14,022	4,649	25	18,696	2,506	170	8	95	2,779	21,475	0%	3.4
Spruce-Larch Mix	251	21	119	0	141	24	2	-	2	27	167	0%	0.7
Total Conifer	**205,773**	**503,605**	**721,435**	**249**	**1,225,289**	**189,722**	**42,052**	**744**	**4,230**	**236,748**	**1,462,037**	**19%**	7.1
Spruce-Hardwood Mix	**309,391**	**2,697,952**	**313,523**	**2,576**	**3,014,051**	**1,365,672**	**183,033**	**5,969**	**16,280**	**1,570,954**	**4,585,005**	**59%**	14.8
Paper Birch	59,032	324,545	4,711	357	329,613	823,288	19,978	9,755	9,190	862,212	1,191,824	15%	20.2
Poplar	3,620	669	25	2	696	1,935	73,171	213	3,200	78,519	79,215	1%	21.9
Salix-Tree	314	97	13	1	110	124	94	3	1,196	1,418	1,528	0%	4.9
Mixed Hardwood	17,222	20,569	598	54	21,220	53,855	82,968	10,942	27,932	175,696	196,917	3%	11.4
Total Hardwood	**80,188**	**345,879**	**5,347**	**413**	**351,639**	**879,202**	**176,211**	**20,914**	**41,518**	**1,117,845**	**1,469,484**	**19%**	18.3
Tall & Low Shrub	162,184	36,380	3,168	100	39,647	58,610	52,277	4,935	11,182	127,003	166,650	2%	1.0
Dwarf Shrub	182,813	9,492	3,989	16	13,496	15,986	1,898	1,209	601	19,694	33,190	0%	0.2
Herbaceous	215,705	18,955	4,751	30	23,736	31,764	12,092	3,773	3,089	50,717	74,454	1%	0.3
Aquatic	26,450	3,828	315	1	4,144	2,465	279	605	123	3,473	7,616	0%	0.3
Non-vascular	8,717	1,439	409	1	1,849	3,655	169	1,130	52	5,006	6,855	0%	0.8
Sparse Vegetation	14,754	2,965	291	4	3,260	5,290	2,156	1,575	468	9,489	12,749	0%	0.9
Barren	8,310	239	57	0	296	568	476	247	62	1,353	1,648	0%	0.2
Water	39,978	239	44	0	283	285	129	100	70	584	867	0%	0.0
Grand Total	**1,254,262**	**3,620,971**	**1,053,329**	**3,389**	**4,677,689**	**2,553,218**	**470,771**	**41,200**	**77,675**	**3,142,864**	**7,820,554**	**100%**	**6.2**

All other types account for 658,810 acres which is 53% of the total Galena Vicinity area. These acres support very low levels of tree stocking that average less than 1.0 tons/acre. Biomass associated with these non-tree types is typically found in very small and/or very scattered trees that are associated with these non-tree Viereck types. These types are typically not conducive to timber management, harvest, or potential conversion to biomass production stands. However, due to the impact of the past fires in the Galena Vicinity (see Figure 4), some of these acres may be recently burned forestlands currently inhabited by shrubs and in an early stage of succession that will quite probably develop into to a forestland type. Such additional forestland acres will result in an increase of biomass inventory. A determination of anticipated biomass inventory from these transitional acres was not in the scope of this study and these potential forestland acres are not included in any growth and harvest projections, even though they may return to forestland type acres in the future.

In summary, many of the higher tonnage/acre stands that would most likely support future biomass harvest operations are found on the White Spruce, Mixed Spruce-Hardwood, Paper Birch, Balsam Poplar, and Mixed Hardwood type acres. These types account for 396,060 acres or 32% of the total area and 6,246,738 dry tons or 80% of the total Biomass Inventory of the Galena Vicinity. All of these acres average 15.8 tons/acre. In all likelihood, these acres will form the basis of future biomass harvest operations as they have the higher tons/acre figures that will result in harvesting fewer acres each year to support desired biomass harvest levels thereby resulting in lower harvest and reforestation costs.

Biomass Inventory by Land Ownership

Land Ownership for the Galena Vicinity was broken into 10 major classes, as represented in Figure 10. These major Land Ownership classes include the Bureau of Land Management, US Fish & Wildlife Service, US Military, Native Patent Allotments, Native Patent Lands – Doyon, Native Patent Lands– Gana-A'Yoo, Native Selected Lands, State Patent Lands, State Selected Lands, and lands within the City Limits of Galena (BLM-SDMS, 2012).

Tables 5 and 6 show the Biomass Inventory Cft3 and tonnage values by major Land Ownership class. These two tables list the acreage and inventory figures by species and in total for the major Land Ownership classes in the Galena Vicinity.

Land ownership is significant to this assessment as certain types of ownership may preclude acreage and the biomass on these lands from being available for harvest now or in the future. The most notable case involves the lands owned by the US Fish & Wildlife Service (USF&WS) in the Innoko and Koyukuk National Wildlife Refuges that fall within the Galena Vicinity. Biomass production is not one of the goals of USF&WS resource management practices and in some cases may be forbidden by laws designed to protect the refuges and wildlife that use this habitat. As shown in Tables 5 and 6, the USF&WS owns 259,773 acres of this area which is approximately 21% or one-fifth of the total area.

Figure 10: Land Ownership in the Galena Vicinity

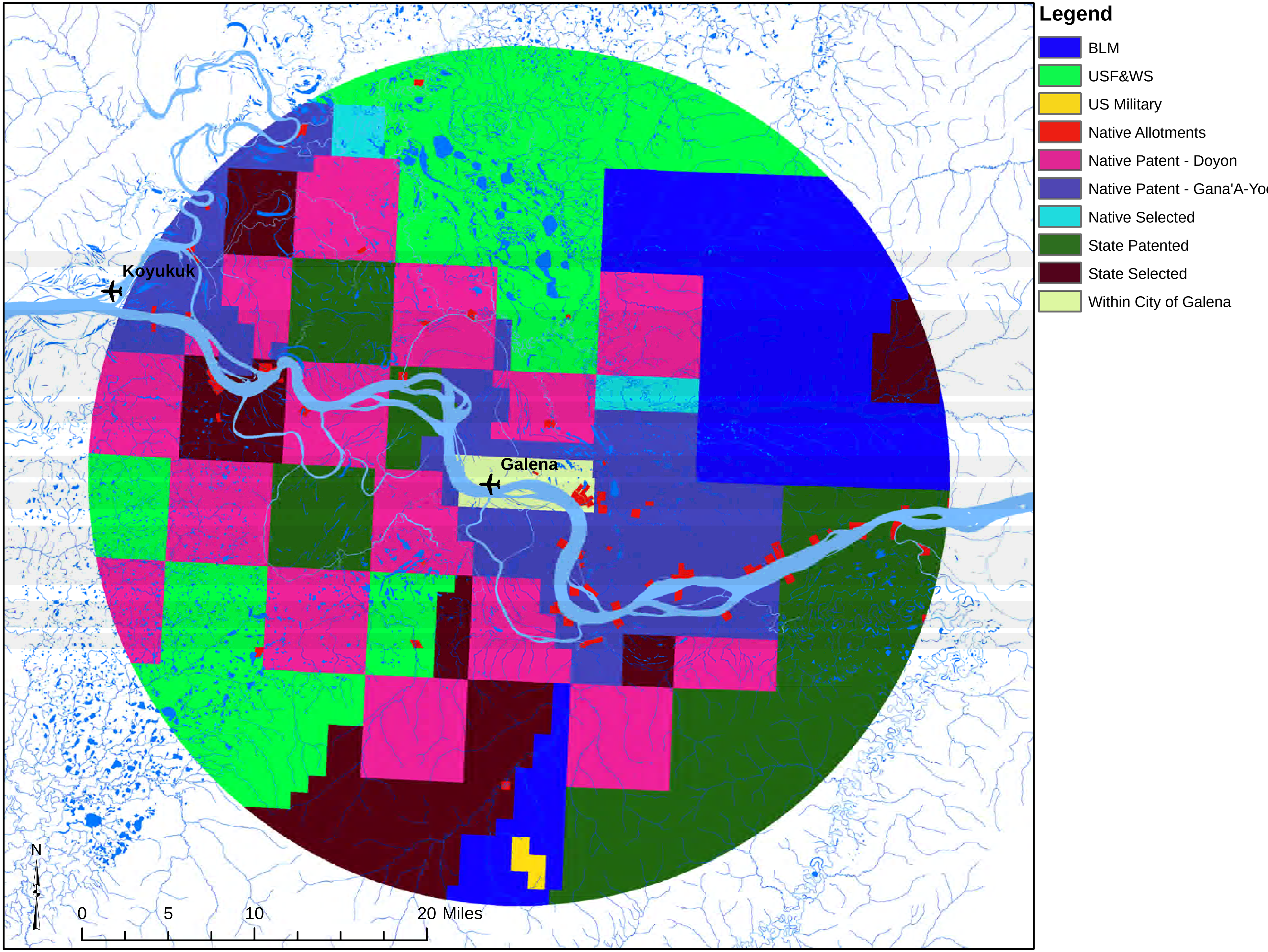


Table 5: Volume (Cft3) and Area By Land Ownership - as of 1/1/2012

Owner Entity	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total
1 - BLM	Unreserved	166,238	217,334	117,812	340	335,486	132,317	22,191	3,276	2,774	160,558	496,044	10%
	Reserved	12,463	36,239	6,134	106	42,479	25,475	2,164	385	564	28,588	71,067	1%
	Subtotal	178,702	253,573	123,946	447	377,965	157,792	24,355	3,661	3,338	189,146	567,111	11%
2 - USF&WS	Unreserved	233,790	103,245	63,216	322	166,783	80,195	31,583	2,481	4,422	118,681	285,464	6%
	Reserved	25,982	45,517	11,233	118	56,867	37,696	9,149	1,937	2,931	51,711	108,579	2%
	Subtotal	259,773	148,762	74,449	439	223,650	117,890	40,731	4,418	7,353	170,392	394,042	8%
3 - US-Military	Unreserved	2,495	6,969	3,103	3	10,075	2,789	234	62	23	3,107	13,182	0%
	Reserved	66	448	89	0	537	94	8	1	1	104	642	0%
	Subtotal	2,561	7,417	3,192	4	10,612	2,883	241	63	24	3,212	13,824	0%
4 - Native-Patent Allotments	Unreserved	8,083	27,554	3,675	30	31,259	13,948	2,897	782	626	18,253	49,511	1%
	Reserved	802	4,072	463	4	4,538	1,982	680	210	170	3,042	7,580	0%
	Subtotal	8,886	31,626	4,138	34	35,797	15,930	3,578	992	795	21,295	57,092	1%
5 - Native-Patent Doyon	Unreserved	266,771	467,852	178,039	805	646,695	241,686	94,167	4,029	14,484	354,366	1,001,062	20%
	Reserved	22,940	80,118	14,413	150	94,682	48,038	14,652	1,411	4,105	68,206	162,888	3%
	Subtotal	289,711	547,970	192,452	955	741,377	289,724	108,819	5,440	18,589	422,572	1,163,949	23%
6 - Native-Patent Gana-A'Yoo	Unreserved	150,569	403,330	73,526	667	477,522	200,415	64,882	3,545	12,479	281,322	758,844	15%
	Reserved	15,175	64,796	6,618	116	71,531	33,213	16,593	2,315	4,188	56,309	127,840	3%
	Subtotal	165,743	468,126	80,144	783	549,053	233,628	81,475	5,860	16,667	337,631	886,684	18%
7 - Native-Select	Unreserved	11,595	11,039	3,776	40	14,855	11,011	1,550	196	555	13,313	28,168	1%
	Reserved	1,915	5,362	489	19	5,869	5,314	678	84	320	6,396	12,265	0%
	Subtotal	13,510	16,401	4,265	59	20,724	16,325	2,229	280	875	19,709	40,433	1%
8 - State-Patent	Unreserved	186,731	596,864	212,885	509	810,258	224,917	49,913	3,810	8,772	287,411	1,097,669	22%
	Reserved	13,773	68,945	14,061	67	83,073	30,980	7,268	1,192	1,610	41,050	124,123	2%
	Subtotal	200,504	665,808	226,946	576	893,331	255,897	57,181	5,002	10,381	328,462	1,221,792	24%
9 - State-Select	Unreserved	111,966	301,462	121,621	241	423,324	123,758	32,125	1,731	3,927	161,540	584,865	12%
	Reserved	8,624	42,695	6,708	51	49,455	19,261	6,855	717	1,384	28,217	77,672	2%
	Subtotal	120,590	344,158	128,329	292	472,779	143,019	38,980	2,448	5,311	189,758	662,537	13%
10 - Within Galena City Limits	Unreserved	13,675	12,462	701	48	13,211	10,562	9,315	562	2,206	22,644	35,855	1%
	Reserved	814	1,851	88	4	1,943	1,838	2,325	288	584	5,034	6,977	0%
	Subtotal	14,489	14,313	789	52	15,154	12,400	11,639	850	2,789	27,678	42,833	1%
Grand Total	Total Unreserved	1,151,913	2,148,110	778,354	3,005	2,929,468	1,041,597	308,857	20,475	50,268	1,421,196	4,350,664	86%
	Total Reserved	102,554	350,043	60,296	635	410,974	203,892	60,372	8,540	15,854	288,658	699,632	14%
	Grand Total	**1,254,467**	**2,498,153**	**838,650**	**3,640**	**3,340,442**	**1,245,489**	**369,229**	**29,014**	**66,122**	**1,709,854**	**5,050,296**	**100%**

Table 6: Tonnage (Dry) and Area By Land Ownership - as of 1/1/2012

Owner Entity	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total
1 - BLM	Unreserved	166,238	316,068	145,151	246	461,465	271,250	28,293	4,652	3,332	307,527	768,992	10%
	Reserved	12,463	52,135	7,232	97	59,464	52,225	2,759	546	650	56,181	115,645	1%
	Subtotal	178,702	368,203	152,383	343	520,929	323,474	31,053	5,199	3,982	363,707	884,636	11%
2 - USF&WS	Unreserved	233,790	150,499	78,437	171	229,106	164,400	40,268	3,524	5,171	213,361	442,468	6%
	Reserved	25,982	65,994	14,175	91	80,260	77,276	11,664	2,750	3,377	95,068	175,328	2%
	Subtotal	259,773	216,493	92,611	263	309,367	241,675	51,932	6,274	8,548	308,429	617,796	8%
3 - US-Military	Unreserved	2,495	10,099	3,808	4	13,911	5,717	298	88	28	6,131	20,042	0%
	Reserved	66	644	116	0	760	194	10	2	1	206	966	0%
	Subtotal	2,561	10,743	3,924	4	14,671	5,911	308	89	30	6,337	21,008	0%
4 - Native-Patent Allotments	Unreserved	8,083	39,912	4,738	33	44,683	28,593	3,694	1,110	732	34,130	78,813	1%
	Reserved	802	5,894	606	5	6,505	4,063	868	298	197	5,425	11,931	0%
	Subtotal	8,886	45,807	5,345	37	51,188	32,657	4,562	1,409	929	39,556	90,744	1%
5 - Native-Patent Doyon	Unreserved	266,771	678,303	225,364	708	904,375	495,457	120,063	5,721	17,063	638,304	1,542,680	20%
	Reserved	22,940	115,478	17,541	158	133,177	98,478	18,682	2,004	4,744	123,908	257,085	3%
	Subtotal	289,711	793,781	242,906	866	1,037,552	593,935	138,745	7,725	21,808	762,212	1,799,764	23%
6 - Native-Patent Gana-A'Yoo	Unreserved	150,569	581,769	93,209	752	675,730	410,852	82,725	5,035	14,573	513,185	1,188,914	15%
	Reserved	15,175	93,270	8,463	130	101,864	68,087	21,156	3,287	4,836	97,367	199,231	3%
	Subtotal	165,743	675,039	101,672	882	777,594	478,939	103,881	8,322	19,409	610,551	1,388,145	18%
7 - Native-Select	Unreserved	11,595	15,984	4,559	26	20,568	22,572	1,977	279	641	25,469	46,038	1%
	Reserved	1,915	7,741	603	17	8,361	10,894	865	119	367	12,244	20,605	0%
	Subtotal	13,510	23,724	5,162	43	28,929	33,466	2,841	398	1,008	37,713	66,643	1%
8 - State-Patent	Unreserved	186,731	867,613	269,683	486	1,137,782	461,082	63,639	5,410	10,510	540,640	1,678,423	21%
	Reserved	13,773	99,767	16,764	79	116,610	63,510	9,267	1,693	1,866	76,335	192,945	2%
	Subtotal	200,504	967,380	286,447	566	1,254,392	524,591	72,906	7,103	12,375	616,976	1,871,368	24%
9 - State-Select	Unreserved	111,966	437,682	153,666	266	591,614	253,704	40,959	2,457	4,763	301,883	893,496	11%
	Reserved	8,624	61,570	8,184	66	69,820	39,485	8,741	1,019	1,606	50,850	120,669	2%
	Subtotal	120,590	499,252	161,850	332	661,434	293,188	49,700	3,476	6,368	352,732	1,014,166	13%
10 - Within Galena City Limits	Unreserved	13,675	17,878	923	49	18,850	21,652	11,876	798	2,543	36,869	55,719	1%
	Reserved	814	2,665	108	5	2,778	3,769	2,964	409	673	7,814	10,593	0%
	Subtotal	14,489	20,543	1,031	54	21,628	25,420	14,840	1,207	3,216	44,684	66,312	1%
Grand Total	Total Unreserved	1,151,913	3,115,806	979,538	2,740	4,098,084	2,135,277	393,792	29,074	59,357	2,617,500	6,715,584	86%
	Total Reserved	102,554	505,158	73,791	649	579,598	417,979	76,975	12,126	18,318	525,398	1,104,996	14%
	Grand Total	**1,254,467**	**3,620,964**	**1,053,329**	**3,389**	**4,677,682**	**2,553,256**	**470,767**	**41,200**	**77,675**	**3,142,897**	**7,820,580**	**100%**

However, the tonnage on the USF&WS lands is estimated to total only 617,796 tons or 8% of the total biomass inventory. These figures show that of the total Galena Vicinity tonnage, a relatively small portion (8%) is located on USF&WS lands.

There may also be some reservations regarding harvesting of biomass on Native Allotments or within the City Limits of Galena due to the proximity of harvest operations to local homes and the private ownership of these parcels. Both of these ownership classes each total about 14,000 acres or 1% of the Galena Vicinity total area and 66,000 tons or 1% of the total tonnage. While these lands may certainly contribute some biomass to future harvest levels, these are relatively insignificant amounts of tonnage when considered over a long-term planning period for a sustainable harvest level that could be as high as 20,000 tons per year.

The most significant landowners in the Galena Vicinity are the State of Alaska, owning lands that total 321,093 acres and have an estimated tonnage of 2,885,533 or 37% of the total estimated tonnage; Native Patent - Doyon Ltd. owning lands that total 289,711 acres and have an estimated tonnage of 1,799,764 or 23% of the total estimated volume; the Native Patent - Gana-A'Yoo owning lands that total 165,743 acres and have an estimated tonnage of 1,388,145 or 18% of the total estimated volume; and the Bureau of Land Management owning lands that total 178,702 acres and have an estimated tonnage of 884,636 or 11% of the total estimated volume. These four land owners possess 955,249 acres or 76% of the Galena Vicinity that have 89% of the total tonnage on these lands. There is a high likelihood that any future harvest operations in the Galena Vicinity will involve biomass harvest agreements with these four landowners.

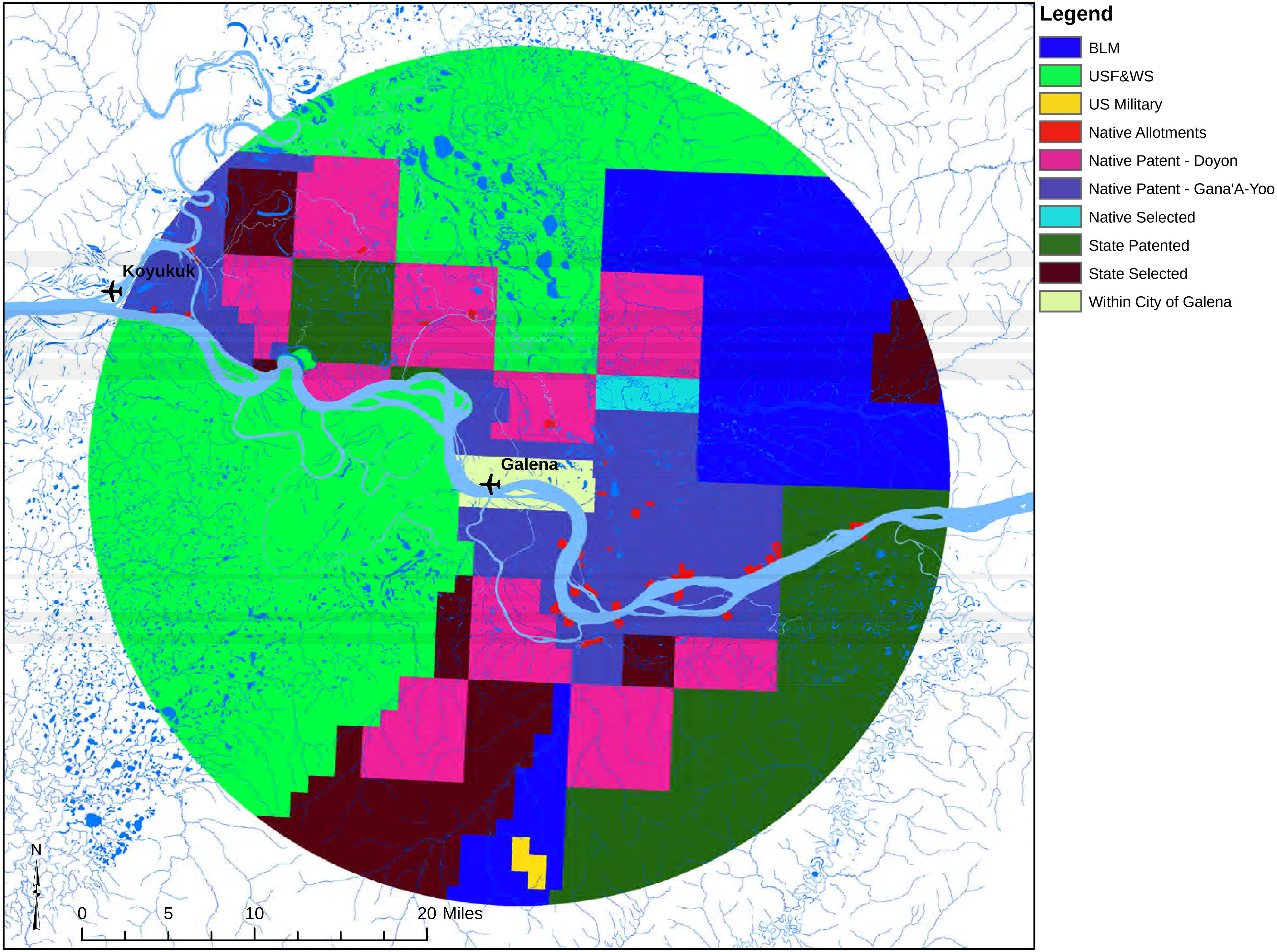
Tables 5 and 6 do include the "Reserved" subcategory that reflects acreage and inventory in streamside and water-body protection zones. By subtracting these "Reserved" acreage and tonnage estimates from the four major land owners' figures referenced above, we find that these three major land owners possess 882,275 acres potentially available for harvest that contain 6,958,079 tons or 89% of the total tonnage of the Galena Vicinity.

Overall, the "Reserved" subcategory contains 102,554 acres or 8% of the area of the Galena Vicinity and 1,104,996 tons or 14% of the estimated total tonnage of the Galena Vicinity. Nearly half of the tonnage on these lands is white spruce while another 38% is paper birch. 25% of the "Reserved" acres fall on the USF&WS lands indicating a slightly higher proportion of water features on these lands when compared to the rest of the Galena Vicinity.

Biomass Inventory by Land Administration

Land Administration for the Galena Vicinity was broken into 10 major classes, as represented in Figure 11. These major Land Administration classes include the same classes that were defined as Land Ownership classes, which were Bureau of Land Management, US Fish & Wildlife Service, US Military, Native Patent Allotments, Native

Figure 11: Land Administration in the Galena Vicinity



Patent Lands – Doyon, Native Patent Lands– Gana-A'Yoo, Native Selected Lands, State Patent Lands, State Selected Lands, and lands within the City Limits of Galena. Tables 7 and 8 show the Biomass Inventory Cft3 and tonnage values by major Land Administration class. These two tables list the acreage and inventory figures by species and in total for the major Land Administration classes in the Galena Vicinity.

Similar to Land Ownership, Land Administration may be significant to this assessment, as certain types of administrative authority may preclude acreage and the biomass on these lands from being available for harvest now or in the future. As with Land Ownership, the most notable case involves the lands administered by the US Fish & Wildlife Service that fall within the Galena Vicinity. Some privately and publicly owned lands fall within USF&WS refuge boundaries. While land owners may certainly have rights to harvest biomass on their lands administered by USF&WS, this may involve administrative and environmental cans-of-worms that may be better left unopened. Many of these lands are in-holdings and the regulatory safeguards necessary to protect refuge lands may prove to be costly when compared to harvesting non-USF&WS administered lands, making these lands less desirable to include in biomass harvest operations.

As shown in Tables 7 and 8, lands administered by USF&WS total 461,822 acres or 37% of the Galena Vicinity, up from 21% of the total area based on land ownership. The tonnage on the land administered by USF&WS totals 1,776,516 or 23% of the total tonnage of the Galena Vicinity, up from 8% of the total tonnage based on land ownership. Much of this increase in acreage and tonnage for lands administered by USF&WS comes from Native Patent lands owned by Doyon Ltd. and Gana-A'Yoo that fall within the Innoko and Koyukuk National Wildlife Refuges.

The other most significant land administrators in the Galena Vicinity are the State of Alaska, with lands that total 267,348 acres and have an estimated tonnage of 2,283,207 or 29% of the total estimated tonnage; Native Patent - Doyon Ltd. with lands that total 171,833 acres and have an estimated tonnage of 1,191,105 or 15% of the total estimated volume; the Native Patent - Gana-A'Yoo with lands that total 144,492 acres and have an estimated tonnage of 1,237,262 or 16% of the total estimated volume; and the Bureau of Land Management with lands that total 178,702 acres and have an estimated tonnage of 884,636 or 11% of the total estimated volume. These four land administrators manage 762,374 acres or 61% (down from 78% of land owned) of the Galena Vicinity that have total tonnage of 5,866,346 or 75% (down from 89% of tonnage owned) of the total tonnage on these lands. As with land ownership, there is still a very significant amount of biomass potentially available for harvest of the lands administered by these four entities and there is a high likelihood that any future harvest operations in the Galena Vicinity will involve biomass harvest agreements with these four land administrators.

Table 7: Volume (Cft3) and Area By Administrative Entity - as of 1/1/2012													
Admin Entity	**Species or Group/Feature**	**Acreage**	**White Spruce**	**Black Spruce**	**Other/ Larch**	**Total Conifer**	**Paper Birch**	**Balsam Poplar**	**Aspen**	**Other/ Salix**	**Total Hardwood**	**Grand Total**	**Percent of Total**
1 - BLM	Unreserved	166,238	217,334	117,812	340	335,486	132,317	22,191	3,276	2,774	160,558	496,044	9.8%
	Reserved	12,463	36,239	6,134	106	42,479	25,475	2,164	385	564	28,588	71,067	1.4%
	Subtotal	178,702	253,573	123,946	447	377,965	157,792	24,355	3,661	3,338	189,146	567,111	11.2%
2 - USF&WS	Unreserved	419,522	397,601	142,038	813	540,453	229,717	120,862	6,069	20,243	376,891	917,344	18.2%
	Reserved	42,300	103,415	20,234	211	123,859	69,126	26,169	4,154	7,171	106,620	230,479	4.6%
	Subtotal	461,822	501,016	162,272	1,024	664,312	298,843	147,031	10,223	27,415	483,511	1,147,823	22.7%
3 - US-Mil	Unreserved	2,495	6,969	3,103	3	10,075	2,789	234	62	23	3,107	13,182	0.3%
	Reserved	66	448	89	0	537	94	8	1	1	104	642	0.0%
	Subtotal	2,561	7,416	3,192	4	10,612	2,883	241	63	24	3,212	13,824	0.3%
4 - Native-Patent Allotments	Unreserved	4,505	15,135	2,038	13	17,185	8,911	1,455	623	332	11,320	28,505	0.6%
	Reserved	347	1,543	182	2	1,727	844	380	137	85	1,446	3,173	0.1%
	Subtotal	4,853	16,678	2,220	15	18,912	9,755	1,835	761	417	12,766	31,679	0.6%
5 - Native-Patent Doyon	Unreserved	158,710	318,661	128,230	544	447,435	168,374	45,048	2,509	6,678	222,609	670,044	13.3%
	Reserved	13,123	46,362	8,428	91	54,880	30,513	7,147	861	2,021	40,541	95,422	1.9%
	Subtotal	171,833	365,023	136,658	635	502,315	198,887	52,195	3,370	8,699	263,150	765,466	15.2%
6 - Native-Patent Gana-A'Yoo	Unreserved	131,255	360,990	69,191	595	430,776	179,505	55,592	3,076	10,503	248,676	679,452	13.5%
	Reserved	13,237	55,819	5,816	108	61,743	29,036	14,581	1,709	3,576	48,901	110,645	2.2%
	Subtotal	144,492	416,809	75,007	703	492,519	208,541	70,173	4,785	14,079	297,577	790,096	15.6%
7 - Native-Select	Unreserved	6,428	4,852	1,034	25	5,911	6,350	396	122	313	7,181	13,091	0.3%
	Reserved	1,232	3,155	260	16	3,430	3,660	160	31	152	4,002	7,432	0.1%
	Subtotal	7,660	8,006	1,294	41	9,341	10,010	555	153	465	11,183	20,523	0.4%
8 - State-Patent	Unreserved	156,232	567,324	208,732	426	776,482	201,628	32,586	2,851	4,851	241,916	1,018,398	20.2%
	Reserved	12,382	65,969	13,953	60	79,981	28,158	3,916	710	849	33,633	113,615	2.2%
	Subtotal	168,614	633,292	222,685	485	856,463	229,786	36,502	3,561	5,701	275,550	1,132,012	22.4%
9 - State-Select	Unreserved	92,192	245,709	105,384	188	351,281	100,732	20,926	1,311	2,285	125,254	476,534	9.4%
	Reserved	6,541	34,908	5,098	38	40,045	15,052	3,502	263	839	19,656	59,700	1.2%
	Subtotal	98,734	280,617	110,482	227	391,325	115,784	24,428	1,574	3,124	144,910	536,235	10.6%
10 - Within Galena City Limits	Unreserved	14,312	13,538	791	57	14,386	11,274	9,568	576	2,265	23,684	38,070	0.8%
	Reserved	863	2,185	103	4	2,292	1,933	2,347	289	597	5,166	7,458	0.1%
	Subtotal	15,174	15,723	894	61	16,678	13,207	11,915	865	2,862	28,850	45,528	0.9%
	Total Unreserved	1,151,889	2,148,111	778,353	3,005	2,929,469	1,041,596	308,857	20,475	50,268	1,421,196	4,350,664	86.1%
	Total Reserved	102,555	350,042	60,296	635	410,974	203,892	60,373	8,540	15,854	288,658	699,632	13.9%
	Grand Total	**1,254,444**	**2,498,153**	**838,649**	**3,640**	**3,340,442**	**1,245,488**	**369,229**	**29,014**	**66,122**	**1,709,854**	**5,050,296**	**100.0%**

Table 8: Tonnage (Dry) and Area By Administrative Entity - as of 1/1/2012

Admin Entity	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total
1 - BLM	Unreserved	166,238	316,068	145,151	246	461,465	271,250	28,293	4,652	3,332	307,527	768,992	9.8%
	Reserved	12,463	52,135	7,232	97	59,464	52,225	2,759	546	650	56,181	115,645	1.5%
	Subtotal	178,702	368,203	152,383	343	520,929	323,474	31,053	5,199	3,982	363,707	884,636	11.3%
2 - USF&WS	Unreserved	419,522	575,214	178,947	691	754,852	470,921	154,099	8,618	23,648	657,286	1,412,138	18.1%
	Reserved	42,300	149,406	25,530	188	175,124	141,708	33,365	5,899	8,281	189,253	364,378	4.7%
	Subtotal	461,822	724,620	204,477	879	929,976	612,629	187,465	14,516	31,930	846,540	1,776,516	22.7%
3 - US-Mil	Unreserved	2,495	10,099	3,808	4	13,911	5,717	298	88	28	6,131	20,042	0.3%
	Reserved	66	644	116	0	760	194	10	2	1	206	966	0.0%
	Subtotal	2,561	10,743	3,924	4	14,671	5,911	308	89	30	6,337	21,008	0.3%
4 - Native-Patent Allotments	Unreserved	4,505	21,941	2,635	16	24,592	18,267	1,855	885	389	21,396	45,988	0.6%
	Reserved	347	2,236	236	2	2,474	1,730	484	195	99	2,508	4,983	0.1%
	Subtotal	4,853	24,177	2,871	18	27,066	19,998	2,339	1,080	488	23,905	50,970	0.7%
5 - Native-Patent Doyon	Unreserved	158,710	462,655	161,649	459	624,762	345,166	57,437	3,562	7,914	414,080	1,038,842	13.3%
	Reserved	13,123	66,898	10,045	99	77,041	62,552	9,112	1,223	2,335	75,222	152,263	1.9%
	Subtotal	171,833	529,552	171,693	558	701,804	407,718	66,549	4,785	10,250	489,301	1,191,105	15.2%
6 - Native-Patent Gana-A'Yoo	Unreserved	131,255	520,983	87,608	659	609,249	367,986	70,879	4,369	12,283	455,517	1,064,766	13.6%
	Reserved	13,237	80,323	7,383	120	87,826	59,523	18,591	2,426	4,130	84,670	172,496	2.2%
	Subtotal	144,492	601,306	94,991	778	697,075	427,509	89,471	6,795	16,413	540,188	1,237,262	15.8%
7 - Native-Select	Unreserved	6,428	7,047	1,236	16	8,299	13,018	505	173	359	14,055	22,354	0.3%
	Reserved	1,232	4,532	324	14	4,870	7,503	203	44	174	7,924	12,794	0.2%
	Subtotal	7,660	11,580	1,560	30	13,169	20,521	708	217	533	21,978	35,148	0.4%
8 - State-Patent	Unreserved	156,232	825,430	264,652	384	1,090,465	413,339	41,547	4,049	5,968	464,903	1,555,368	19.9%
	Reserved	12,382	95,478	16,628	71	112,176	57,725	4,993	1,008	988	64,713	176,889	2.3%
	Subtotal	168,614	920,908	281,279	455	1,202,641	471,064	46,540	5,056	6,956	529,616	1,732,257	22.1%
9 - State-Select	Unreserved	92,192	356,964	132,802	210	489,976	206,500	26,680	1,862	2,822	237,863	727,839	9.3%
	Reserved	6,541	50,357	6,170	54	56,580	30,857	4,465	374	971	36,667	93,247	1.2%
	Subtotal	98,734	407,320	138,972	263	546,556	237,357	31,145	2,235	3,793	274,530	821,086	10.5%
10 - Within Galena City Limits	Unreserved	14,312	19,407	1,051	57	20,514	23,112	12,200	818	2,612	38,742	59,257	0.8%
	Reserved	863	3,149	128	6	3,283	3,963	2,992	411	689	8,054	11,336	0.1%
	Subtotal	15,174	22,556	1,178	63	23,797	27,075	15,191	1,229	3,301	46,796	70,593	0.9%
	Total Unreserved	1,151,889	3,115,807	979,537	2,740	4,098,085	2,135,277	393,793	29,074	59,357	2,617,500	6,715,585	85.9%
	Total Reserved	102,555	505,158	73,791	649	579,598	417,979	76,975	12,126	18,318	525,398	1,104,996	14.1%
	Grand Total	**1,254,444**	**3,620,965**	**1,053,329**	**3,389**	**4,677,683**	**2,553,256**	**470,768**	**41,200**	**77,674**	**3,142,898**	**7,820,581**	**100.0%**

Biomass Inventory by Distance from Galena

Distance from Galena has been developed as an attribute to characterize the Biomass Inventory. It is used as a relative measure of difficulty in performing harvest and associated transportation operations. This relative measure was used in scheduling harvest units by year and by five-year period so that that overall cumulative distance of operations was balanced from period to period with respect to how the biomass inventory was distributed through the different Distance Zones. Using this approach, the Biomass Inventory would not be “cherry-picked,” where all the closest and lowest cost harvest units were harvested during the first few decades resulting in what appeared to be very favorable results, only to realize twenty years later that costs were now going to rise very sharply because operations had to move out farther and farther away from town because all the biomass in close proximity was gone.

These resulting Distance Zones are shown in Figure 12. They were created based on an equal area approach, whereby the areas of the closest zones (from 5 to 18 miles out) were nearly equal and the areas of the farthest zones (past 21 miles) were also comparable in size. The resulting Distance Zones represent the Distance from Galena as from 0-4 miles, 5-9 miles, 10-13 miles, 14-16 miles, 17-18 miles, 19-21 miles, 22 miles, 23 miles, 24 miles, and 25 miles. Biomass may be summarized within these zones to estimate its distribution throughout these zones which may then be used to guide the selection of harvest units when modeling the harvest during any 5-year period.

As noted by Will Putman in his Ft. Yukon report these type distance measures reflect “straight-line proximity distance measurements” and the actual distance to any point will be affected by streams, rivers, lakes, land topography, time of the year, and the ownership and administration of the land between Galena and any biomass inventory/harvest unit location (Putman, 2010). They are not meant to be exact measures of distance but rather relative measures designed to provide a means of characterizing the Biomass Inventory.

Tables 9 and 10 show the Biomass Inventory Cft3 and tonnage values by Distance Zone. These two tables list the acreage and inventory figures by species and in total for the ten Distance Zones in the Galena Vicinity. As was shown previously, these tables again show that we are dealing with Total Cft3 and tonnage values of approximately 5,050,000 Cft3 and 7,820,000 dry tons in the Galena Working Circle. Our Total “Reserved” acreage is about 102,500 acres on which there are about 700,000 Cft3 and 1,100,000 dry tons of biomass. Our Total “Unreserved” acreage is about 1,150,000 acres on which there are about 4,350,000 Cft3 and 6,700,000 dry tons of biomass.

Only about 2% of the total tonnage or 157,000 dry tons are estimated to be on the 29,700 acres of “Unreserved” lands located within four miles of Galena. Only 8% of the total tonnage or 632,000 dry tons of biomass on 120,000 “Unreserved” acres are located from 5 to 9 miles of Galena. This means that 90% of the total Biomass

Figure 12: Galena Vicinity Distance (Zones)

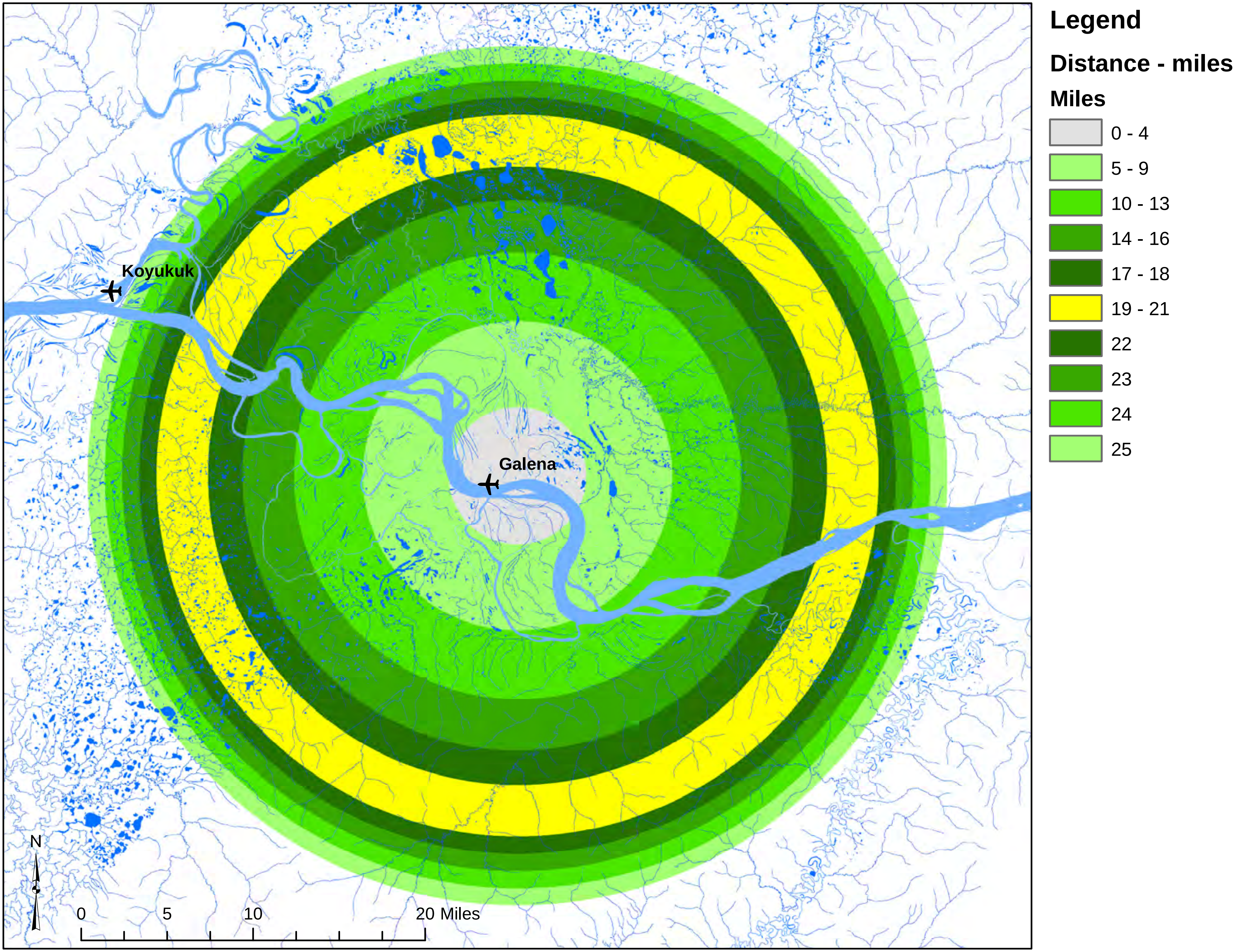


Table 9: Total Volume (Cft3) and Area By Distance Zone - as of 1/1/2012

Distance Zone	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total	Cumulat. % of Total
Zone 0	Unreserved	29,727	40,364	2,485	185	43,035	35,713	13,927	972	3,761	54,373	97,407	1.9%	1.9%
< 5 miles	Reserved	2,392	7,022	371	19	7,412	6,182	4,265	408	1,139	11,994	19,406	0.4%	0.4%
	Subtotal	32,119	47,387	2,856	204	50,447	41,895	18,192	1,380	4,900	66,366	116,813	2.3%	2.3%
Zone 1	Unreserved	119,639	185,097	28,990	618	214,705	135,018	32,483	2,533	8,148	178,181	392,887	7.8%	9.7%
5 to 9 miles	Reserved	10,825	31,934	2,505	109	34,548	27,309	8,484	1,220	2,624	39,636	74,184	1.5%	1.9%
	Subtotal	130,464	217,032	31,495	727	249,254	162,327	40,967	3,752	10,772	217,817	467,071	9.2%	11.6%
Zone 2	Unreserved	161,835	232,276	71,947	513	304,736	150,750	53,197	3,623	9,932	217,501	522,237	10.3%	20.0%
10 to 13 miles	Reserved	14,786	44,701	6,529	112	51,342	33,526	8,649	1,440	2,647	46,262	97,604	1.9%	3.8%
	Subtotal	176,621	276,977	78,476	625	356,078	184,276	61,846	5,063	12,578	263,763	619,841	12.3%	23.8%
Zone 3	Unreserved	160,202	292,049	106,303	423	398,775	148,041	46,067	3,225	7,007	204,341	603,116	11.9%	32.0%
14 to 16 miles	Reserved	14,412	44,379	7,988	91	52,458	27,334	6,751	1,376	1,815	37,277	89,735	1.8%	5.6%
	Subtotal	174,614	336,428	114,291	514	451,233	175,375	52,819	4,601	8,822	241,618	692,851	13.7%	37.6%
Zone 4	Unreserved	124,846	264,432	102,755	274	367,461	126,524	32,973	2,394	4,063	165,954	533,415	10.6%	42.6%
17 to 18 miles	Reserved	11,642	40,933	8,441	63	49,437	21,442	5,867	1,040	1,276	29,625	79,061	1.6%	7.1%
	Subtotal	136,488	305,364	111,197	337	416,897	147,966	38,840	3,434	5,338	195,579	612,476	12.1%	49.7%
Zone 5	Unreserved	216,991	430,961	177,756	396	609,113	177,369	49,462	3,014	6,184	236,029	845,141	16.7%	59.3%
19 to 21 miles	Reserved	17,846	65,295	12,858	95	78,248	32,706	8,175	1,042	1,829	43,753	122,001	2.4%	9.5%
	Subtotal	234,837	496,256	190,614	491	687,361	210,076	57,637	4,056	8,014	279,781	967,142	19.2%	68.8%
Zone 6	Unreserved	78,938	152,907	62,485	149	215,540	59,282	17,816	1,097	2,467	80,662	296,202	5.9%	65.2%
22 miles	Reserved	7,369	26,571	5,055	37	31,663	13,507	4,964	566	1,134	20,171	51,834	1.0%	10.6%
	Subtotal	86,307	179,478	67,540	186	247,203	72,789	22,780	1,663	3,601	100,832	348,035	6.9%	75.7%
Zone 7	Unreserved	83,276	173,420	66,242	152	239,814	67,662	22,010	1,095	2,720	93,487	333,301	6.6%	71.8%
23 miles	Reserved	7,051	27,832	5,141	31	33,004	13,049	4,080	374	933	18,437	51,441	1.0%	11.6%
	Subtotal	90,327	201,252	71,384	183	272,819	80,711	26,090	1,469	3,653	111,924	384,742	7.6%	83.3%
Zone 8	Unreserved	86,788	191,507	75,366	165	267,037	72,065	19,951	1,063	2,890	95,969	363,006	7.2%	78.9%
24 miles	Reserved	7,567	28,421	4,775	37	33,234	13,163	4,808	439	1,338	19,748	52,982	1.0%	12.6%
	Subtotal	94,354	219,928	80,142	202	300,271	85,229	24,758	1,502	4,228	115,717	415,988	8.2%	91.6%
Zone 9	Unreserved	89,672	185,097	84,025	131	269,253	69,172	20,972	1,459	3,097	94,699	363,952	7.2%	86.1%
25 miles	Reserved	8,665	32,954	6,632	42	39,628	15,673	4,329	635	1,120	21,757	61,385	1.2%	13.9%
	Subtotal	98,337	218,051	90,657	173	308,880	84,845	25,301	2,094	4,217	116,456	425,336	8.4%	100.0%
Grand Total	Unreserved	1,151,915	2,148,109	778,354	3,005	2,929,468	1,041,596	308,857	20,475	50,268	1,421,195	4,350,663	86.1%	
	Total Reserved	102,553	350,043	60,296	636	410,975	203,892	60,372	8,540	15,854	288,658	699,633	13.9%	
	Grand Total	**1,254,468**	**2,498,152**	**838,651**	**3,640**	**3,340,443**	**1,245,488**	**369,229**	**29,014**	**66,122**	**1,709,853**	**5,050,296**	**100.0%**	

Table 10: Tonnage (Dry) and Area By Distance Zone - as of 1/1/2012

Distance Zone	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total	Cumulat. % of Total
Zone 0	Unreserved	29,727	57,301	3,169	209	60,679	73,212	17,757	1,381	4,331	96,679	157,359	2.0%	2.0%
< 5 miles	Reserved	2,392	10,094	469	25	10,587	12,673	5,438	579	1,313	20,003	30,590	0.4%	0.4%
	Subtotal	32,119	67,395	3,638	234	71,267	85,885	23,194	1,959	5,644	116,682	187,949	2.4%	2.4%
Zone 1	Unreserved	119,639	264,948	35,174	634	300,757	276,787	41,416	3,596	9,426	331,224	631,981	8.1%	10.1%
5 to 9 miles	Reserved	10,825	45,862	3,128	112	49,103	55,983	10,817	1,732	3,022	71,554	120,656	1.5%	1.9%
	Subtotal	130,464	310,810	38,302	747	349,859	332,770	52,233	5,328	12,447	402,778	752,637	9.6%	12.0%
Zone 2	Unreserved	161,835	337,234	90,894	444	428,572	309,039	67,826	5,145	11,591	393,600	822,172	10.5%	20.6%
10 to 13 miles	Reserved	14,786	64,640	7,990	109	72,739	68,729	11,028	2,045	3,053	84,854	157,593	2.0%	3.9%
	Subtotal	176,621	401,874	98,885	553	501,311	377,767	78,854	7,189	14,644	478,454	979,765	12.5%	24.6%
Zone 3	Unreserved	160,202	424,460	136,345	329	561,134	303,485	58,736	4,579	8,339	375,139	936,273	12.0%	32.6%
14 to 16 miles	Reserved	14,412	64,062	9,921	85	74,068	56,035	8,608	1,954	2,100	68,698	142,766	1.8%	5.8%
	Subtotal	174,614	488,522	146,266	413	635,202	359,520	67,344	6,534	10,439	443,837	1,079,039	13.8%	38.4%
Zone 4	Unreserved	124,846	384,769	129,269	229	514,267	259,375	42,041	3,400	4,877	309,693	823,960	10.5%	43.1%
17 to 18 miles	Reserved	11,642	59,070	10,308	61	69,438	43,956	7,480	1,477	1,481	54,394	123,832	1.6%	7.4%
	Subtotal	136,488	443,839	139,577	290	583,706	303,331	49,521	4,877	6,358	364,086	947,792	12.1%	50.5%
Zone 5	Unreserved	216,991	626,122	223,211	332	849,665	363,609	63,063	4,279	7,406	438,357	1,288,022	16.5%	59.6%
19 to 21 miles	Reserved	17,846	94,307	15,642	98	110,047	67,048	10,423	1,480	2,119	81,070	191,118	2.4%	9.8%
	Subtotal	234,837	720,429	238,853	430	959,712	430,656	73,487	5,759	9,525	519,427	1,479,139	18.9%	69.4%
Zone 6	Unreserved	78,938	221,827	78,002	130	299,960	121,527	22,716	1,558	2,972	148,772	448,732	5.7%	65.3%
22 miles	Reserved	7,369	38,380	6,135	37	44,552	27,689	6,329	804	1,311	36,133	80,685	1.0%	10.8%
	Subtotal	86,307	260,207	84,138	167	344,512	149,216	29,044	2,362	4,283	184,906	529,417	6.8%	76.2%
Zone 7	Unreserved	83,276	251,480	82,608	153	334,242	138,707	28,063	1,555	3,247	171,572	505,814	6.5%	71.8%
23 miles	Reserved	7,051	40,216	6,247	34	46,497	26,751	5,202	531	1,080	33,564	80,061	1.0%	11.9%
	Subtotal	90,327	291,696	88,855	187	380,738	165,458	33,265	2,086	4,326	205,136	585,874	7.5%	83.6%
Zone 8	Unreserved	86,788	278,303	95,306	152	373,761	147,734	25,437	1,510	3,471	178,151	551,912	7.1%	78.8%
24 miles	Reserved	7,567	40,971	5,909	42	46,922	26,985	6,130	624	1,544	35,283	82,205	1.1%	12.9%
	Subtotal	94,354	319,273	101,215	194	420,683	174,719	31,567	2,133	5,015	213,434	634,116	8.1%	91.8%
Zone 9	Unreserved	89,672	269,363	105,559	128	375,049	141,802	26,739	2,072	3,699	174,312	549,361	7.0%	85.9%
25 miles	Reserved	8,665	47,556	8,042	47	55,644	32,131	5,520	901	1,295	39,846	95,490	1.2%	14.1%
	Subtotal	98,337	316,919	113,600	175	430,694	173,933	32,259	2,973	4,994	214,158	644,851	8.2%	100.0%
Grand Total	Unreserved	1,151,915	3,115,807	979,538	2,740	4,098,085	2,135,276	393,792	29,074	59,357	2,617,499	6,715,584	85.9%	
	Total Reserved	102,553	505,157	73,791	649	579,598	417,979	76,975	12,126	18,318	525,398	1,104,995	14.1%	
	Grand Total	**1,254,468**	**3,620,964**	**1,053,330**	**3,389**	**4,677,683**	**2,553,255**	**470,767**	**41,200**	**77,675**	**3,142,896**	**7,820,579**	**100.0%**	

Inventory is growing in the “Unreserved” portions of stands 10 or more miles from Galena. It is apparent that if significant biomass harvest levels of as much as 20,000 dry tons per year are going to be undertaken in the future, that a significant amount of the biomass resource is going to be harvested from stands at least 10 miles from Galena.

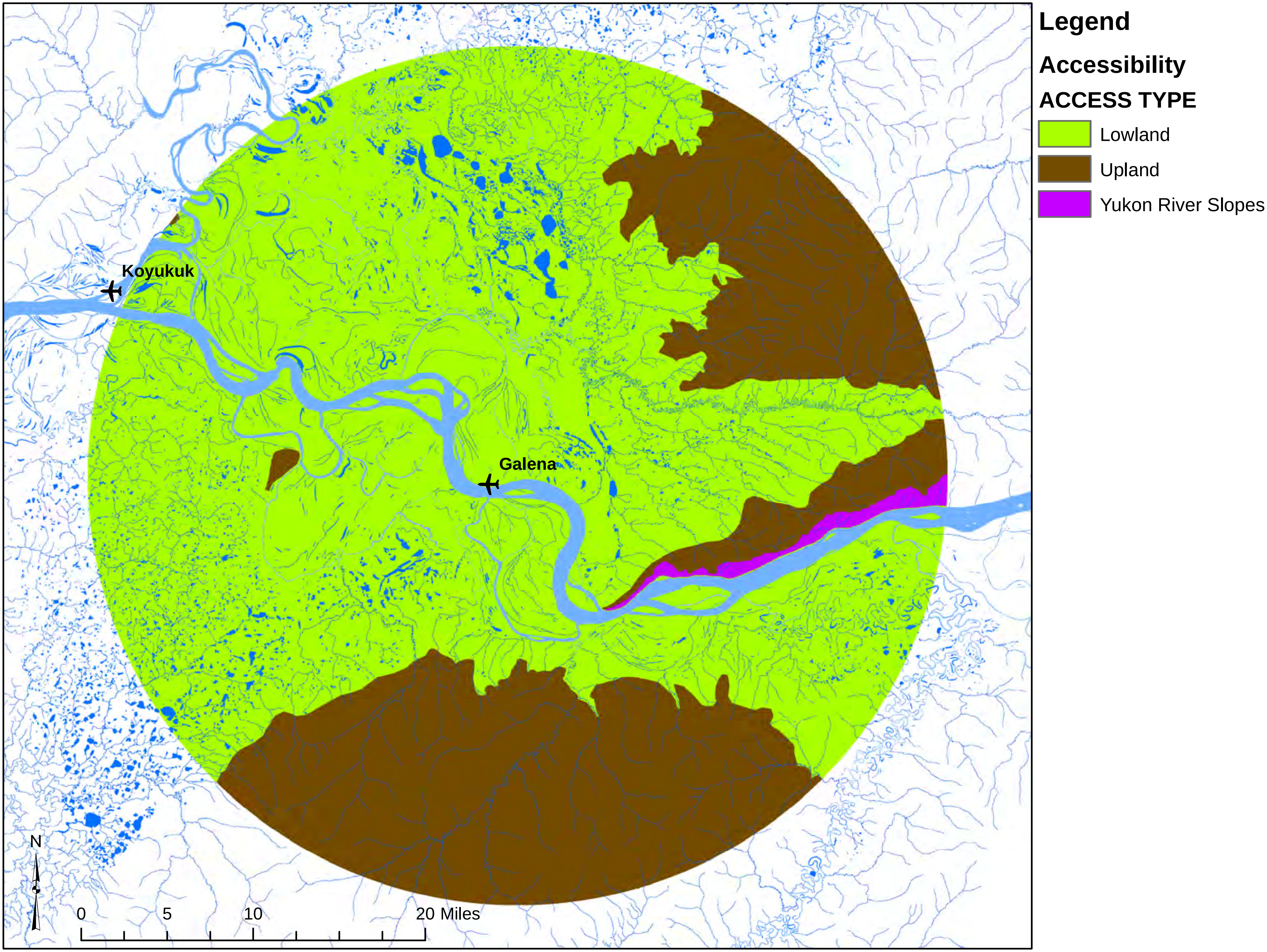
An additional 10 % of the total tonnage or 822,000 dry tons are estimated to be on the 162,000 acres of “Unreserved” lands located within between 10 and 13 miles from Galena, meaning that only a total of 20% of the Biomass Inventory is within 13 miles of Galena. As we go further out to 16 miles another 935,000 dry tons on “Unreserved” 160,000 acres are added to the totals meaning that only 32.6% of the Total Biomass Inventory or 2,547,000 dry tons of biomass are located within 16 miles of Galena. At a biomass harvest level of 20,000 dry tons per year, this tonnage would last over 100 years, but we would have to be able to harvest about 80% of the existing Biomass Inventory to accomplish this level of harvest on a continual basis.

Approximately half of the “Unreserved” Biomass Inventory is located within 19 miles of Galena meaning that the other half is located from 19-25 miles of Galena. All these figures indicate that transportation of biomass from future harvest locations to Galena will require considerable effort and that there will likely be a need to develop and manage different types of transportation efforts in order to minimize road building and maintenance activities and associated transportation costs. In addition, as transportation distance appears to be an issue, future plans should attempt to focus harvest activity for a period of time, such as a 5-year period or a decade, within specific areas that can be accessed by a few roads that are maintained and lengthened each year, rather than by undertaking a scattered shotgun-like approach to developing and maintaining many miles of roads throughout the Galena Vicinity each year.

Biomass Inventory by Access Class

Another landscape characteristic that will likely influence future biomass harvest activity is the varied accessibility to different regions of the Galena Vicinity. GRS has identified three major classes of accessibility as shown in Figure 13. These classes of accessibility are Lowland, Upland, and Yukon River Slopes. The Lowland Access Class represents portions of the Galena Vicinity that are very flat with little change in elevation that are characterized by the presence of many lakes, streams, bodies of water, marshes, and very wet herbaceous meadows. The damp wet nature of these lowland areas makes road building into and through these areas virtually impossible during the spring, summer, and fall seasons. These lowland areas will likely require Winter Access for harvest and transportation activities as the biomass may be harvested and transported to Galena far easier when the ground and water are frozen rather than when it is in a wet or liquid state. The second class of accessibility is the Upland Class of lands. Lands in this class are characterized by moderate slope of at least 3-5% and a general lack of the hydrologic features and damp wet areas (surface water limitations) that characterize the lowland areas. Most of these upland areas are to the far south, east, and northeast of Galena. These areas appear to have soils that are well enough

Figure 13: Galena Vicinity Access Types



drained to enable summer season harvest and transportation operations. More gently sloped portions of these areas may also be accessible in the winter months, provided the winter equipment can operate in these sloped portions of the Galena Vicinity. These upland areas represent summer and possibly all-season access (summer and winter) access and transportation networks will likely need to be developed, if the biomass on these acres is going to be harvested. The third accessibility class is the Yukon River Slopes class. Lands in his class may have very limited accessibility due to its steepness of slopes in this area. These steeply sloped areas were noted along the slopes on the north side of the Yukon River from approximately 10 to 25 miles upriver from Galena. The steepness of some of these lands might require cable yarding operations to harvest the biomass on these lands, if these lands can be harvested at all. The steepness of these lands in combination with their proximity to the Yukon River may constrain these areas from future harvest.

Tables 11 and 12 show the Biomass Inventory acreage, Cft3, and tonnage values by Access Class. Of the total estimated area of 1,254,636 acres in the Galena Working Circle about 70% of the area is designated as the Lowland Class, about 29% is designated as the Upland Class, and the remaining 1% of the area is designated as the Yukon River Slope Class. Of the total biomass of 7,820,554 tons 49.5% or 3,874,000 tons are located within the "Unreserved" Lowland Class areas while 34.9% of the biomass or 2,727,000 tons are located within the "Unreserved" Upland Class areas. Only 1.5% of the total biomass or 115,000 tons are located within the "Unreserved" Yukon River Slopes area. The Upland Class acres average 7.8 tons/acre, the Lowland acres average only 4.9 tons/acre, and the Yukon River Slopes acres average 13.7 tons/acre.

Biomass Inventory by Transportation Cost Projections

Transportation Cost is modeled by combining Distance from Galena and Access Class information. Access Class costs were estimated at $2/ton/mile within the Upland Class (summer/all-season access) and $4/ton/mile within the Lowland and Yukon River Slopes classes (winter access). Cost estimates were additive for Upland areas which require transportation across a combination of Upland and Lowland areas when transporting biomass from the harvest location to Galena. In addition, transportation distances in each Upland area were estimated based upon the distance of each harvest location to a centralized collection point (log deck) located in each Upland area near its boundary with a Lowland area across which the biomass would eventually be transported to Galena. It must be noted that all of this information is an estimate and used for the purpose of modeling relative transportation cost. All of these estimates of relative cost will need refinement as better information regarding specific equipment, means of transportation, and access become known in the future. The resulting Transportation Cost estimates and approximate Upland collection point locations are shown in Figure 14. Tables 13 and 14 show the Biomass Inventory acreage, Cft3, and tonnage values by estimated Transportation Cost classes.

Table 11: Volume (Cft3) and Area By Access Type - as of 1/1/2012

Access Zone	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total
1 - Lowland	Unreserved	795,648	1,203,396	351,246	2,496	1,557,138	648,923	233,551	13,124	42,130	937,728	2,494,865	49.4%
	Reserved	83,200	253,478	41,621	538	295,636	165,575	54,901	8,088	15,131	243,695	539,331	10.7%
	Subtotal	878,848	1,456,874	392,867	3,033	1,852,774	814,498	288,452	21,212	57,261	1,181,422	3,034,196	60.1%
2 - Upland	Unreserved	348,024	910,037	423,419	480	1,333,936	365,802	73,865	5,635	7,876	453,177	1,787,113	35.4%
	Reserved	19,030	93,650	18,483	97	112,230	37,390	5,392	415	712	43,910	156,140	3.1%
	Subtotal	367,054	1,003,686	441,902	577	1,446,166	403,192	79,257	6,050	8,588	497,087	1,943,253	38.5%
3 - Yukon River Slopes	Unreserved	8,419	34,644	3,684	29	38,357	26,857	1,441	1,716	262	30,277	68,634	1.4%
	Reserved	315	2,914	192	1	3,107	926	79	37	11	1,052	4,159	0.1%
	Subtotal	8,734	37,558	3,876	30	41,464	27,783	1,520	1,753	273	31,328	72,793	1.4%
Grand Total	Total Unreserved	1,152,091	2,148,076	778,350	3,005	2,929,431	1,041,582	308,857	20,475	50,268	1,421,182	4,350,613	86.1%
	Total Reserved	102,546	350,042	60,296	636	410,973	203,891	60,372	8,540	15,854	288,656	699,629	13.9%
	Grand Total	**1,254,636**	**2,498,118**	**838,646**	**3,640**	**3,340,404**	**1,245,473**	**369,229**	**29,014**	**66,122**	**1,709,838**	**5,050,241**	**100.0%**

Table 12: Tonnage (Dry) and Area By Access Type - as of 1/1/2012

Access Zone	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total
1 - Lowland	Unreserved	795,648	1,740,017	435,757	2,176	2,177,951	1,330,290	297,779	18,636	49,148	1,695,853	3,873,804	49.5%
	Reserved	83,200	365,898	51,267	516	417,681	339,429	70,000	11,485	17,465	438,378	856,059	10.9%
	Subtotal	878,848	2,105,915	487,025	2,692	2,595,632	1,669,720	367,779	30,121	66,612	2,134,231	4,729,863	60.5%
2 - Upland	Unreserved	348,024	1,325,251	538,803	531	1,864,586	749,895	94,178	8,001	9,889	861,962	2,726,548	34.9%
	Reserved	19,030	135,048	22,257	131	157,437	76,650	6,875	590	840	84,955	242,391	3.1%
	Subtotal	367,054	1,460,299	561,060	663	2,022,022	826,544	101,053	8,591	10,729	946,917	2,968,939	38.0%
3 - Yukon River Slopes	Unreserved	8,419	50,539	4,978	33	55,550	55,057	1,838	2,437	320	59,652	115,202	1.5%
	Reserved	315	4,209	266	2	4,476	1,898	100	52	13	2,063	6,539	0.1%
	Subtotal	8,734	54,748	5,244	34	60,026	56,955	1,938	2,489	333	61,715	121,740	1.6%
Grand Total	Total Unreserved	1,152,091	3,115,807	979,539	2,740	4,098,086	2,135,242	393,795	29,074	59,356	2,617,467	6,715,553	85.9%
	Total Reserved	102,546	505,154	73,790	649	579,593	417,977	76,975	12,126	18,318	525,396	1,104,989	14.1%
	Grand Total	**1,254,636**	**3,620,961**	**1,053,329**	**3,389**	**4,677,679**	**2,553,219**	**470,770**	**41,200**	**77,674**	**3,142,863**	**7,820,542**	**100.0%**

Figure 14: Galena Vicinity Transportation Costs

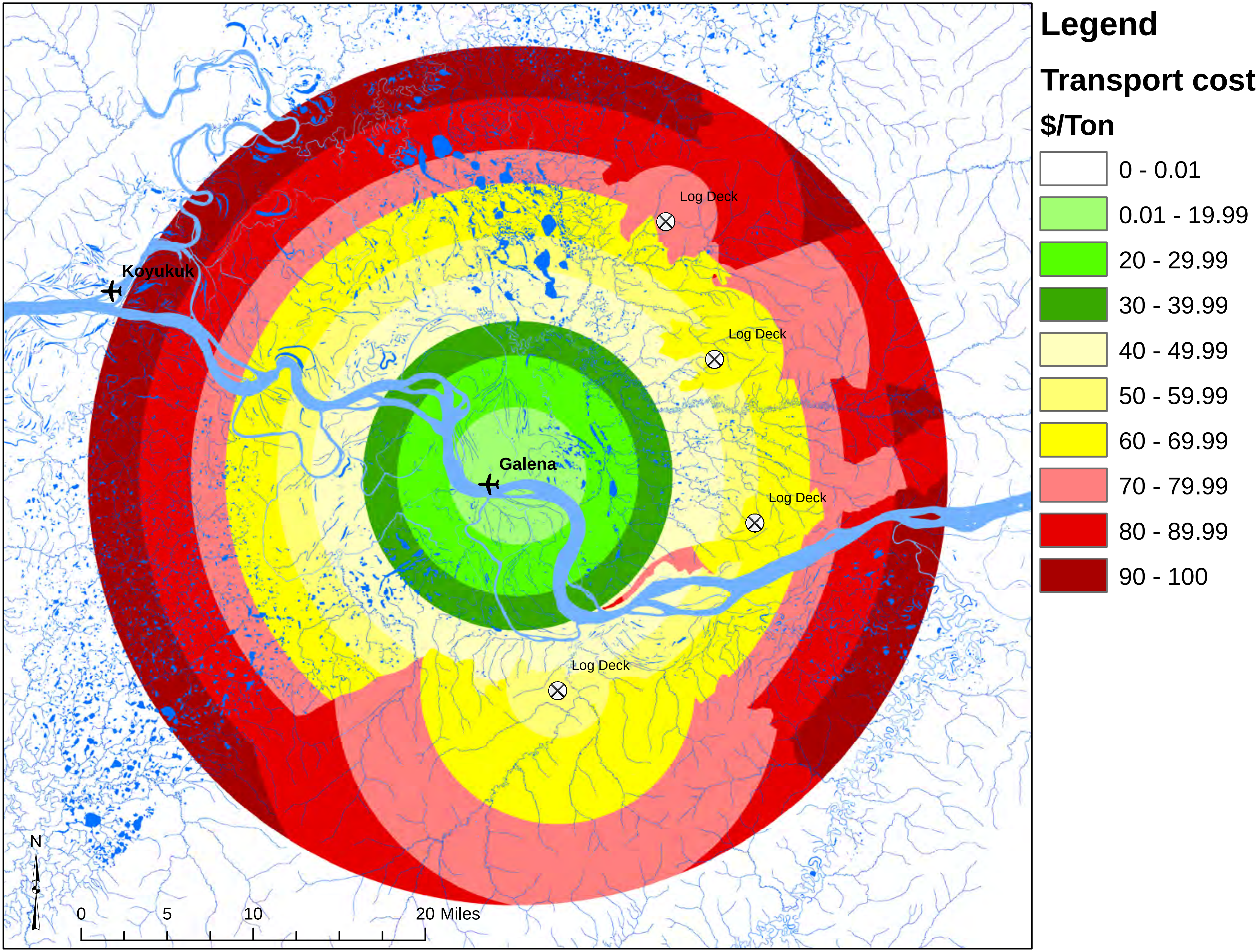


Table 13: Volume (Cft3) and Area By Transportation Cost Class - as of 1/1/2012

Transportation Cost Class	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total	Cumulat. % of Total
≤ $19/Dton	Unreserved	29,727	40,364	2,485	185	43,035	35,713	13,927	972	3,761	54,373	97,407	2%	2%
	Reserved	2,392	7,022	371	19	7,412	6,182	4,265	408	1,139	11,994	19,406	0%	0%
	Subtotal	32,119	47,387	2,856	204	50,447	41,895	18,192	1,380	4,900	66,366	116,813	2%	2%
$20 - $29/Dton	Unreserved	61,470	86,530	10,992	332	97,853	70,729	14,732	1,342	4,285	91,088	188,941	4%	6%
	Reserved	4,763	14,044	846	47	14,937	12,273	4,208	683	1,283	18,447	33,384	1%	1%
	Subtotal	66,233	100,574	11,838	379	112,791	83,002	18,940	2,025	5,568	109,534	222,325	4%	7%
$30 - $39/Dton	Unreserved	58,179	98,567	17,998	287	116,852	64,289	17,751	1,190	3,863	87,094	203,946	4%	10%
	Reserved	6,062	17,891	1,659	62	19,611	15,036	4,276	537	1,340	21,189	40,801	1%	2%
	Subtotal	64,241	116,458	19,656	349	136,463	79,326	22,027	1,727	5,204	108,283	244,746	5%	12%
$40 - $49/Dton	Unreserved	108,541	138,101	37,440	343	175,883	98,218	32,914	2,133	6,737	140,002	315,885	6%	16%
	Reserved	10,575	31,588	4,028	81	35,697	24,031	6,325	1,132	2,028	33,516	69,213	1%	3%
	Subtotal	119,116	169,689	41,468	424	211,580	122,249	39,239	3,265	8,765	173,517	385,098	8%	19%
$50 - $59/Dton	Unreserved	85,074	124,606	40,901	262	165,769	71,043	33,041	1,864	5,328	111,276	277,045	5%	21%
	Reserved	7,547	21,107	3,291	52	24,450	15,863	4,868	729	1,303	22,763	47,213	1%	4%
	Subtotal	92,621	145,713	44,192	314	190,219	86,906	37,909	2,593	6,631	134,039	324,258	6%	26%
$60 - $69/Dton	Unreserved	198,035	436,756	184,355	450	621,561	202,462	52,022	4,073	6,855	265,412	886,973	18%	39%
	Reserved	17,414	57,632	12,072	101	69,805	32,720	7,671	1,563	1,754	43,708	113,514	2%	6%
	Subtotal	215,448	494,389	196,427	551	691,366	235,182	59,693	5,636	8,609	309,120	1,000,487	20%	45%
$70 - $79/Dton	Unreserved	222,753	552,303	235,842	376	788,521	220,804	47,607	3,469	6,151	278,029	1,066,550	21%	60%
	Reserved	16,248	73,025	12,789	83	85,896	31,528	5,899	925	1,384	39,736	125,632	2%	9%
	Subtotal	239,001	625,328	248,631	459	874,417	252,332	53,505	4,394	7,534	317,765	1,192,182	24%	69%
$80 - $89/Dton	Unreserved	226,592	368,145	151,006	413	519,563	152,317	51,447	2,894	6,731	213,389	732,952	15%	75%
	Reserved	19,363	65,850	13,655	103	79,608	34,075	10,886	1,219	2,379	48,559	128,166	3%	11%
	Subtotal	245,955	433,994	164,661	516	599,171	186,392	62,333	4,113	9,110	261,948	861,119	17%	86%
$90 - $99/Dton	Unreserved	110,888	204,003	62,534	259	266,795	84,868	30,879	1,453	4,303	121,503	388,299	8%	82%
	Reserved	11,594	39,038	7,015	55	46,108	20,167	8,137	753	2,188	31,245	77,353	2%	13%
	Subtotal	122,482	243,041	69,548	314	312,903	105,035	39,015	2,206	6,492	152,749	465,652	9%	95%
≥ $100/Dton	Unreserved	50,651	98,732	34,801	99	133,631	41,154	14,537	1,085	2,254	59,030	192,661	4%	86%
	Reserved	6,597	22,846	4,570	33	27,449	12,017	3,838	591	1,056	17,502	44,951	1%	14%
	Subtotal	57,248	121,578	39,370	132	161,080	53,171	18,375	1,677	3,310	76,532	237,612	5%	100%
Grand Total	Total Unreserved	1,151,909	2,148,107	778,352	3,005	2,929,463	1,041,596	308,857	20,475	50,268	1,421,195	4,350,659	86%	
	Total Reserved	102,553	350,042	60,296	636	410,974	203,892	60,372	8,540	15,854	288,658	699,632	14%	
	Grand Total	**1,254,462**	**2,498,149**	**838,648**	**3,640**	**3,340,437**	**1,245,488**	**369,229**	**29,014**	**66,122**	**1,709,853**	**5,050,290**	**100%**	

Table 14: Tonnage (Dry) and Area By Transportation Cost Class - as of 1/1/2012

Transportation Cost Class	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total	Cumulat. % of Total
	Unreserved	29,727	57,301	3,169	209	60,679	73,212	17,757	1,381	4,331	96,679	157,359	2%	2%
≤ $19/Dton	Reserved	2,392	10,094	469	25	10,587	12,673	5,438	579	1,313	20,003	30,590	0%	0%
	Subtotal	32,119	67,395	3,638	234	71,267	85,885	23,194	1,959	5,644	116,682	187,949	2%	2%
	Unreserved	61,470	123,416	13,380	344	137,140	144,995	18,783	1,906	4,945	170,629	307,769	4%	6%
$20 - $29/Dton	Reserved	4,763	20,160	1,084	49	21,293	25,159	5,365	969	1,478	32,971	54,265	1%	1%
	Subtotal	66,233	143,576	14,464	393	158,433	170,154	24,148	2,875	6,424	203,600	362,034	5%	7%
	Unreserved	58,179	141,532	21,794	291	163,617	131,793	22,633	1,690	4,480	160,596	324,213	4%	10%
$30 - $39/Dton	Reserved	6,062	25,702	2,044	63	27,809	30,825	5,452	763	1,543	38,582	66,392	1%	2%
	Subtotal	64,241	167,235	23,838	354	191,427	162,617	28,085	2,453	6,024	199,178	390,605	5%	12%
	Unreserved	108,541	200,224	46,536	293	247,053	201,346	41,965	3,029	7,829	254,169	501,223	6%	17%
$40 - $49/Dton	Reserved	10,575	45,646	4,957	79	50,681	49,264	8,064	1,607	2,337	61,273	111,953	1%	3%
	Subtotal	119,116	245,870	51,492	372	297,734	250,610	50,030	4,636	10,166	315,442	613,176	8%	20%
	Unreserved	85,074	180,620	52,017	218	232,855	145,639	42,127	2,646	6,239	196,651	429,506	5%	22%
$50 - $59/Dton	Reserved	7,547	30,549	4,080	48	34,677	32,518	6,207	1,035	1,504	41,265	75,942	1%	4%
	Subtotal	92,621	211,169	56,097	266	267,532	178,157	48,334	3,682	7,743	237,915	505,447	6%	26%
	Unreserved	198,035	635,908	234,513	358	870,779	415,048	66,328	5,783	8,289	495,448	1,366,227	17%	39%
$60 - $69/Dton	Reserved	17,414	83,136	14,715	100	97,951	67,076	9,781	2,219	2,036	81,113	179,063	2%	7%
	Subtotal	215,448	719,044	249,228	457	968,729	482,124	76,109	8,003	10,325	576,561	1,545,290	20%	46%
	Unreserved	222,753	803,085	298,713	361	1,102,159	452,648	60,698	4,925	7,535	525,807	1,627,965	21%	60%
$70 - $79/Dton	Reserved	16,248	105,299	15,774	98	121,171	64,633	7,521	1,314	1,606	75,073	196,243	3%	9%
	Subtotal	239,001	908,383	314,487	459	1,223,329	517,280	68,219	6,239	9,141	600,880	1,824,208	23%	69%
	Unreserved	226,592	534,307	188,508	339	723,153	312,251	65,595	4,109	7,999	389,954	1,113,107	14%	75%
$80 - $89/Dton	Reserved	19,363	95,162	16,368	101	111,631	69,855	13,879	1,731	2,754	88,219	199,850	3%	12%
	Subtotal	245,955	629,468	204,876	440	834,784	382,105	79,475	5,840	10,753	478,173	1,312,956	17%	86%
	Unreserved	110,888	295,815	77,935	233	373,983	173,980	39,370	2,063	5,064	220,477	594,460	8%	82%
$90 - $99/Dton	Reserved	11,594	56,422	8,700	55	65,176	41,343	10,374	1,069	2,526	55,313	120,489	2%	13%
	Subtotal	122,482	352,237	86,634	288	439,159	215,323	49,745	3,132	7,590	275,790	714,948	9%	95%
	Unreserved	50,651	143,596	42,972	95	186,663	84,366	18,535	1,541	2,646	107,088	293,751	4%	86%
≥ $100/Dton	Reserved	6,597	32,989	5,602	32	38,624	24,635	4,893	840	1,219	31,587	70,211	1%	14%
	Subtotal	57,248	176,584	48,575	127	225,286	109,000	23,429	2,381	3,866	138,675	363,961	5%	100%
Grand Total	Total Unreserved	1,151,909	3,115,803	979,537	2,740	4,098,081	2,135,275	393,792	29,074	59,357	2,617,498	6,715,578	86%	
	Total Reserved	102,553	505,158	73,792	649	579,599	417,979	76,975	12,126	18,318	525,398	1,104,996	14%	
	Grand Total	**1,254,462**	**3,620,961**	**1,053,329**	**3,389**	**4,677,679**	**2,553,254**	**470,766**	**41,200**	**77,675**	**3,142,895**	**7,820,574**	**100%**	

Only 501,000 dry tons or 17% of the “Unreserved” dry tonnage is in Cost classes ≤ $49/ton. Approximately 39% of the total tonnage is in the “Unreserved” Cost classes that are ≤ $69/ton and 60% of the total tonnage is in the “Unreserved” Cost classes that are ≤ $79/ton meaning that the median transportation cost/ton falls within the $70-79/ton Cost class. These relatively high transportation cost estimates reflect the results shown by Distance Zone in which half of the “Unreserved” tonnage was located approximately 19 miles or more from Galena.

As transportation costs do seem to be relatively high, it is anticipated that these type costs will comprise a significant component of the total cost of procuring biomass for energy production in Galena.

Availability of the Biomass Inventory

The Biomass Inventory values listed in Tables 3 and 4 show an estimated total inventory of 5,050,194 Cft3 and 7,820,554 dry tons that appear to provide a more than adequate foundation for future biomass harvests of up to 20,000 dry tons per year. However, this is a total Biomass Inventory and this entire inventory is not available for harvest. Any planning applications like this project should be based on what is available for use rather than the gross total values.

Showing the Biomass Inventory in Tables 5 through14 with respect to different characteristics of the Galena Vicinity, such as ownership, accessibility, and distance, helps one better understand the nature of this inventory and recognize potential limitations or concerns regarding its future use. Based upon the information that has been developed and potential limitations that GRS has identified, the Available Biomass Inventory can now be estimated by constraining or removing biomass from the Total Biomass Inventory by removing lands that for one reason or another are either constrained from harvest or are believed to be undesirable or impractical to harvest.

The first step in determining the Available Biomass Inventory was actually performed during the development of a Harvest Unit map data set. During this process, all non-tree type stands with less than 2 tons/acre or 10% tree cover were excluded from the harvest units that were developed. These stands were not included in harvest units as it is unlikely these non-tree type stands will support future forestry operations or are financially or environmentally impractical to harvest.

The second step in determining the Available Biomass Inventory is to constrain or remove from consideration the biomass growing on lands that GRS believes are not advisable to include in this planning effort. Biomass on lands that are environmentally sensitive, economically impractical, or restricted from harvest should not be included in the Available Biomass Inventory. These lands include all areas (102,554 acres) within the water-feature protection zones previously categorized as “Reserved.” Biomass in these protection zones is not available for harvest on publicly owned lands, and while portions of the biomass on these type lands may be harvested on privately owned lands, this would be undertaken at a greater effort and higher cost. For the purposes of this study, all biomass within the water-feature protection zones will not be included in the Available Biomass Inventory. Other biomass that will be removed from consideration is that on all lands (259,773 acres) owned by USF&WS. Lastly, GRS believes that biomass operations on private lands within USF&WS refuge boundaries (202,050 acres) should not be considered for future harvest, as such operations may face many environmental and regulatory issues that should only be undertaken if absolutely necessary. In other words, all biomass on lands owned or administered by USF&WS should not be included in the Available Biomass Inventory. Lastly, all lands (8,734 acres) in the Yukon River Slopes access class should be withheld from the Available Biomass Inventory due to their often steep terrain and proximity to the Yukon River.

The Available Biomass Inventory, based upon the aforementioned land and biomass removals is shown in Tables 15 and 16. These tables summarize Available acreage, Cft3, and dry tonnage by Access and Distance classes. Distance Zones have been collapsed into three Distance Classes representing near Galena (0-9 miles), mid-range from Galena (9-18 miles), and far from Galena (19-25 miles). All Reserved and otherwise constrained acres, Cft3, and tonnage have been removed from these figures. Table 16 shows that the total amount of biomass considered to be available for harvest and energy production is 5,137,991 dry tons or 65.6 % of the Total Biomass Inventory of 7,820,554 tons.

Of note is that only 611,990 tons or 12% of the available biomass is located within 9 miles of Galena and all of this biomass is in the Lowland access area. In addition, the Available Biomass Inventory is split almost 50/50 between Lowland (2,511,865 tons) and Upland (2,586,127) access areas. This inventory is also split nearly 50/50 between harvest units within 18 miles of Galena (2,593,862 tons) and units 19-25 miles from Galena (2,544,329 tons).

Given harvest level goals of as much as 20,000 tons/year this means that If transportation to Upland areas is not going to be developed at some future time, then biomass harvesting from the highest cost Lowland areas 19-25 miles from Galena will be necessary to meet the maximum planned biomass needs. This would likely result in higher total biomass procurement costs, as projected biomass transportation costs are higher on the Lowland winter access areas 19-25 miles from Galena than they are on the Upland summer access areas 10-18 miles from Galena. The potential impact(s) of such management choices can be demonstrated now through simulation of the long-term harvesting of the Available Biomass Inventory.

Table 15: Available Volume (Cft3) by Access and Distance

Access Area	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total
Lowland	≤ 9 miles	47,809	179,955	26,792	575	207,323	132,688	29,546	2,047	7,397	171,678	379,001	11%
	10 - 18 miles	82,662	299,460	86,362	648	386,470	171,871	44,478	2,649	7,923	226,920	613,390	18%
	≥ 19 miles	75,943	358,613	106,988	348	465,949	127,450	42,643	1,553	6,202	177,848	643,797	19%
	Total Lowland	206,414	838,028	220,142	1,571	1,059,741	432,008	116,668	6,248	21,522	576,447	1,636,188	49%
Upland	≤ 9 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	10 - 18 miles	82,568	325,545	142,578	173	468,296	152,934	31,362	2,421	2,655	189,373	657,668	20%
	≥ 19 miles	133,984	543,049	267,012	198	810,259	190,726	31,361	2,386	3,505	227,978	1,038,237	31%
	Total Upland	216,552	868,594	409,590	371	1,278,554	343,660	62,723	4,807	6,160	417,350	1,695,905	51%
Yukon River	≤ 9 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	10 - 18 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	≥ 19 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	Total Yukon River	-	-	-	-	-	-	-	-	-	-	-	0%
		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Total	≤ 9 miles	47,809	179,955	26,792	575	207,323	132,688	29,546	2,047	7,397	171,678	379,001	11%
	10 - 18 miles	165,230	625,004	228,940	821	854,765	324,805	75,841	5,070	10,578	416,293	1,271,058	38%
	≥ 19 miles	209,927	901,663	373,999	546	1,276,208	318,176	74,004	3,940	9,706	405,826	1,682,034	50%
	Grand Total	**422,966**	**1,706,623**	**629,731**	**1,941**	**2,338,295**	**775,669**	**179,391**	**11,056**	**27,682**	**993,797**	**3,332,092**	**100%**
	Percent of Total	**100%**	**51%**	**19%**	**0%**	**70%**	**23%**	**5%**	**0%**	**1%**	**30%**	**100%**	

Table 16: Available Tonnage (Dry) by Access and Distance

Access Area	Species or Group/Feature	Acreage	White Spruce	Black Spruce	Other/ Larch	Total Conifer	Paper Birch	Balsam Poplar	Aspen	Other/ Salix	Total Hardwood	Grand Total	Percent of Total
Lowland	≤ 9 miles	47,809	257,617	32,583	647	290,847	272,011	37,671	2,906	8,555	321,143	611,990	12%
	10 - 18 miles	82,662	433,592	106,127	526	540,246	352,335	56,710	3,761	9,262	422,068	962,314	19%
	≥ 19 miles	75,943	520,211	131,864	342	652,418	261,272	54,370	2,206	7,295	325,143	977,561	19%
	Total Lowland	206,414	1,211,421	270,574	1,515	1,483,510	885,618	148,751	8,873	25,112	1,068,355	2,551,865	50%
		49%	49%	34%	77%	45%	56%	65%	57%	76%	57%	50%	
Upland	≤ 9 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	10 - 18 miles	82,568	475,625	183,212	219	659,056	313,515	39,987	3,438	3,363	360,303	1,019,359	20%
	≥ 19 miles	133,984	789,839	337,808	245	1,127,892	390,990	39,985	3,389	4,514	438,877	1,566,768	30%
	Total Upland	216,552	1,265,465	521,020	464	1,786,948	704,505	79,972	6,827	7,876	799,179	2,586,127	50%
		51%	51%	66%	23%	55%	44%	35%	43%	24%	43%	50%	
Yukon River Slopes	≤ 9 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	10 - 18 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	≥ 19 miles	-	-	-	-	-	-	-	-	-	-	-	0%
	Total Yukon River	-	-	-	-	-	-	-	-	-	-	-	0%
		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Total	≤ 9 miles	47,809	257,617	32,583	647	290,847	272,011	37,671	2,906	8,555	321,143	611,990	12%
	10 - 18 miles	165,230	909,218	289,338	745	1,199,302	665,850	96,697	7,199	12,625	782,371	1,981,673	39%
	≥ 19 miles	209,927	1,310,051	469,672	587	1,780,310	652,261	94,355	5,595	11,809	764,020	2,544,329	50%
	Grand Total	**422,966**	**2,476,885**	**791,593**	**1,979**	**3,270,458**	**1,590,123**	**228,723**	**15,699**	**32,988**	**1,867,534**	**5,137,991**	**100%**
	Percent of Total	**100%**	**48%**	**15%**	**0%**	**64%**	**31%**	**4%**	**0%**	**1%**	**36%**	**100%**	

Harvest Projections

Harvest projection is a useful forest management tool, as it provides a means of estimating long-term sustainable levels of harvest under different management scenarios. Multiple scenarios may be developed and resource managers can evaluate and compare the results to determine future management practices. Site-specific harvest guidance can be provided, as well as estimates of benefits and costs specifically associated with different management alternatives. However, it must always be remembered that results are modeled estimates and are always subject to review (human interpretation) and modification prior to their actual implementation.

The projection of a long-term non-declining yield or harvest projection involves the application of a harvest strategy to an existing inventory that will be grown over time. As harvest units are selected for harvest they are replaced by reforested stands of a similar nature that will grow and develop to eventually be harvested again at some future time. As harvest operations are forecast and implemented in the model, growth is projected on remaining unharvested stands, and inventory levels are updated. In a fully regulated forest, maximum harvest would be achieved when the forest acreage is evenly distributed throughout the different age classes and the growth of the forest is available for harvest in the oldest (mature) age class of the forest. Unfortunately, due to past fire and logging history, Galena does not have anything close to a fully regulated forest, and harvests will have to be managed to see that future harvest levels can be maintained over time.

The non-declining aspect of such a projection means that current harvest levels will not be decreased in the future, but will be planned so that they can be maintained at current or higher levels in the future. Such decreases in harvest most often happen when old growth or mature timber stands, which typically have high biomass/acre and whose growth may have already peaked, are harvested more rapidly than the other stands of the area are capable of growing, eventually resulting in a lower young growth based inventory and eventual declines in harvest levels as the younger forest stands cannot support the past higher levels of harvest. This situation can be avoided if the harvest level that is implemented never exceeds the growth of the forest.

Inventory Projection

The starting inventory for all harvest projections is the Available Biomass Inventory as of 1/1/2012 shown in Tables 15 and 16. These values represent the total biomass estimated to be present in the harvest units that are in the Harvest Unit map data set.

Growth Projection

One benefit of GRS's field data collection methodology is that stand lists are developed for every stand that is inventoried. This stand list information may then used to generate inventory estimates for every stand in the Stand Inventory map data set. GRS software can then grow this stand list data through time, recalculate the grown tree volumes, and estimate growth on a stand by stand basis. In addition, GRS collected radial growth, height, and age data from suitable site trees on sample sites to enable modification or calibration of stand growth estimates.

GRS field sample data were initially used to forecast growth and site productivity. The radial increment core data indicated average growth rates from as high as 20 rings/inch (rpi) to as low as 80 rpi. Associated tree heights ranged from as much as 90 feet tall to nearly 0 for trees that were often 80-90 years old. Our field assessment data basically indicated three levels of productivity – good, average, and poor. On the basis of a very limited set of field observation GRS estimated average levels of diameter and height growth for the different productivity levels as shown in Table 17.

Table 17: Average Diameter and Height Growth Rates

Site	Conifer Rings/inch	Conifer Height (ft/Year)	Hardwood Rings/inch	Hardwood Height (ft/Year)
Good	24	0.75	28	0.6
Average	32	0.50	36	0.4
Poor	40	0.25	50	0.2

Stand mortality was estimated at between 1 to 5% per 5-year period, depending on the stocking levels and productivity of the stand. Mortality was projected to be higher in more heavily stocked and lower productivity stands. GRS tested these growth and mortality estimates and found that the application of these growth and mortality values tended to result in tree stands of a comparable stocking and size to what we observed in the field, when these rates were applied for 90-100 years. Initially, these growth and mortality rates were used to grow existing and harvested/reforested stands. While these values appear to represent very slow individual tree growth rates that represent approximately 1-2% change per year over the course of a 90 or 100 year period, much higher percent (%) cubic volume growth rates were observed when trees in existing stand lists were grown and processed using the species-specific volume equations. The 1-2% diameter and height changes equated to 6-12% increases in cubic volume over a 5-year period (this is likely due to the manner in which volume functions work and how cubic volume estimates are related geometrically to increases in diameter and height growth; e.g. a 13" dbh tree might have four to five times the volume of a 6" dbh tree). Such growth increases seemed much higher than anticipated! Not wanting to project growth over the next 50-100 years at levels that some might consider unreasonably high levels, and not wanting anyone to focus on these growth rates, as opposed to the harvest projections, an alternate approach was implemented to grow existing stands; cubic volume growth was limited to a 1% increase in cubic growth per year. This growth level equates to an average of approximately 8 ft3/acre/year or 0.12 tons/acre/year for all grown stands. While this low level represents a very conservative approach, by using it the growth projections used in this study will not yield results that are overly optimistic and change the focus of this effort, or play a role in possibly indicating that substantially higher harvest levels are possible when that may not be the case. Growth can be adjusted upward in the future as more growth data are obtained and analyzed that warrant such increases.

It is noteworthy that this low 1% cubic volume growth level, when applied to the Galena Vicinity Available Biomass Inventory of 5,137,997 tons, amounts to an annual biomass growth estimate of 51,380 tons/year, a level considerably higher than the maximum targeted harvest level of 20,000 tons/year. As a result, even using this very low 1% growth rate, the Available Biomass Inventory is actually experiencing a positive change in total tonnage with each passing year during which growth exceeds harvest.

Lastly, as stands are harvested, they are replaced in the inventory with a reforested stand of comparable species composition and growth potential that will be grown using the stand table approach and the growth rates listed in Table 17.

Cost Projections

Cost projections used in this study are to a large degree based upon values presented by Will Putman in his 2010 Fort Yukon Biomass Resource Assessment with some minor modifications. Galena does not have any timber harvest cost history and the projection of such costs is rather nebulous at this point in time. What is important is that costs of a correct relative magnitude are used so that costs, when compared, will tend to reflect the relative total cost associated with different timber harvesting alternatives. For example, summer season transportation and harvest costs may be significantly lower than winter season transportation, as biomass may be hauled by truck over gravel or dirt roads rather than on winter roads. Similarly, harvesting lower volume/acre stands should cost more per ton than harvesting higher volume/acre stands and hauling material a long distance should cost more than hauling the same material a short distance. When developing cost estimates for alternatives we must assume that the costs used will be sensitive to the different harvest activities, so that different alternatives and scenarios may be ranked correctly based upon their relative benefits (harvest levels) and associated costs. The costs shown in Table 18 were used to develop the cost estimates for the harvest scenarios modeled in this study.

Costs concerned with equipment purchases or road development and construction have not been included in these cost estimates. These costs reflect biomass harvest investments that will be amortized over the life of the equipment or roads and their costs will be charged to the volume that is produced. Costs per ton for such expenses may be developed, once these costs are known, by spreading these costs over the total number of tons of biomass harvested. Consequently, the higher the harvest level, the lower the cost per ton for equipment and road construction.

Table 18: Biomass Procurement Costs		
Cost Category	$$ Per Acre	$$ Per Ton
Stumpage	$ -	$ 5.00
Harvest	$ 250.00	$ 10.00
Transportation		
Winter Access		$4.00/mile
Summer Access		$2.00/mile
Reforestation	$ 100.00	
Administration	$ 10.00	$ 1.00

All cost projections developed for the harvest projections will be expressed in terms of 2012 values with no discounting of future costs for time. As a result, all cost estimates are in terms of 2012 values.

Selection Priorities

The development of harvest projections must involve the development of priorities that can be used to select harvest units from a pool of available units; these selected units then comprise annual and periodic harvest plans. Three different selection criteria were used to develop the harvest projections for the Galena Vicinity. All of these criteria were selected because they will tend to decrease the costs of harvest operations over the entire harvest projection period. These criteria were:

1. Biomass/Acre – harvest units with the highest volume/acre will be selected before stands with lower volume/acre. This strategy works in two ways. This criterion tends to select harvest units comprised of more mature stands first, but it also tends to select harvest units comprised of the Spruce-Hardwood Mix, hardwood, and White Spruce type stands, rather than Black Spruce stands that may be harder to regenerate. This strategy will also allow lower volume/acre stands to grow and develop into higher volume/acre stands before they are harvested.

2. Direction from Galena – harvest units will be selected within a geographic direction from Galena rather than using a shotgun approach and letting the model select units from any region of the Galena Vicinity. Transportation costs will tend to be less if harvest units are selected in a similar direction from Galena that may be accessed by the same transportation system(s), as this will require less overall development and maintenance of the transportation system(s) than if

transportation systems are needed to access the entire Galena Vicinity during each year or harvest period.

The biomass available for harvest will be tracked within areas centered around Galena. Harvest units will be selected for operation during any given 5-year harvest period from the area with the highest available biomass at the start of the harvest period. The available biomass per area will be recalculated at the start of each 5-year harvest period based upon past harvest activity and growth.

3. Distance from Galena – harvest units within a geographic direction from Galena will be selected so they are balanced with respect to the distance that the harvested biomass must be transported back to Galena. Implementation of this distance criterion will tend to balance transportation costs from period to period for each option, rather than having high variability in periodic transportation costs because the model selects units that are geographically clustered either closer to Galena or farther from Galena than the average distance the biomass is located from Galena.

The *harvestBiomass* Application

GRS has developed and used harvest modeling applications since 1999 when GRS developed the ***harvest*** application and used it in California to model harvest levels for Sustained Yield Management Plans required by the California Forest Practices Act. GRS's ***harvest*** application integrates stand inventory information, growth projections, harvest level options, and selection criteria to model harvest projects. GRS has modified the ***harvest*** application to perform site-specific biomass harvest modeling such as is required to develop harvest projections for this project. The modified application is called ***harvestBiomass***.

Harvest Alternatives

Harvest alternatives were developed using ***harvestBiomass*** to determine whether or not the maximum annual target level of 20,000 dry tons could be maintained (if this level can be achieved, then all lesser levels of harvest can also be achieved). In order to provide a long-term harvest perspective, GRS developed projections that extend to the year 2111. Five different harvest scenarios were developed, based upon the major goals and objectives of this study and the characteristics of the Available Biomass Inventory. Options included different approaches with respect to land accessibility, as well as distance from Galena, as these are both significant landscape characteristics of the Galena Vicinity that will influence the Available Biomass Inventory and overall cost of procuring biomass during future biomass procurement efforts.

The five harvest scenarios that were modeled using ***harvestBiomass*** are:

1. **Acc1-Dist4** - Harvest biomass only within 18 miles of Galena on the Lowland Access Class lands. The initial available biomass for this option totals 1,574,304 dry tons.

   This option would concentrate harvest activities nearer Galena in Lowland Access areas at a lower transportation cost, without having to access biomass in more distant areas or in Upland Access areas. The potential detriment of this plan would be the intensive level of harvest that would occur in the immediate vicinity of Galena, as significant amounts of available biomass would be harvested during the 100 year projection period. In addition, the more intensive approach would require the harvest of areas of lower biomass/acre, including some harvest units with greater amounts of black spruce.

2. **Acc1** - Harvest biomass only on the Lowland Access Class lands. The initial available biomass for this option is 2,551,865 dry tons. This option was selected to determine if operations could be concentrated on Lowland Access areas without having to access biomass on Upland Access areas.

   This scenario would decrease the intensity of harvest activities within the immediate vicinity of Galena and provide a larger pool of stands/harvest units for selection, resulting in harvesting areas having higher biomass/acre. The potential detriment of this plan is the higher cost of transporting biomass that would be incurred by conducting Lowland harvest operations in areas 19-25 miles from Galena.

3. **Acc1&2** - Harvest biomass from both the Lowland and Upland Access Class lands. The initial available biomass for this option is 5,137,991 dry tons.

   This option would decrease the reliance on harvesting only Lowland Access areas with higher per ton transportation costs and replacing some of those harvest areas with Upland Access areas that may have lower transportation costs. The larger pool of available biomass and dramatically larger area under forest management would enable greater selectivity in choosing harvest areas, potentially leading to lower environmental impact of harvest operations. The average biomass/acre harvested would likely increase. In addition, some harvest activities and environmental impacts would be shifted from the Lowland Access areas near the Yukon River into the surrounding Upland Access areas. The potential detriment of this plan is that development of the transportation system in the Upland Access areas would have to be undertaken at the start of the planning period and would contribute significant startup costs in additional to equipment, facility, and personnel startup costs. Upland road system development would likely result in greater environmental impacts in the Upland Access areas. In addition, the significant inventory and higher biomass/acre of Upland stands added to the harvest pool might tend to shift some operations farther out from town, as the model harvests biomass proportionate to its distribution in the Galena Vicinity. This might possibly result in higher transportation costs associated with the biomass harvested in Upland Access areas.

4. **<u>Acc1D3/20-Acc1&2</u>** – Harvest biomass only within 16 miles of Galena on the Lowland Access Class lands for the first 20 years of the projection period, then harvest biomass from both the Lowland and Upland Access Class lands. The initial available biomass for this option is 1,574,304 dry tons for the first 20 years of the plan; upon initiation of operations in Upland units, the available biomass pool jumps to 5,137,991 dry tons for the duration of the plan.

   This option would focus harvest operations on the closer Lowland Access areas for the first 20 years and then switch to a combination of Lowland and Upland Access areas after the biomass procurement program has become well established. Upland transportation development costs would be delayed for 20 years and funds could be collected over the first 20 years of harvest operations to support subsequent Upland transportation system development efforts (for example, $1,000,000 of transportation development costs spread over 400,000 tons of biomass harvested during the first 20 years would result in adding an additional fee of $2.50/ton to the biomass procurement costs in order to collect sufficient funds necessary to support subsequent transportation development needs in the Upland areas). The alternative's large amount of available biomass would enable greater selectivity in choosing harvest areas potentially leading to harvesting higher biomass/acre harvest units. Spreading harvest operations over such a large area would likely result in less environmental impact near Galena. The potential detriment of this plan is similar to Option 3 above (**Acc1&2)** that operations will be spread throughout Lowland and Upland areas as far as 25 miles from Galena possibly resulting in higher transportation costs. In addition, Upland road system development would likely result in greater environmental impacts in the Upland Access areas.

5. **Acc1D3/20-Acc1&2Dist5** – This option is very similar to Option 4 above, but with one deviation. As with option 4 biomass is harvested only near town (within 16 miles) on the Lowland (winter) Access Class lands for the first 20 years of the projection period. After 20 years biomass is harvested from both the Lowland and Upland Access Class lands that are within 21 miles from Galena (4 miles less than Option 4). The initial available biomass for this option is 1,574,304 dry tons for the first 20 years of the plan; upon initiation of operations in Upland units, the available biomass pool jumps to approximately 2,862,000 dry tons for the duration of the plan.

   This option would focus harvest operations on the closer Lowland Access areas for the first 20 years and then switch to a combination of Lowland and Upland Access areas within 21 miles of Galena after the program has become well established. Upland transportation development costs would be delayed and funds could be collected over the first 20 years of harvest operations to support subsequent Upland transportation development efforts similar previously described under Option 4. The somewhat larger amount of available biomass would enable greater selectivity in choosing harvest areas potentially leading to lower environmental impact near Galena and along the Yukon River than for Options 1 and 2. Transportation costs should be lower than Options 3 and 4, as transportation would not be required out to 25 miles from Galena. Road building in the Upland areas would be more limited than in Options 3 and 4. The potential detriment of this plan is that harvest operations may still be too intensive near Galena and in Lowland areas along the Yukon River leading to potentially higher environmental impact in these areas. Road system development in the Upland Access areas would be considerably less than in Options 3 and 4 resulting in less environmental impact(s) under this option.

Harvest Projection Results

Biomass and Acreage

The ***harvestBiomass*** model results of all five harvest scenarios demonstrate that all five options are viable with respect to procuring the maximum target biomass harvest level of 20,000 tons/year. Therefore, as stated previously, lower annual and periodic levels of biomass harvest can be undertaken and sustained in the Galena Vicinity (higher levels were not modeled). The periodic average annual flow of biomass, for all five modeled harvest scenarios, is shown in **Figure 15**, along with the average annual number of acres harvested for each modeled option. All options tend to demonstrate that after the initial 10-15 years of harvesting, the number of acres harvested gradually declines over time to about half the initial number of acres harvested. This decline in acres harvested is because there is a surplus of available biomass, the biomass inventory is growing (growth exceeds harvest), and biomass/acre levels are gradually increasing over time in stands that have not been harvested. Harvesting units having higher levels of biomass/acre means fewer acres need to be harvested per year to generate the same level of biomass harvest.

While the ability to achieve the maximum harvest biomass target level of 20,000 tons/year was met by all five scenarios, each scenario was undertaken with different selection criteria and constraints. The site-specific harvest locations for each modeled scenario are mapped in **Figures 16-20.** Each figure shows the locations of the harvest units that would be harvested to meet the target harvest level. Harvest units are color coded to represent their different harvest levels in terms of tons/acre. Of particular note is that the mapped results for Options 1 and 2, which are more limited in their area of available biomass, show a higher concentration of operations (more intensive) in those specific areas. In addition, these mapped results for Options 1 and 2 show that far more harvest units of lower biomass/acre (as indicated by the area of yellow, orange, and red colored harvest units) are being harvested under these alternatives, than do the mapped results of Options 3 – 5, which all represent less intensive approaches due to the larger areas and pools of biomass available for harvest under these options.

Figure 15: Long-term Sustained Biomass and Acreage Harvest Projections 2012-2111

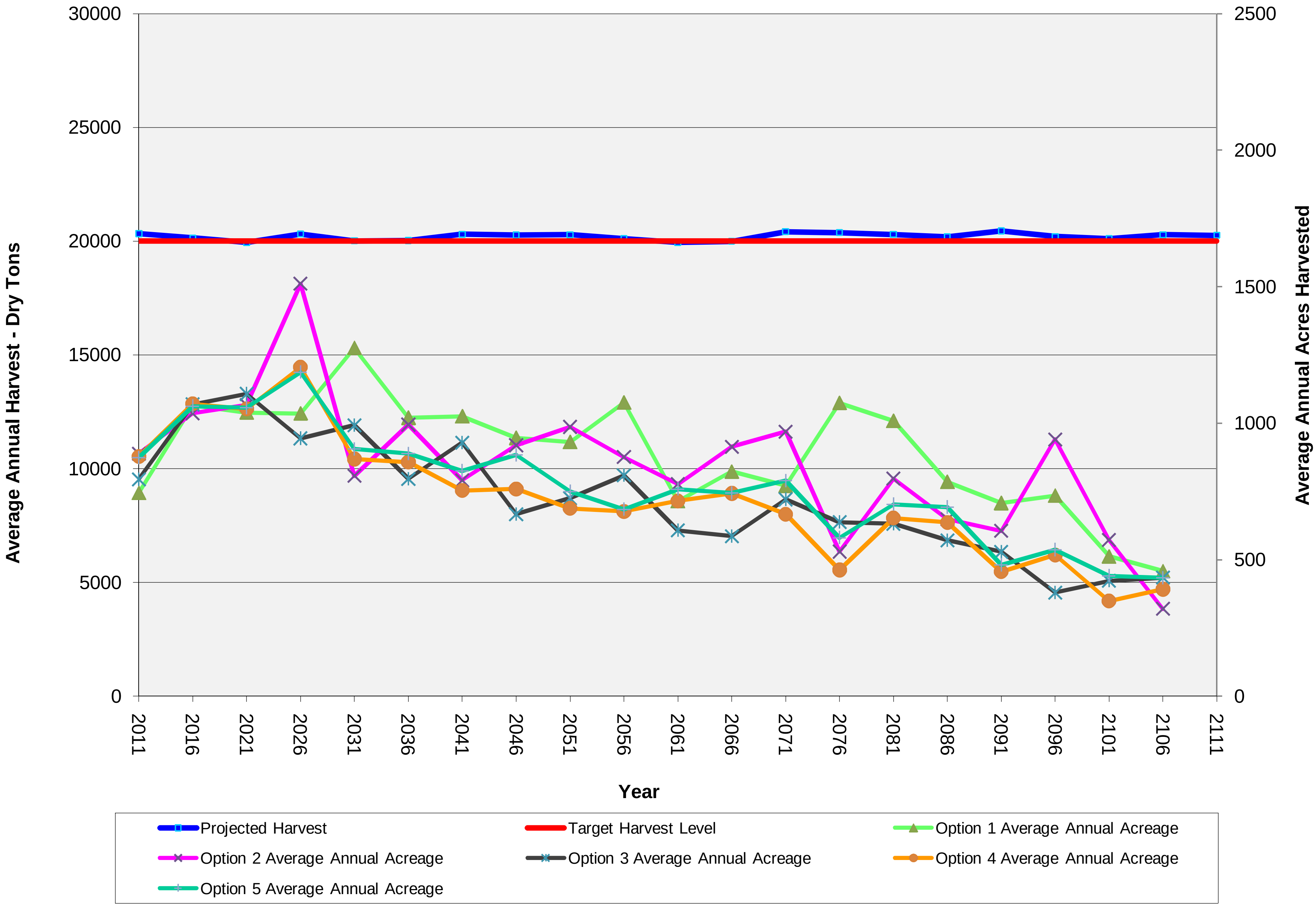
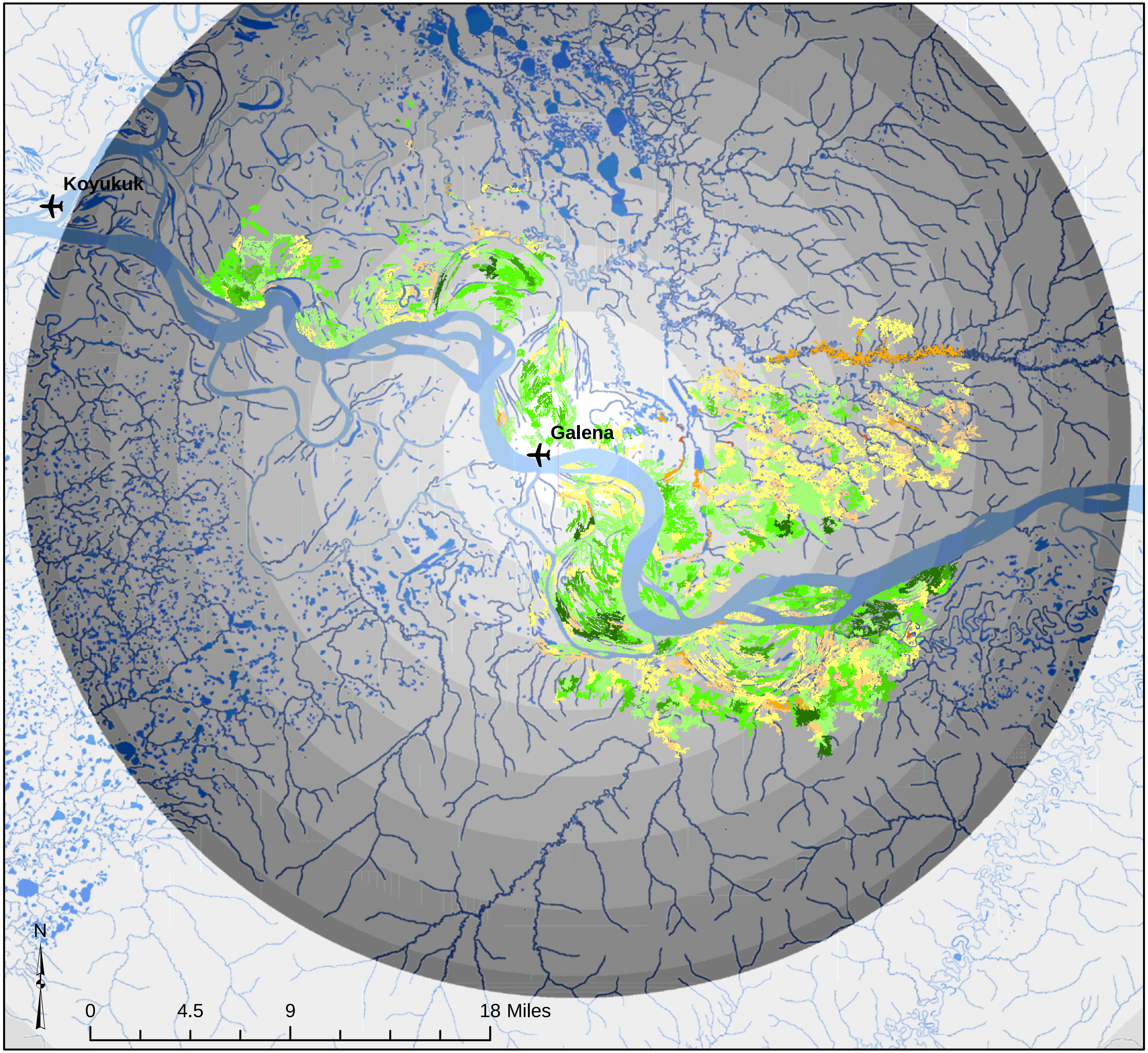


Figure 16: Option 1 Modeled Harvest Units and Biomass/Acre



Option 1:

A1D4

TONS Per ACRE

0.0
0.01 - 4.0
4.01 - 10.0
10.01 - 15.0
15.01 - 20.0
20.01 - 25.0
25.01 - 30.0
30.01 - 35.0
35.01 - 40.0
>= 40.01

Figure 17: Option 2 Modeled Harvest Units and Biomass/Acre

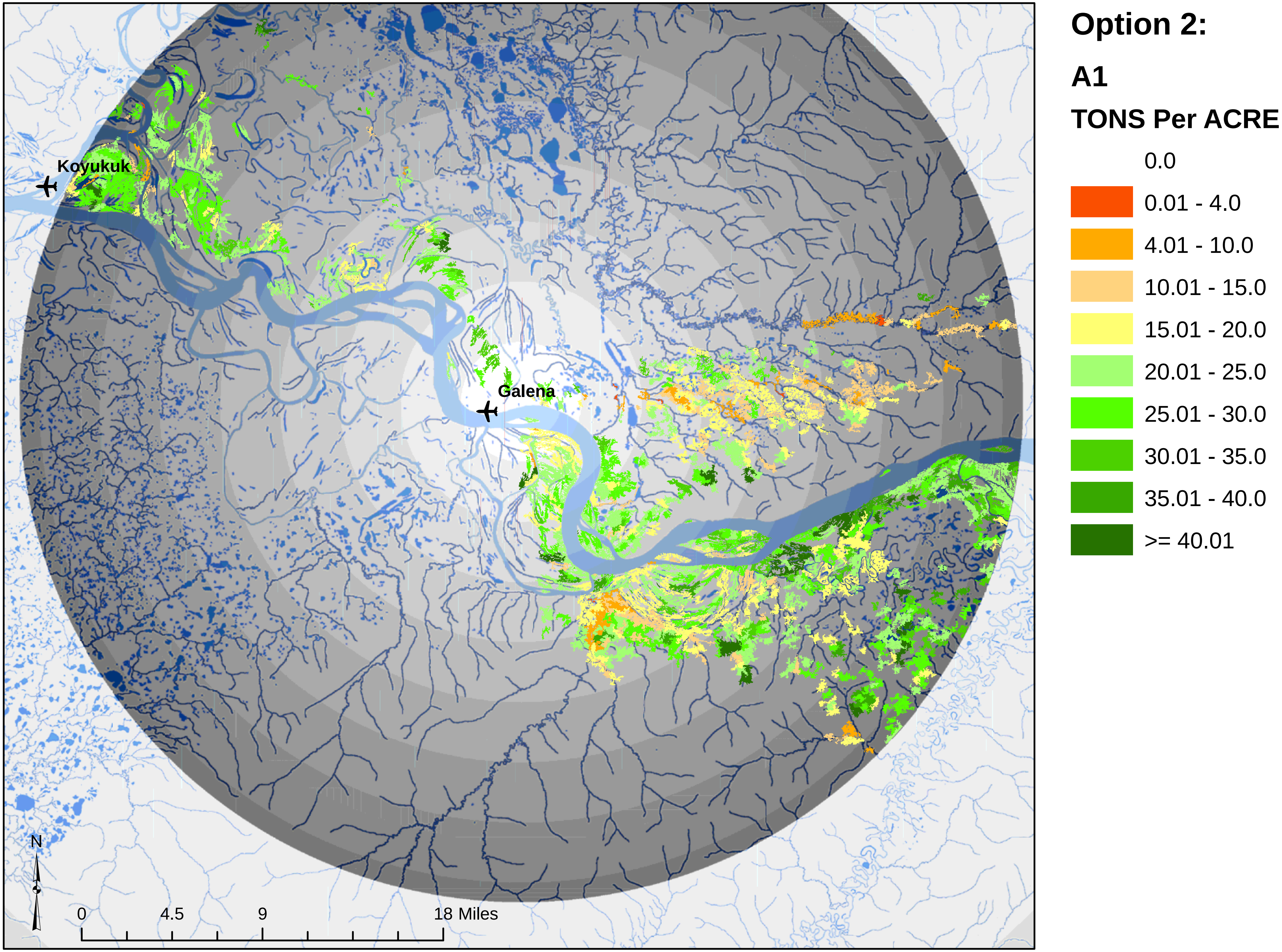


Figure 18: Option 3 Modeled Harvest Units and Biomass/Acre

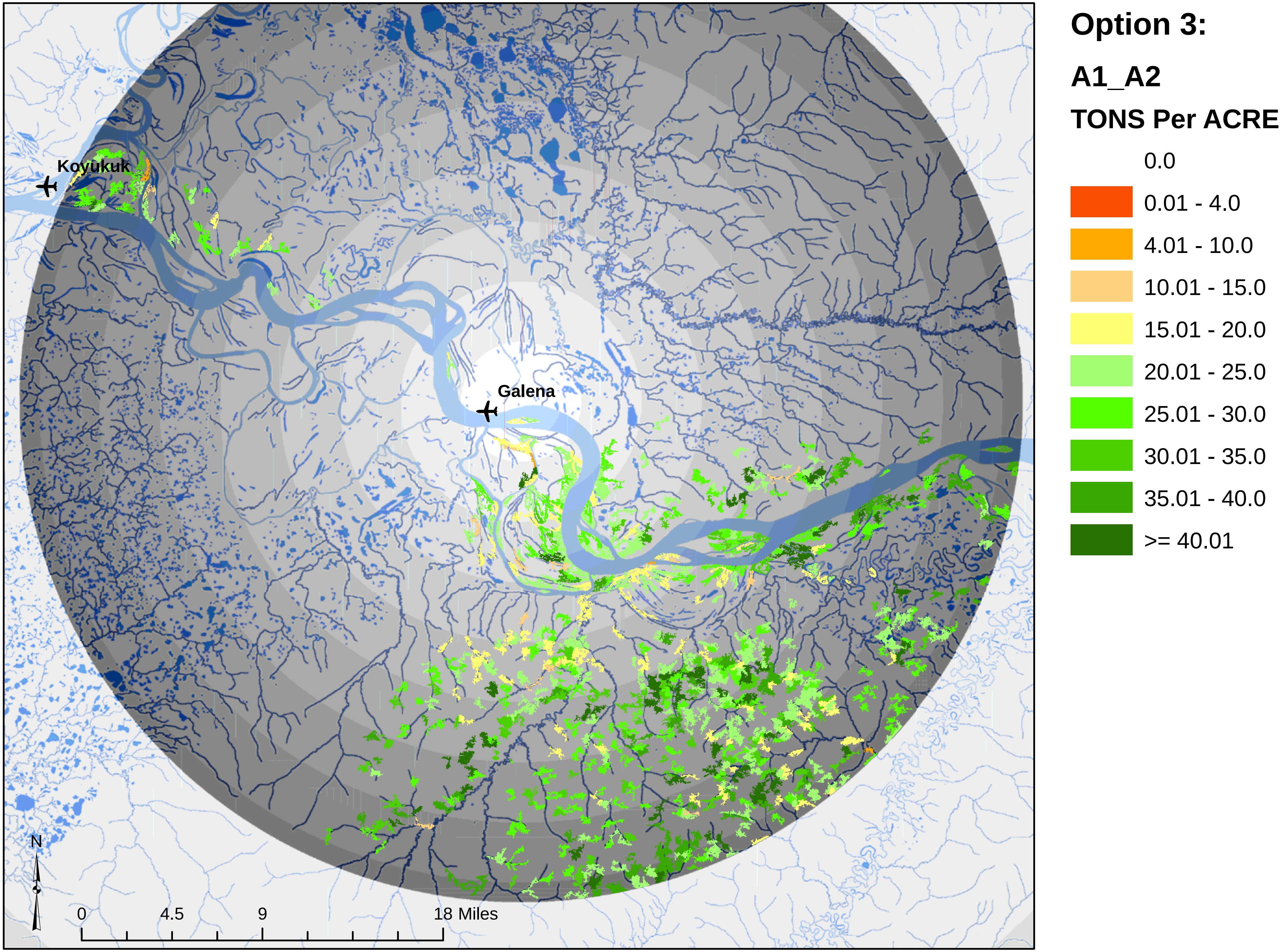


Figure 19: Option 4 Modeled Harvest Units and Biomass/Acre

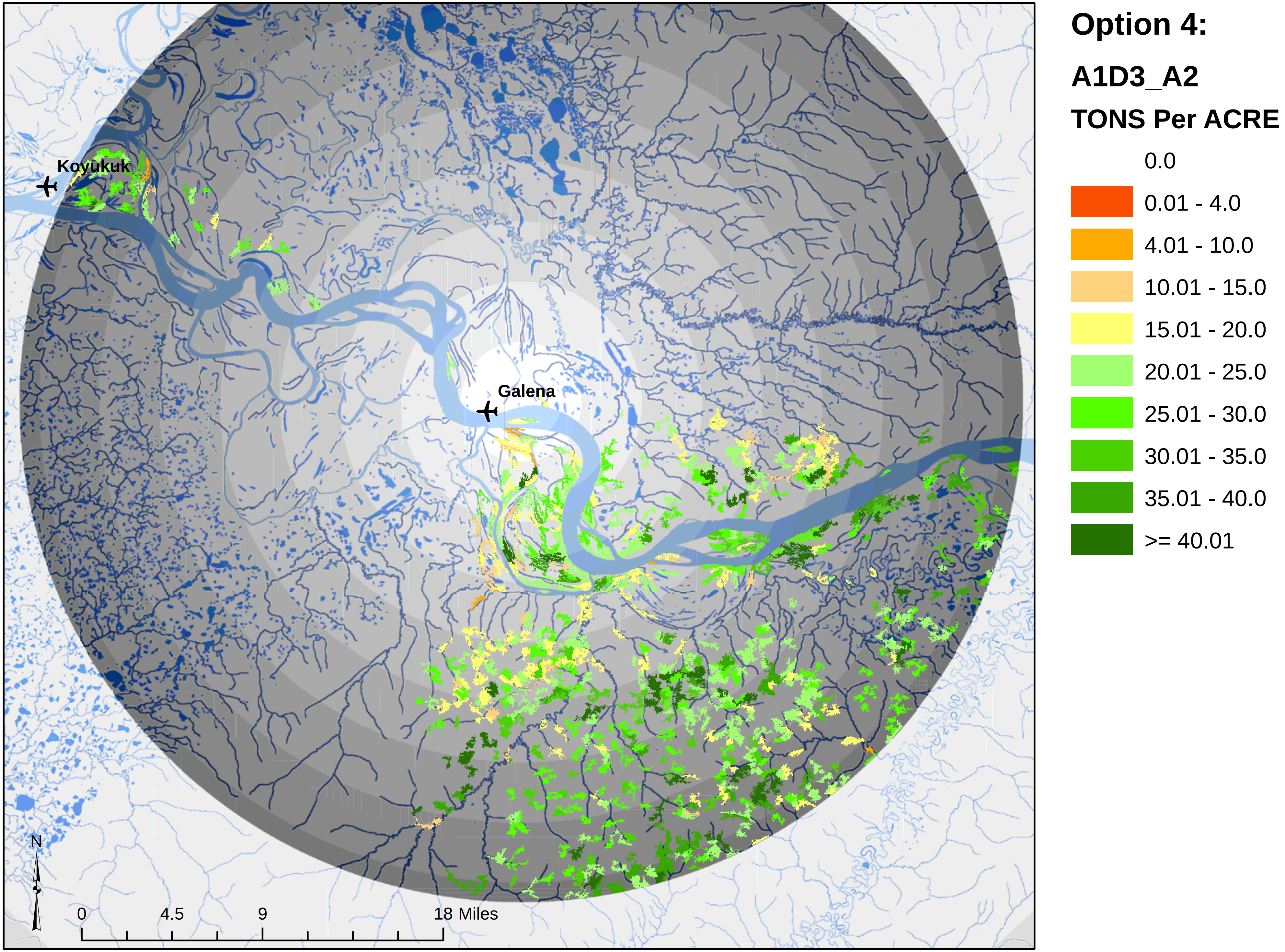
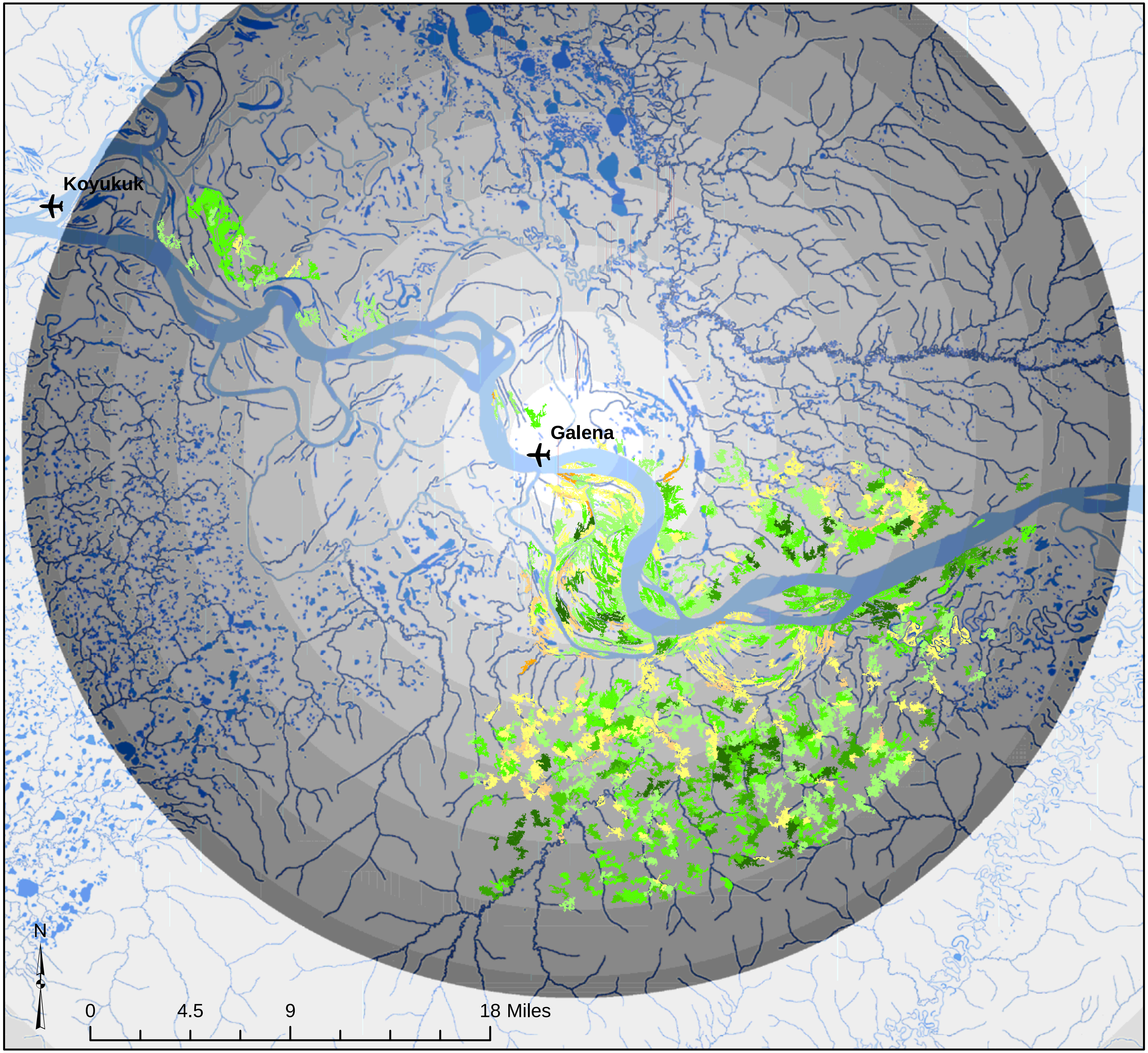


Figure 20: Option 5 Modeled Harvest Units and Biomass/Acre



Option 5:

A1D3_A2D5

TONS Per ACRE

	0.0
	0.01 - 4.0
	4.01 - 10.0
	10.01 - 15.0
	15.01 - 20.0
	20.01 - 25.0
	25.01 - 30.0
	30.01 - 35.0
	35.01 - 40.0
	>= 40.01

The projected decadal inventory, growth, and harvest levels for each of the five options are shown in Tables 19-23 and displayed graphically in associated Figures 21-25. All of these tables and figures show the same general trend under all five harvest options that biomass growth on Available Biomass Inventory acres in the Galena Vicinity is exceeding the targeted biomass harvest level of 20,000 dry tons/year and that the total Available Biomass Inventory is increasing over time. Of note is that biomass harvested under Options 1 and 2 that involve only Lowland Access areas have a higher percentage of hardwood composition (44% and 39% respectively) than does the biomass harvested under Options 3-5, which average 32%, 33%, and 37% respectively. In addition, one aspect of these results not shown in these summary data, but included in the harvest unit specific detailed listings generated by ***harvestBiomass,*** is that during the 2101-2110 decade of Option 1 the model actually begins to harvest for a second time acres that were previously harvested and reforested during the first decade of Option 1. This indicates, as shown in Figure 16, that the modeled harvest operations are intensive enough that by 2101 most of the higher biomass producing forestlands have now been harvested and managed reforested forestlands are now being selected for subsequent harvests into the 2100's, even though there has been a very sizable accumulation of biomass on other nearby lands not included in this harvest scenario.

A summary of the total biomass harvested, acres logged, and average tons/acre harvested by option is included the leftmost portion of Table 24. A summary of the average annual biomass harvested, acres logged, and average ton/acre harvested by option is included the leftmost portion of Table 25. All five options show a total biomass harvest of nearly 2,000,000 dry tons during the 2012-2110 projection period. Total harvest acreages for the Lowland only harvest Options 1 and 2 are approximately 8,000-17,000 acres higher than the harvested acres of the combined Lowland and Upland harvest options. These higher levels of harvested acres correspond with the lower average tons/acre levels for units harvested under Options 1 and 2 that average of 2.5 to 5 tons/acre lower than the tons/acre values for the combined Lowland and Upland harvest options. Some might think this means that Lowland areas support lower stand biomass, but instead this simply demonstrates that the larger area of available harvest under Options 3-5 enables greater opportunity to be more selective harvesting the higher biomass/acre harvest units while dispersing harvest operations over a larger area and potentially decreasing harvest intensity in the areas subject to harvest procurement operations.

Biomass Procurement Cost Estimates

Biomass procurement costs for each option were developed by applying the Forest Management Cost estimates listed in Table 19 to the site-specific harvest unit acreages and biomass values of harvest units selected and harvested as ***harvestBiomass*** processed each alternative harvest scenario. Table 24 contains the total estimated cost by category for each modeled option, as well as cost/ton estimates. Figure 26 illustrates these biomass procurement costs by category and option.

Table 19: Option 1 - Projected Periodic Total Available Biomass Inventory, Growth, and Harvest Levels by Decade from 2012-2110

	Inventory - Dry Tons			Growth - Dry Tons			Harvest - Dry Tons		
Period	**Conifer**	**Hardwood**	**Total**	**Conifer**	**Hardwood**	**Total**	**Conifer**	**Hardwood**	**Total**
2012-2020	3,270,458	1,867,534	5,137,991	343,893	200,225	544,118	101,349	60,093	161,442
2021-2030	3,513,002	2,007,666	5,520,668	400,382	235,391	635,773	120,571	81,598	202,169
2031-2040	3,792,813	2,161,459	5,954,272	427,396	241,875	669,272	102,876	97,216	200,092
2041-2050	4,117,333	2,306,119	6,423,451	470,051	273,671	743,722	110,501	88,869	199,370
2051-2060	4,476,883	2,490,920	6,967,803	518,678	300,614	819,293	100,609	99,203	199,812
2061-2070	4,894,952	2,692,331	7,587,283	584,987	349,930	934,917	116,052	84,790	200,842
2071-2080	5,363,887	2,957,471	8,321,358	644,688	408,063	1,052,752	103,668	97,676	201,343
2081-2090	5,904,908	3,267,859	9,172,767	736,822	480,630	1,217,451	123,487	79,742	203,229
2091-2100	6,518,242	3,668,747	10,186,989	821,930	554,116	1,376,045	114,679	85,001	199,680
2101-2110	7,225,493	4,137,861	11,363,354	900,698	627,537	1,528,235	112,556	87,707	200,263
2111	8,013,635	4,677,691	12,691,326						
Totals				5,849,526	3,672,052	9,521,578	1,106,349	861,895	1,968,243
							56%	44%	

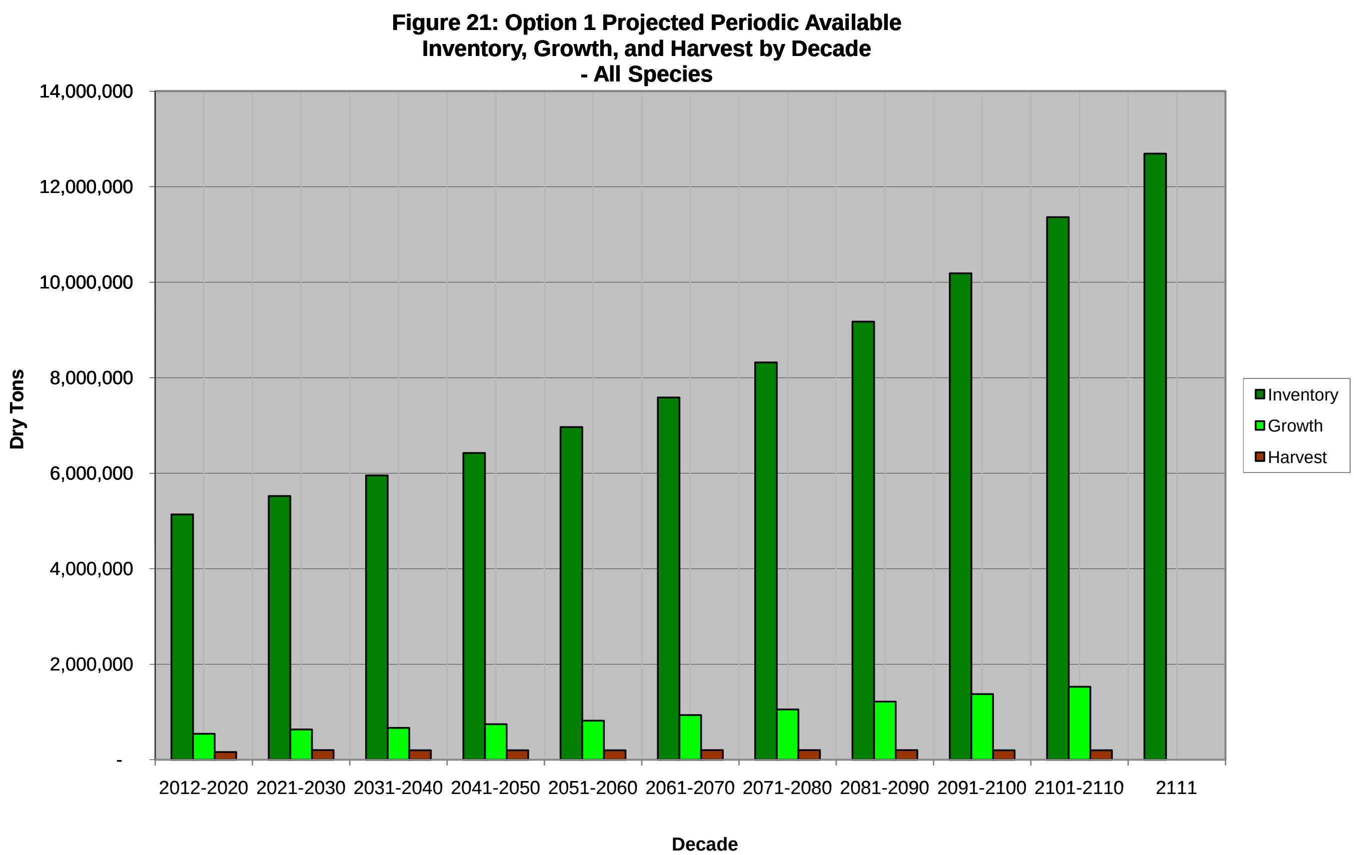


Table 20: Option 2 - Projected Periodic Total Available Biomass Inventory, Growth, and Harvest Levels by Decade from 2012-2110

	Inventory - Dry Tons			Growth - Dry Tons			Harvest - Dry Tons		
Period	**Conifer**	**Hardwood**	**Total**	**Conifer**	**Hardwood**	**Total**	**Conifer**	**Hardwood**	**Total**
2012-2020	3,270,458	1,867,534	5,137,991	342,660	200,073	542,733	108,633	51,557	160,190
2021-2030	3,504,485	2,016,050	5,520,535	397,470	235,630	633,100	121,145	79,345	200,489
2031-2040	3,780,810	2,172,335	5,953,145	420,654	249,316	669,970	136,677	65,011	201,688
2041-2050	4,064,787	2,356,641	6,421,427	470,720	286,002	756,722	135,459	65,411	200,870
2051-2060	4,400,047	2,577,232	6,977,279	512,846	312,410	825,256	110,775	80,849	191,624
2061-2070	4,802,118	2,808,793	7,610,911	583,453	363,309	946,762	117,531	77,371	194,901
2071-2080	5,268,041	3,094,731	8,362,771	646,405	418,998	1,065,402	131,569	68,735	200,304
2081-2090	5,782,876	3,444,993	9,227,869	731,728	494,707	1,226,435	117,903	81,303	199,206
2091-2100	6,396,702	3,858,397	10,255,098	785,678	536,751	1,322,429	110,841	89,404	200,244
2101-2110	7,071,539	4,305,744	11,377,283	895,859	623,055	1,518,915	105,509	94,564	200,073
2111	7,861,890	4,834,235	12,696,125						
Totals				5,787,473	3,720,250	9,507,723	1,196,041	753,549	1,949,590
							61%	39%	

Figure 22: Option 2 Projected Periodic Available Inventory, Growth, and Harvest by Decade - All Species

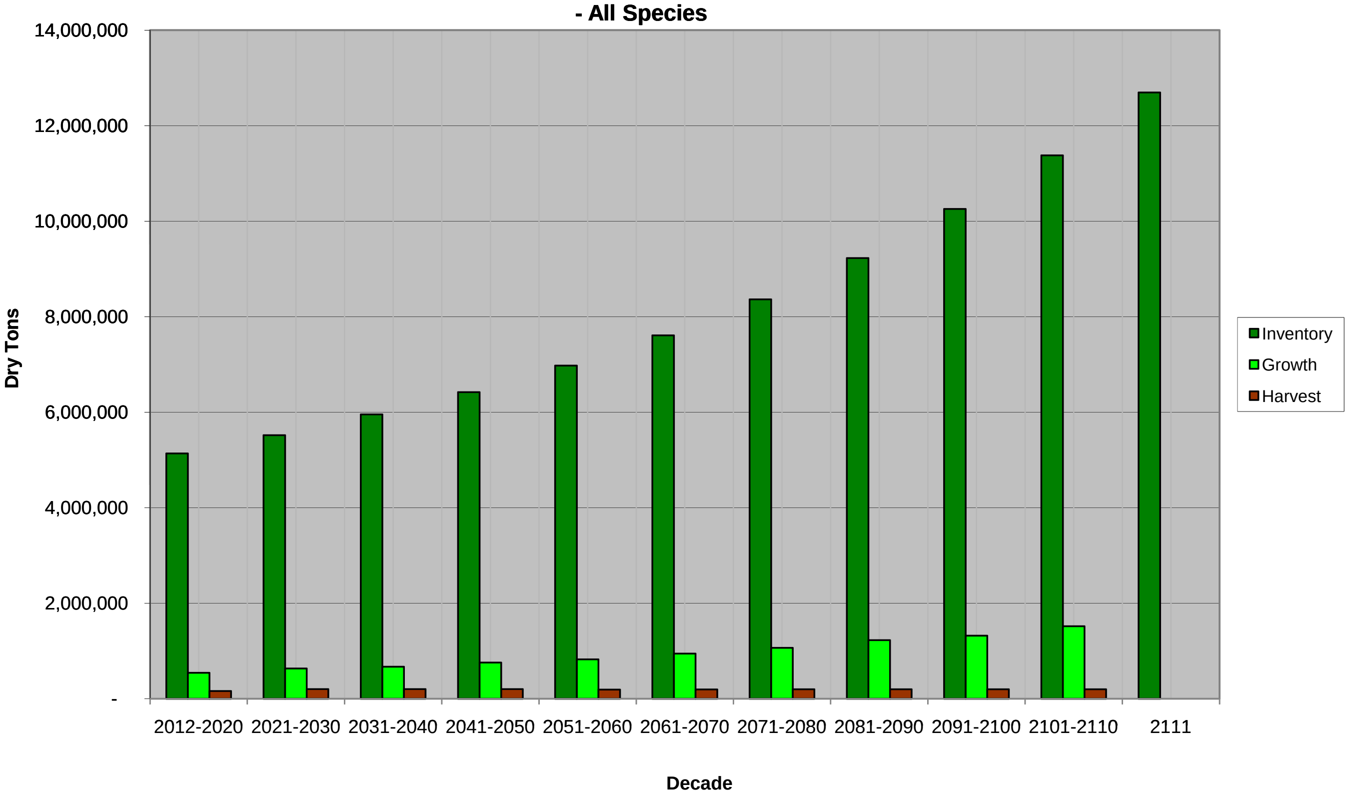


Table 21: Option 3 - Projected Periodic Total Available Biomass Inventory, Growth, and Harvest Levels by Decade from 2012-2110

	Inventory - Dry Tons			Growth - Dry Tons			Harvest - Dry Tons		
Period	**Conifer**	**Hardwood**	**Total**	**Conifer**	**Hardwood**	**Total**	**Conifer**	**Hardwood**	**Total**
2012-2020	3,270,458	1,867,534	5,137,991	344,457	203,072	547,529	113,280	48,396	161,676
2021-2030	3,501,634	2,022,210	5,523,844	399,291	238,710	638,001	133,685	67,606	201,291
2031-2040	3,767,241	2,193,313	5,960,554	439,382	264,899	704,281	137,647	62,561	200,208
2041-2050	4,068,976	2,395,651	6,464,627	467,389	289,379	756,768	137,206	65,676	202,882
2051-2060	4,399,158	2,619,354	7,018,512	510,432	324,087	834,519	136,935	65,006	201,941
2061-2070	4,772,656	2,878,434	7,651,090	568,943	373,095	942,038	144,315	55,388	199,704
2071-2080	5,197,284	3,196,141	8,393,424	624,847	422,116	1,046,963	129,374	74,610	203,984
2081-2090	5,692,757	3,543,646	9,236,403	707,375	499,856	1,207,231	133,589	68,871	202,460
2091-2100	6,266,543	3,974,631	10,241,174	802,170	575,999	1,378,169	139,777	63,481	203,258
2101-2110	6,928,936	4,487,149	11,416,085	887,754	650,187	1,537,941	132,838	69,145	201,983
2111	7,683,852	5,068,190	12,752,042						
Totals				5,752,040	3,841,398	9,593,438	1,338,645	640,742	1,979,387
							68%	32%	

Figure 23: Option 3 Projected Periodic Available Inventory, Growth, and Harvest by Decade - All Species

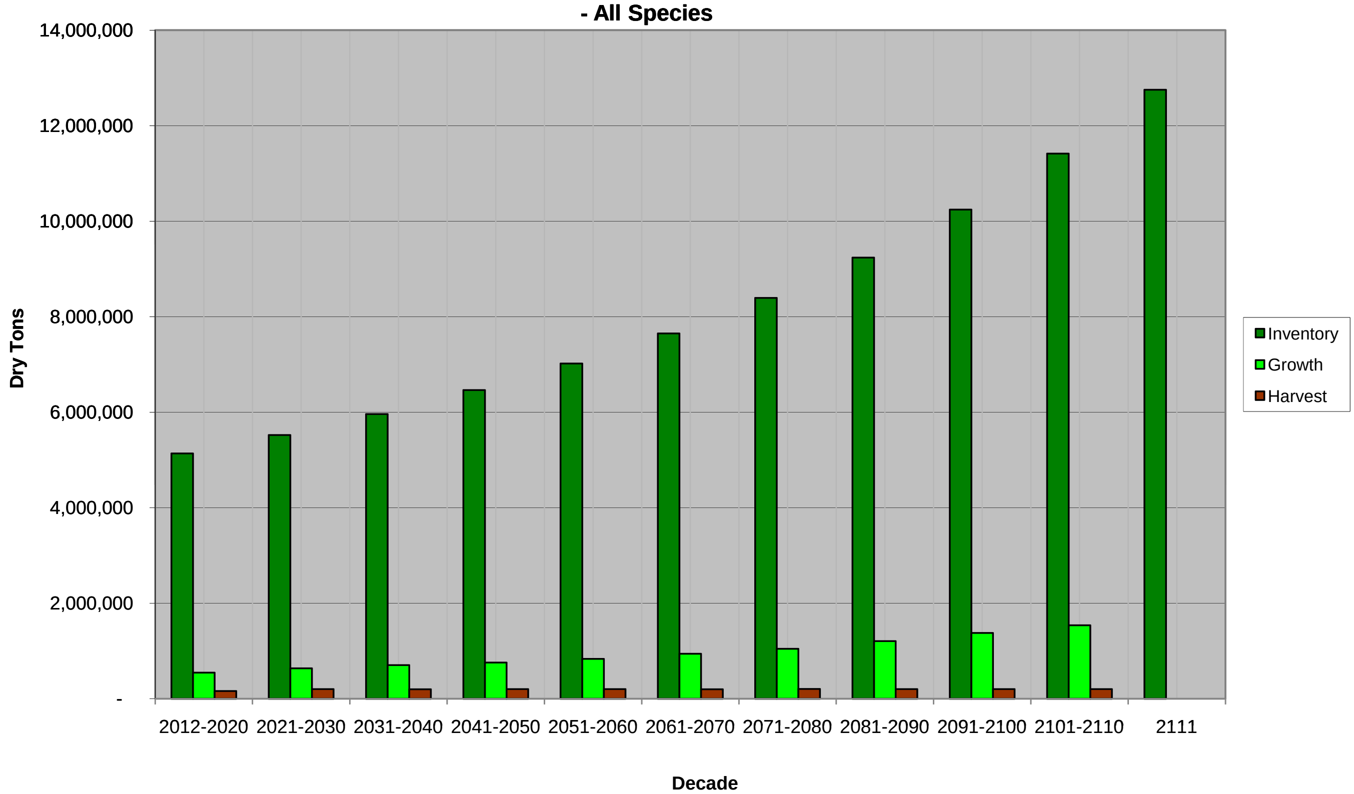


Table 22: Option 4 - Projected Periodic Total Available Biomass Inventory, Growth, and Harvest Levels by Decade from 2012-2110

	Inventory - Dry Tons			Growth - Dry Tons			Harvest - Dry Tons		
Period	Conifer	Hardwood	Total	Conifer	Hardwood	Total	Conifer	Hardwood	Total
2012-2020	3,270,458	1,867,534	5,137,991	340,386	202,043	542,430	96,270	65,569	161,839
2021-2030	3,514,574	2,004,008	5,518,582	398,596	230,204	628,800	115,398	84,680	200,078
2031-2040	3,797,772	2,149,532	5,947,304	443,523	261,401	704,924	140,747	59,997	200,743
2041-2050	4,100,548	2,350,937	6,451,484	478,107	289,549	767,657	145,907	54,555	200,462
2051-2060	4,432,748	2,585,931	7,018,679	519,004	324,262	843,267	135,103	65,131	200,233
2061-2070	4,816,649	2,845,063	7,661,712	545,242	354,856	900,097	130,569	70,636	201,205
2071-2080	5,231,322	3,129,282	8,360,604	632,667	427,863	1,060,530	145,019	55,866	200,885
2081-2090	5,718,970	3,501,280	9,220,249	718,852	506,709	1,225,561	133,825	66,708	200,533
2091-2100	6,303,997	3,941,281	10,245,278	796,077	577,327	1,373,404	149,830	56,859	206,689
2101-2110	6,950,243	4,461,750	11,411,993	885,711	643,840	1,529,551	130,131	74,122	204,253
2111	7,705,824	5,031,468	12,737,291						
Totals				5,758,165	3,818,055	9,576,220	1,322,799	654,121	1,976,920
							67%	33%	

Figure 24: Option 4 Projected Periodic Available Inventory, Growth, and Harvest by Decade - All Species

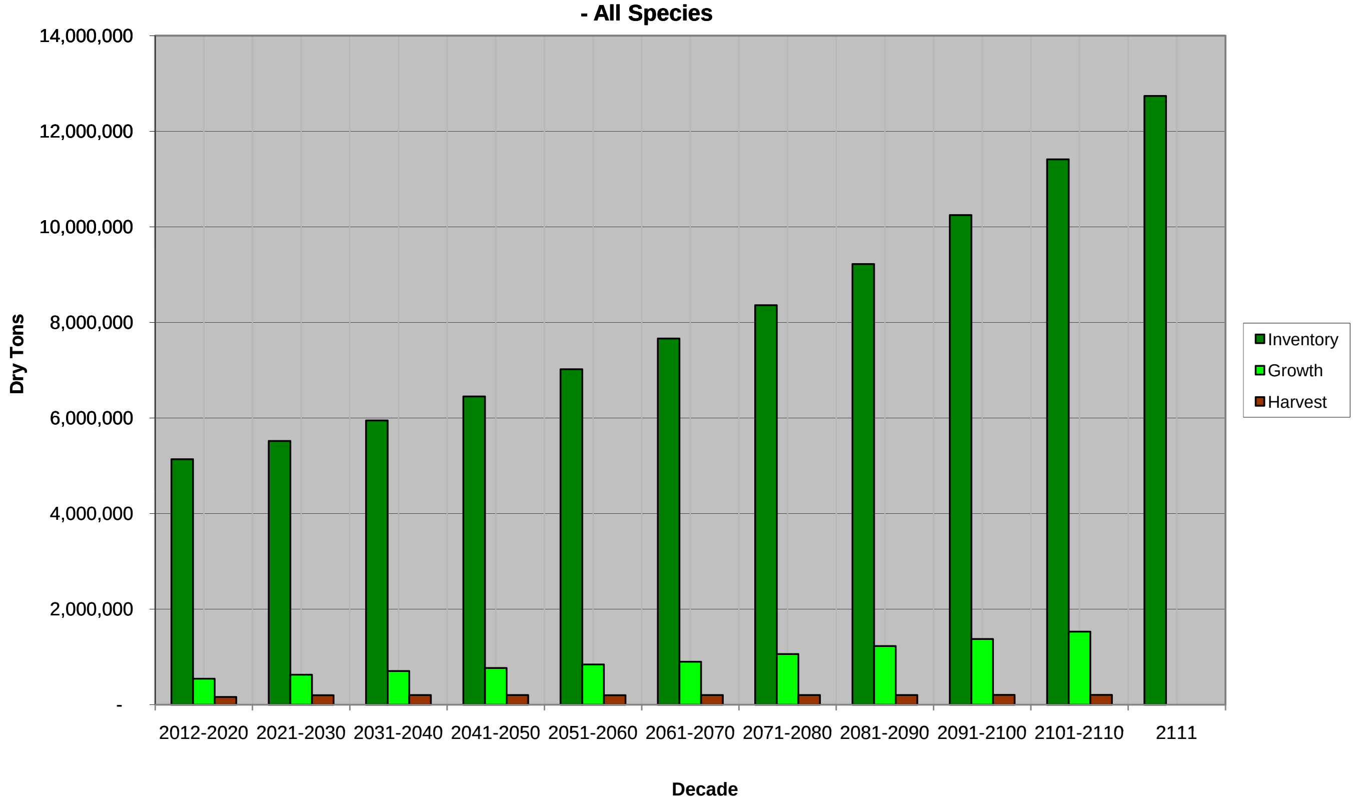


Table 23: Option 5 - Projected Periodic Total Available Biomass Inventory, Growth, and Harvest Levels by Decade from 2012-2110

	Inventory - Dry Tons			Growth - Dry Tons			Harvest - Dry Tons		
Period	Conifer	Hardwood	Total	Conifer	Hardwood	Total	Conifer	Hardwood	Total
2012-2020	3,270,458	1,867,534	5,137,991	340,392	201,914	542,305	94,755	65,899	160,654
2021-2030	3,516,094	2,003,548	5,519,643	398,475	229,841	628,316	116,448	83,951	200,399
2031-2040	3,798,121	2,149,439	5,947,560	439,957	257,780	697,737	127,978	69,562	197,540
2041-2050	4,110,100	2,337,657	6,447,757	469,898	282,414	752,312	132,318	60,118	192,436
2051-2060	4,447,679	2,559,953	7,007,632	523,639	323,352	846,991	118,979	72,701	191,680
2061-2070	4,852,339	2,810,604	7,662,943	570,289	361,642	931,931	120,410	79,148	199,558
2071-2080	5,302,218	3,093,098	8,395,316	640,663	424,598	1,065,261	128,758	72,301	201,059
2081-2090	5,814,123	3,445,395	9,259,518	718,764	497,262	1,216,027	126,700	72,973	199,673
2091-2100	6,406,187	3,869,685	10,275,872	797,987	569,110	1,367,097	130,238	58,595	188,832
2101-2110	7,073,936	4,380,200	11,454,136	884,109	636,176	1,520,285	121,961	78,754	200,715
2111	7,836,085	4,937,622	12,773,706						
Totals				5,784,172	3,784,089	9,568,260	1,218,545	714,001	1,932,546
							63%	37%	

Figure 25: Option 5 Projected Periodic Available Inventory, Growth, and Harvest by Decade - All Species

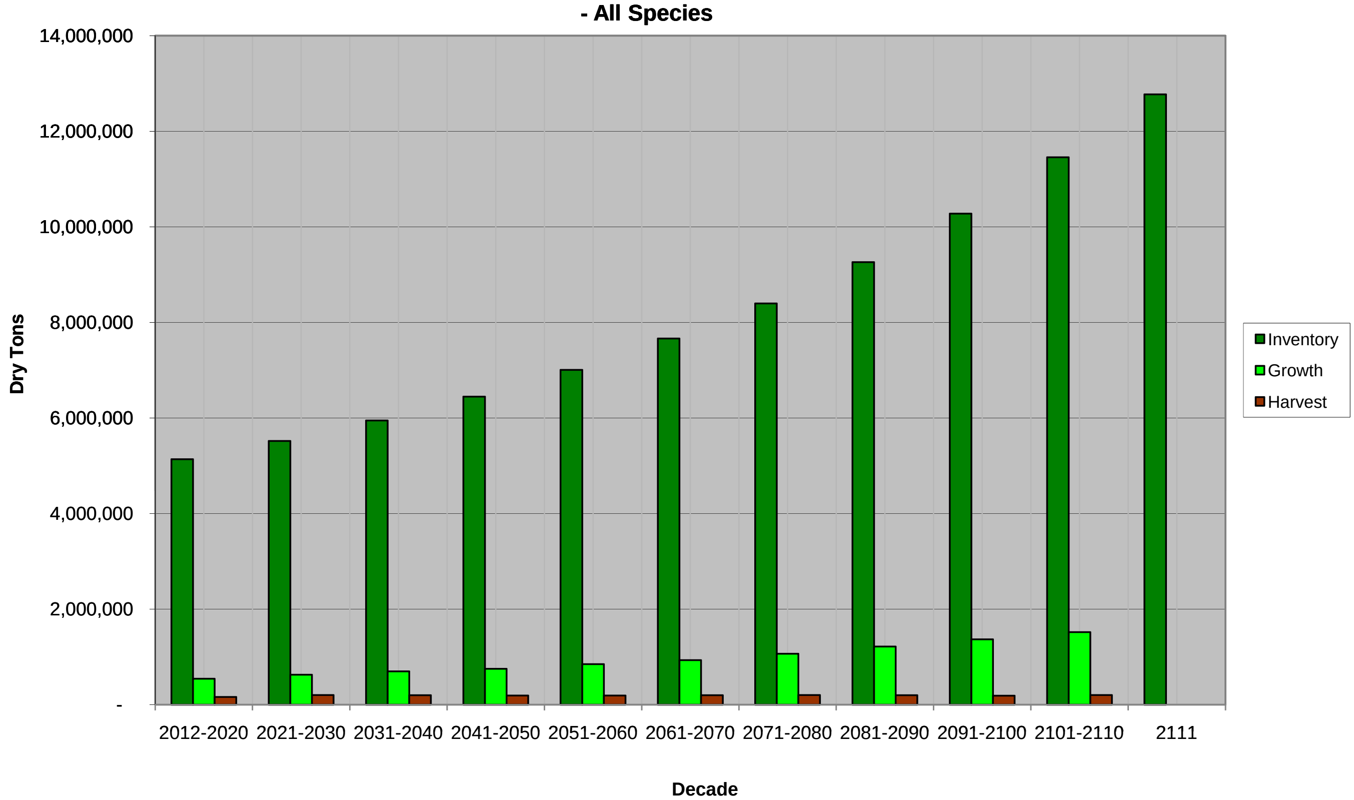


Table 24 and Figure 26

Table 25 and Figure 27

Total Cost estimates for the entire projection period ranged from a low of approximately $153 million ($77.90/ton) for Option 1 to a high of over $188 million ($95.18/ton) for Option 3, a difference of approximately $33 million or $16.28/ton. The total estimated cost of $168 million ($86.78/ton) for Option 5 falls between these two extremes, whereas the $183 million ($93.71/ton) cost of Option 2 and $187 million ($94.44/ton) cost of Option 4 fall very close to the highest cost level of Option 3.

Table 25 contains the estimated average annual cost by category for each modeled option, as well as $cost/ton estimates. Figure 27 illustrates these average annual biomass procurement costs by category and option. Total annual costs are estimated to range from a low of approximately $1.6 million/year for Option 1 to a high of approximately $1.9 million/year for Option 3. Option 5, the midrange costing option is approximately $1.7 million/year. Figure 28 shows the average annual biomass procurement costs for each option by decade. The average annual biomass procurement costs by category that comprise the figures shown in Table 25 are shown by decade for each option in figures 29-33.

The values in tables 24 and 25 indicate that the most significant cost category is the Transportation Costs, as these costs range from 59% to 70% of the total biomass procurement costs that have been modeled. Transportation Costs are projected to be more than 59% percent of total procurement costs in all five modeled scenarios. Harvest and Stumpage Costs were the next most significant cost category ranging from 25% to 34% of the total biomass procurement costs. Reforestation Costs were a relatively small component of total costs comprising from 4-6% of total costs and Administration Costs ranged from only 1-2% of the total costs.

Ranking options based upon Total Costs is directly related to the ranking of alternatives based upon Transportation Costs. A comparison of these cost estimates make it perfectly clear why Options 2-4 had the highest total estimated biomass procurement costs and cost in terms of tons/acre. Options 2-4 have Transportation Costs that are $31 to $41 million higher than Option 1 and $12 to $22 million more than Option 5. All of these three higher cost options were based upon harvesting biomass from the most distant parts of the Galena Vicinity, including the furthest Distance Zones located 22-25 miles from Galena. It is apparent that shifting harvest operations into the most distant areas of the Galena Vicinity, in order to harvest higher biomass/acre stands and potentially lessen the harvest intensity and environmental impact of harvest operations near Galena and the Yukon River, certainly has a cost associated with this strategy; this cost can be estimated as the difference in the estimates of biomass procurement costs.

Ranking options based upon other non-transportation costs yields a different ranking of alternatives. Harvest and Stumpage Costs, Reforestation Costs, and Administration Costs are lowest for Options 3 and 4 and slightly higher for Option 5. These costs are related to both the acreage and biomass/acre harvested and not its location. Options 3 and 4, which involve the largest areas of available inventory, have the highest average tons/acre values at 27.89 and 27.79 tons/acre. Option 5 is slightly lower at 25.60 tons/acre. Option 1 and 2 are considerable lower at 22.37 and 23.25 tons/acre.

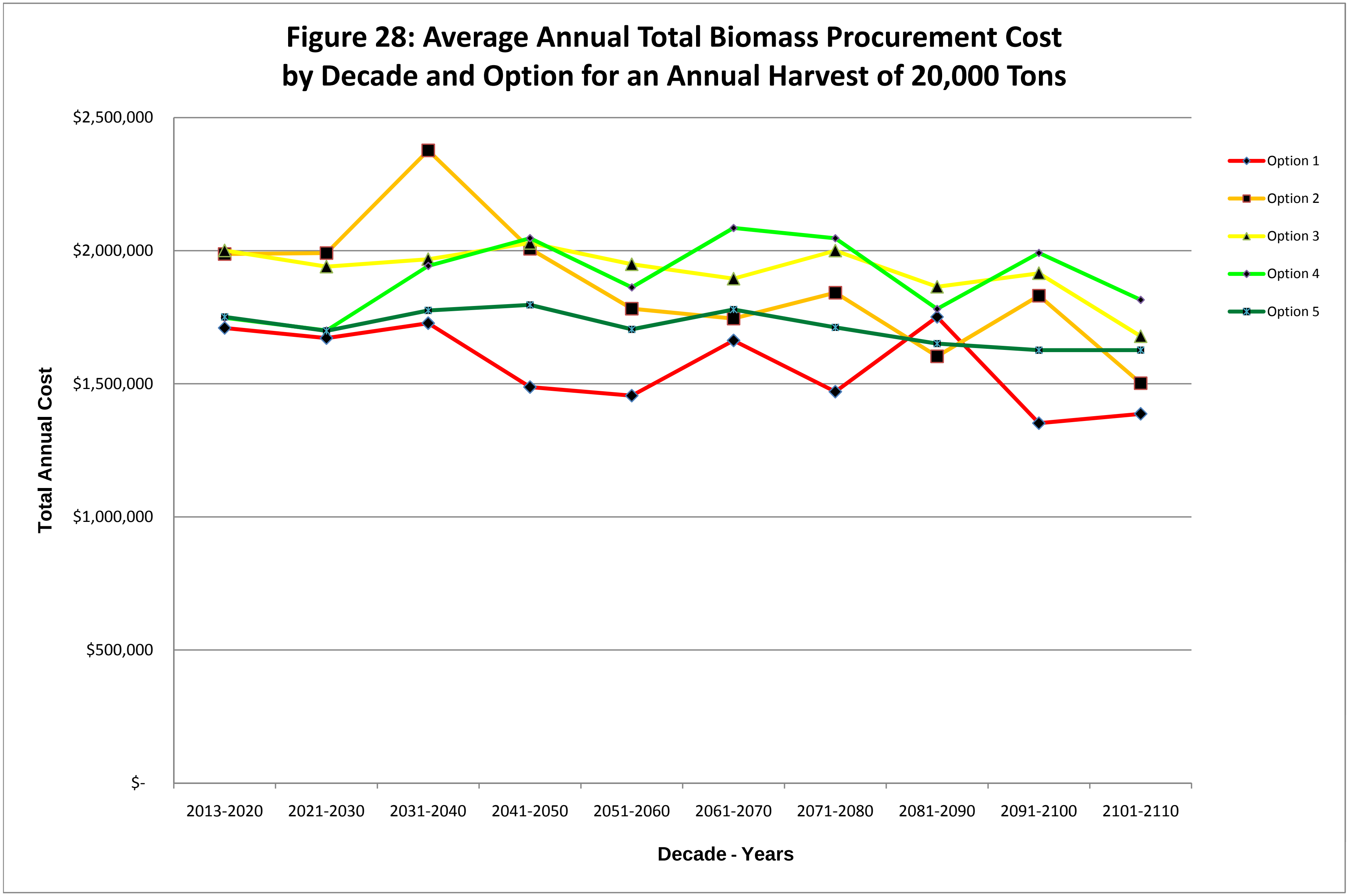


Figure 28: Average Annual Total Biomass Procurement Cost
by Decade and Option for an Annual Harvest of 20,000 Tons
Total Annual Cost
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$-
2013-2020
2021-2030
2031-2040
2041-2050
2051-2060
2061-2070
2071-2080
2081-2090
2091-2100
2101-2110
Decade - Years
Option 1
Option 2
Option 3
Option 4
Option 5

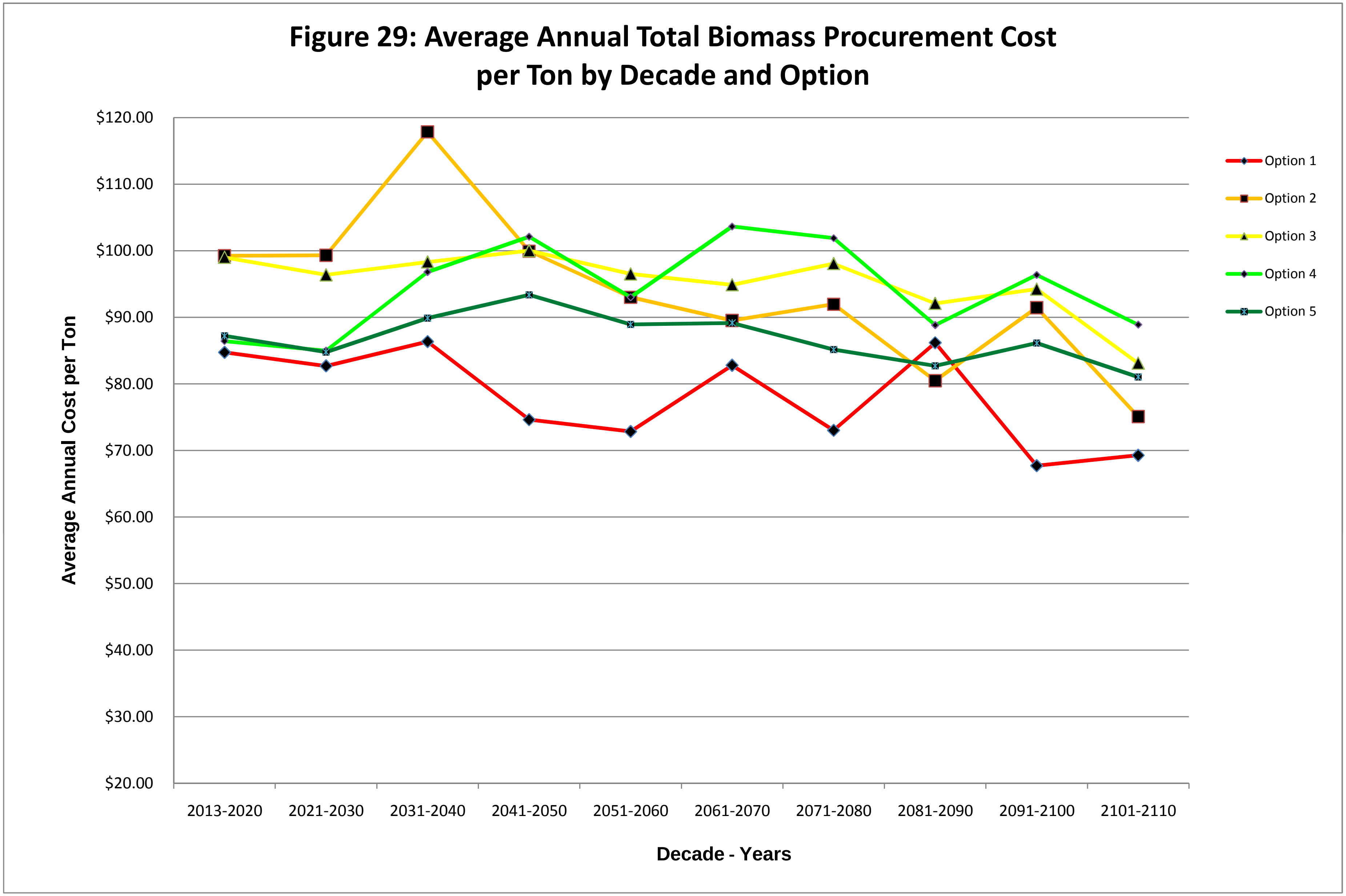


Figure 29: Average Annual Total Biomass Procurement Cost
per Ton by Decade and Option
$120.00
$110.00
$100.00
$90.00
$80.00
$70.00
$60.00
$50.00
$40.00
$30.00
$20.00
Average Annual Cost per Ton
2013-2020
2021-2030
2031-2040
2041-2050
2051-2060
2061-2070
2071-2080
2081-2090
2091-2100
2101-2110
Decade - Years
Option 1
Option 2
Option 3
Option 4
Option 5

Figure 30

Figure 31

Figure 32

Figure 33

Figure 34

These other non-transportation costs for Options 1 and 2 are from $5 to 6 million higher than the same costs for Options 3 and 4 and approximately $5 million higher than Option 5. Just as there was a difference in Transportation Costs associated with shifting harvest operations farther away from Galena, there is also a difference in non-transportation costs that is related to being able to select for harvest those units with higher tons/acre levels which results in lower acreages being harvested per year and most likely a corresponding decrease in the intensity of forest management operations.

While Option 1 has the lowest total biomass procurement cost, it may also have the highest impact on the Lowland Access areas located along the Yukon River within 18 miles of Galena, as it results in a concentration of harvest operations and the highest number of acres logged and reforested on Lowland Access areas near Galena. Option 2 extends harvest operations on Lowland Access areas out through the full 25-mile Galena Vicinity at a significantly higher transportation cost, a slightly lower non-transportation cost, and decreases in the intensity of harvest operations near Galena and the number of acres logged and reforested. Option 3 further extends harvest operations throughout the full 25-mile Galena Vicinity on both Lowland and Upland Access areas resulting in the highest Transportation Costs, the lowest non-transportation costs, the least intensive harvest operations near Galena, and the smallest number of acres logged and reforested. Option 4 is very similar to Option 3 with very slight differences in costs and intensity of operations. Option 5 enables operations in both Lowland and Upland Access areas, but only within 21 miles of Galena, thereby somewhat decreasing transportation costs. This option has the second lowest transportation costs while at the same time results in significantly less intensive harvest operations near Galena and a smaller number of acres logged and reforested than Option 1. This option does however require building of summer season roads which may increase environmental impact of these biomass procurement operations in the Upland Access areas.

Of the five alternatives presented, Options 1 and 5 appear to represent the best alternatives for future biomass procurement efforts in the Galena Vicinity. However, these alternatives only represent options considered during this study and are not the only possible alternatives that may be developed in the future. While cost is significant, it may not be the best measure of determining which harvest option best meets the needs of Galena. Differences in harvest intensity near Galena, acres logged and reforested, Lowland versus Upland operations, and potential environmental impacts all represent non-market (social) values important to the Galena community on which a dollar value may not easily be placed. Ultimately the community of Galena will need to make this decision regarding how biomass procurement operations will proceed.

Harvest Projection Warnings

Each harvest projection of this nature is based upon best estimates of inventory, growth, management options, and cost. The resulting projections are simply plans that may be used to evaluate the feasibility of different alternatives and rank feasible outcomes based upon some measure of the benefits and costs associated with each alternative. Each projection has an associated list of site-specific harvest units to harvest each year in order to implement that projection (plan) and hopefully achieve planned results.

However, such plans undertaken with computer models are by no means all encompassing of every possible management option, constraint, or regulation and are always subject to interpretation, modification, management, and implementation under the direction of a professional resource manager.

In addition, certain risks exist that may potentially threaten the Biomass Inventory and result in problems achieving the future harvest projections. While insects and pathogens do not play a significant role in potentially reducing forestland productivity in the Galena Vicinity (USFWS, 2008), wildfire does present a certain risk. At least 5 major fires since 1969 have burned significant portions of the Galena Vicinity amounting to approximately 614,200 acres or 49% of the total area of this inventory effort. Many of these burned acres are on lands administered by USFWS and BLM. These recently burned lands are not presently considered available for biomass production and harvest now or in the future in any of the five harvest projections.

The Available Biomass Inventory that forms the basis of future biomass procurement efforts is potentially at risk to reduction and damage by wildfire. The magnitude of this risk is unknown and difficult to quantify. However, human activity, including the building of homes in the Wildland Urban Interface, has been shown to increase fire hazard (Syphard et al., 2007) and risk. So has human activity, such as the harvesting and transporting of timber (Huff et al., 1995). As a result, all future harvest and transportation efforts will have to be undertaken with the implementation of maximum fire prevention measures. In addition, the development of a biomass protection plan of some sort may be advisable to identify potential hazards, develop hazard mitigation plans and procedures, and develop fire fighting priorities and plans with respect to the existing biomass resource inventory and the future biomass harvest plan selected for implementation. Such efforts will not ensure that wildfire will not damage or reduce the biomass inventory, but they may reduce future fire hazard and risk of the biomass inventory thereby increasing the likelihood that sufficient biomass will be available for the production of energy and heat in the future. Forest management activities associated with the biomass harvest can also be used to mitigate potential fire hazard and risk through the management and harvest of standing and down biomass fuel levels. Such activities may be integrated with the Galena Community Wildfire Protection Plan to decrease fire hazard and risk in the Galena community and thereby decrease the long-term danger of fire to the Galena community.

Recommendations

1. The maximum biomass target level of 20,000 dry tons per year is a harvest level that is sustainable over the long-term future of 100-years in the Galena Vicinity. All lower harvest levels are also feasible. Lower harvest levels, such as the currently proposed level of 3,000 tons/year, would potentially enable greater selectivity of types of stands and areas to harvest (see recommendation 2 below).

2. Biomass should be harvested from the higher biomass/acre stands that are most often White Spruce, Mixed Spruce, Mixed Spruce-Hardwood, Paper Birch, Balsam Poplar, Salix-tree, or Mixed Hardwood stands. Avoid operations in slow growing lower biomass/acre stands comprised primarily of black spruce, as their stunted form and slow growth is indicative of high procurement costs, low productivity, potential reforestation problems, and possible moisture/permafrost issues.

3. Initiate biomass procurement efforts initially at lower harvest levels before undertaking higher harvest levels, rather than attempting to undertake an initial harvest of 20,000 dry tons in the very first year of operations.

4. Harvest biomass from the Available Biomass Inventory that reflects biomass on areas that do not include USF&WS refuges, water-body and streamside protection zones, and the steeper slopes located along the Yukon River approximately 10-25 upriver from Galena (the Yukon River Slopes Access area). To the extent possible, avoid creating new environmental issues in the Galena Vicinity.

5. Consider harvesting Lowland (winter) Access areas using harvest unit shapes that conform to the gently curved oxbow-like natural boundaries of the present stands rather than implementing unnatural looking square or angular straight boundaries.

6. Thoroughly study the transportation of biomass under winter and summer conditions. Transportation costs comprise such a significant part of the total costs of all five projections developed in this effort that there appear to be significant potential cost savings, if more efficient and effective means of transportation are found and implemented.

7. Thoroughly evaluate Options 1 and 5. Current transportation costs do not likely warrant harvesting material further out than Distance Zone 5 (19-21 miles). Accessing Upland Access areas to the south will require road development efforts and costs, but greatly decrease harvest activity and potential environmental impacts near and around Galena and the Yukon River. As both Options 1 and 5 are based upon harvesting biomass in Lowland (winter) Access areas no more than 18 miles from Galena during the first 15-20 years there is more than adequate time in the next 10-15 years to thoroughly evaluate whether or not to develop the Upland area biomass resource.

8. Develop long-term forest management agreements with the major landowners on whose property biomass harvesting will occur. These projections assume that biomass will be available for harvest on these lands. Doyon, the State of Alaska, the Gana-A'Yoo, and BLM are four such landowners who own sizable portions of the Available Biomass Inventory in the Galena Vicinity. Long-term use agreements could lock in stumpage values, access, management requirements, and harvest regulations pertinent to the future harvest of biomass on these lands.

9. Continue to develop natural resource information that can be used to better forecast individual tree volumes, as well as stand growth and yield. Participate in projects and share data in order to develop better volume and growth models. This may involve the establishment of some permanent growth plots, where growth may be monitored over time and data may be collected to better estimate local growth and yield.

10. Integrate consideration of biomass harvest and forest management efforts near the City of Galena into the Galena Community Wildfire Protection Plan as a means of mitigating fire hazard and risk.

11. Develop a Biomass Wildfire Hazard Assessment and Fire Prevention Plan as part of the Galena Community Wildfire Protection Plan to address the future prevention of wildfire and protection of the biomass resource as biomass harvest and management efforts are undertaken.

12. Plan, plan, plan, and then plan some more!

Deliverables

1. 2 copies of the complete Galena Working Circle GIS (GWCGIS) data set in an ESRI compatible ArcGIS format to The Louden Tribal Council on DVD. Files are shapefiles and grid format files. All GWCGIS data layers are referenced to the Alaska Alber's Equal Area Projection, NAD83 with units of meters (m). The GWCGIS is organized as an ArcGIS v10.x Project. The project .mxd file, as well as layer definition files (.lyr) used to create graphics for this report are included

2. All field data files and associated digital photographs and GPS locations.

3. Landsat TM satellite imagery used during this project and referenced to the GIS data set.

4. Four printed copies of this report.

Acknowledgment

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